RAYAN WOLF

ASSESSING THE IMPACTS OF LABOUR SKILL IMPROVEMENT IN BOLSA FAMÍLIA PROGRAM BENEFICIARIES: A COMPUTABLE GENERAL EQUILIBRIUM MODEL ANALYSIS

Thesis submitted to the Applied Economics Graduate Program of the Universidade Federal de Viçosa in partial fulfillment of the requirements for the degree of *Doctor Scientiae*.

Adviser: Erly Cardoso Teixeira

Co-adviser: Ian Michael Trotter

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The darkest hour is just before the dawn.

Thomas Fuller

ABSTRACT

WOLF, Rayan, D.Sc., Universidade Federal de Viçosa, July 2021. **Assessing the impacts of labour skill improvement in Bolsa Família Program beneficiaries: a computable general equilibrium model analysis**. Adviser: Erly Cardoso Teixeira. Co-adviser: Ian Michael Trotter.

Government transfers to Brazilian families through the Bolsa Família Program have a dual impact on beneficiaries. In the beginning, it plays a fundamental role in raising the well-being of the poorest families, increasing consumption, and temporarily alleviating poverty. In the long term, however, it inhibits the durability of the effects by reducing the price of the labor factor, the main source of income for the poorest families. In this way, the objective of the present study was to evaluate the economic impacts of a policy of qualification of work through professional courses for beneficiary families of Bolsa Família in Brazilian regions. To achieve this objective, the DAYANE model was built, a computable, static, multiregional, and multisectoral general equilibrium applied model. The model is based on the Global Trade Analysis Project (GTAP) and the General Equilibrium Analysis Project of the Brazilian economy (PAEG), presenting Brazil divided into five macro-regions and families divided into ten income classes, in each Brazilian region. Unlike the PAEG, the DAYANE model is developed in GEMPACK language and disaggregates families' schooling into twelve different levels. In building the model, in addition to making the PAEG compatible with the GEMPACK, the preparation of the database required the disaggregation of schooling levels for each income class in the Brazilian regions; of the workforce employed in each sector, by income class in the Brazilian regions; and, of the workforce employed in each sector, by the level of education in the Brazilian regions. In the model, labor qualification shocks were simulated for beneficiaries of the Bolsa Família Program, via vocational courses, from the complete basic and incomplete fundamental levels, and the income of families from the Bolsa Família Program is reduced in proportion to the increase in salary. The results of the study indicate that the qualification of labor, via professional courses, has positive impacts on the wages of families in Brazilian regions, especially in the poorest regions of Brazil. In addition, the study shows that even removing income transfers, via the Bolsa Família Program, in proportion to the increase in the families' salary, the positive results in the total family income are still maintained, and consumption increases. In this way, the study shows that labor qualification policies for families dependent on the Bolsa Família Program improve their economic situation, with income from transfers being replaced by income from work, which indicates that government transfers can cease in response to better gains in the labor market, and also ensure the economic improvement of families dependent on the Program.

Keywords: Welfare. Bolsa Família Program. Skill improvement. Labour market.

RESUMO

WOLF, Rayan, D.Sc., Universidade Federal de Viçosa, julho de 2021. **Avaliando os impactos da qualificação de mão deobra dos beneficiários do Programa Bolsa Família: uma análise de Equilíbrio Geral Computável**. Orientador: Erly Cardoso Teixeira. Coorientador: Ian Michael Trotter.

As transferências governamentais para famílias brasileiras por meio do Programa Bolsa Família têm duplo impacto sobre os beneficiários. No início, desempenha um papel fundamental na elevação do bem-estar das famílias mais pobres, no aumento do consumo e no alívio temporário da pobreza. No longo prazo, porém, inibe a durabilidade dos efeitos ao reduzir o preço do fator trabalho, principal fonte de renda das famílias mais pobres. Dessa forma, o objetivo do presente estudo foi avaliar os impactos econômicos de uma política de qualificação do trabalho por meio de cursos profissionalizantes para famílias beneficiárias do Programa Bolsa Família das regiões brasileiras. Para atingir o objetivo foi construído o modelo DAYANE, um modelo aplicado de equilíbrio geral computável, estático, multirregional e multissetorial. O modelo é baseado no Projeto de Análise do Comércio Global (GTAP) e no Projeto de Análise do Equilíbrio Geral da economia brasileira (PAEG), apresentando o Brasil dividido em cinco macrorregiões e famílias divididas em dez classes de renda, em cada região brasileira. Diferentemente do PAEG, o modelo DAYANE é desenvolvido na linguagem GEMPACK e desagrega a escolaridade das famílias em doze níveis diferentes. Na construção do modelo, além de compatibilizar o PAEG com o GEMPACK, a elaboração do banco de dados exigiu a desagregação dos níveis de escolaridade para cada classe de renda nas regiões brasileiras; da força de trabalho empregada em cada setor, por classe de renda nas regiões brasileiras; e, da força de trabalho empregada em cada setor, pelo nível de escolaridade das regiões brasileiras. No modelo, foram simulados choques de qualificação do trabalho para beneficiários do Programa Bolsa Família, via cursos profissionalizantes, dos níveis básico completo e fundamental incompleto, e a renda das famílias do Programa Bolsa Família é reduzida na proporção do aumento do salário. Os resultados do estudo indicam que a qualificação da mão de obra, via cursos profissionalizantes, tem impactos positivos nos salários das famílias nas regiões brasileiras, principalmente nas regiões mais pobres do Brasil. Além disso, o estudo mostra que mesmo retirando as transferências de renda, por meio do Programa Bolsa Família, na proporção do aumento do salário das famílias, os resultados positivos na renda Famíliar total ainda se mantêm, e o consumo aumenta. Dessa forma, o estudo mostra que as políticas de qualificação do trabalho para as famílias dependentes do Programa Bolsa Família melhoram sua situação econômica, com a substituição da renda das transferências pela renda do trabalho, o que indica que as transferências governamentais podem cessar em função de melhores salários no mercado de trabalho. mercado, e também garantir a melhoria econômica das famílias dependentes do Programa.

Palavras-chave: Bem-estar econômico. Programa Bolsa Família. Qualificação. Mercado de trabalho.

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SUMMARY

1 INTRODUCTION

The concept of poverty can be defined as deprivation of individuals' basic capacities, other than just lower incomes, such as premature death, persistent morbidity, malnutrition and illiteracy, and other disabilities. Ensuring capacity for individuals is important to overcoming income poverty, as the more inclusive the reach of basic education and health services, for example, the greater the likelihood that even the potentially poor have a greater chance. to overcome poverty (SEN, 2001). Therefore, this study analyses the impact of labour improvement on income transfer programs beneficiaries in Brazil.

Conditional Cash Transfer Social Programs require a counterpart from beneficiaries. Such programs are characterized by income transfer, conditional on certain requirements. The requirements are usually related to investments in human capital, such as the requirement of children's school attendance, health, and nutrition. The approach is as much an alternative to more traditional welfare programs as it is a complement to health and education services (RAWLINGS; RUBIO, 2005).

Such programs emerged in Latin America in the 1990s and have since been implemented by many developing countries. In recent years, these programs have become an important component of the social protection systems of their respective countries. Countries like Colômbia - Families in Acción (ATTANASIO; MESNARD, 2006), Mexico - Progresa (COADY; PARKER, 2004), Honduras - Family Assignment Program II, Nicaragua - red de Protección Social, Jamaica - Program for Advancement Through Health and Education (HANDA; DAVIS, 2006), in addition to Brazil - Bolsa Família Program (HALL, 2008; WOLF et al., 2018) are examples of implementing such Programs.

The Bolsa Família Program was created in 2003 to combat poverty and inequality in Brazil. The Program caters to families with per capita income up to R$ 89.00 per month, or with incomes between R$ 89.01 and R$ 178.00, as long as there are children from 0 to 17 years old. The requirements to receive the transfers cover actions in the areas of health, education, and social assistance. Failure to comply with the requirements may lead to the cancellation of the benefit (after some warnings). Table 1 shows the conditionalities required to receive the benefits of the Bolsa Família Program. (MINISTRY OF CITIZENSHIP, 2021).

Table 1 – The Bolsa Família Program conditionalities

Area	Conditionality	Target Audience
Health	Follow-up on children's immunization schedule, growth, and development	Children under 7 years old
	Prenatal care for pregnant and follow-up of breastfeeding mothers	Pregnant and breastfeeding mothers
Ecucation	Enrollment and 85% monthly school attendance	Children and adolescents between 6 and 15 years
	Enrollment and 75% monthly school attendance	Youngs between 16 and 17 years
Social Assistance	Ensure the minimum 85% attendance from children and young until 16 years old at Coexistence and Strengthening Entail Services	Family responsible for registration. Must be one of the family members and resident of the household at least 16 years old
	Participate in activities offered by the Reference Centers for Social Assistance (CRAS) and Specialized Centers for Social Assistance (CREAS)	
	Ensure registration data always updated	

Source: MINISTRY OF CITIZENSHIP (2021), VISDATA (2021)

Since its creation, there are two lines of eligibility on the calculation of the Bolsa Família Program transfers to families. Families that are registered in the Cadastro Único[1] on family income up to the lower eligibility line are considered extremely poor, while those who declare income between this and the upper-income line, are considered poor. These lines are key parameters when considering issues relating to coverage of cash transfer programs (OSORIO; SOARES, 2014).

Social Programs in Brazil adopt, however, different from the (lower) extreme poverty and poverty lines adopted by the World Bank[2]. The changes in benefit design and eligibility lines changed several times during Bolsa Família Existence. Table A.1, in Appendix A, shows all changes. It is important to emphasize that 2007 were included the Youth variable benefit. Another significant adjustment was the inclusion of pregnant and breastfeeding variable benefits, and the expansion of cumulative benefits. More than that, in 2012, one additional essential change was the inclusion of one specific benefit to overcome extreme poverty – called Benefit to Overcome Extreme Poverty[3] (MINISTRY OF CITIZENSHIP, 2021; World Bank, 2021).

1 Identifies and characterizes low-income families. Information such as characteristics of the residence, identification of each person, education, work status, and income, among others, are registered. See: https://www.gov.br/cidadania/pt-br/acoes-e-programas/cadastro-unico

2 See http://wdi.worldbank.org/table

3 If the family, after the Program transfer, continuous under the extreme poverty line (in per capita terms), it will receive an extra transfer equal to the gap to reach the line

There is clear evidence of the Conditional Income Transfer Program's success in increasing enrollment rates, improving preventive health care, increasing household consumption, and the weakening of poverty concerning the provision of social assistance. However, many questions remain unanswered, including the potential of such programs to function well under different conditions, to address a wider range of challenges between poor and vulnerable populations, to prevent the intergenerational transmission of poverty, and issues related to the effects of poverty disincentives and limited impacts on the welfare of beneficiaries (RAWLINGS; RUBIO, 2005).

Between 2001 and 2011, average household income grew by more than 30%, inequality as measured by the Gini coefficient fell by more than 10%, and extreme poverty and poverty rates declined by 4 and 12 percentage points, respectively (SOUZA et al., 2019). Many studies of income inequality in Brazil, such as Araújo (2009), Barros et al. (2010) and Araujo and Morais (2014), the elements responsible for the fall observed in the period before the current scenario of increase is due to transfer programs income and the labour market. For Soares et al. (2006) the challenge against poverty and the reduction in inequality levels in Brazil would hardly be achieved without direct mechanisms of income redistribution. However, if the federal government action focus just on income transfers and assistance to the poor without promoting increased social investment as a whole, it will undermine the purposes of public social protection policies (DORALIZA; FERREIRA; DENÚBILA, 2008).

After 15 years of falling, reaching the lowest level in 2014, the extreme poverty[4] increased by 51.54% in Brazil. In this period, 4.6 million people become extremely poor in the country (6.48% of the Brazilian total population live in this situation). Regarding the population under the poverty line[5], the proportion of the Brazilian population increased to 11.90% in the same period. 5.5 million people are living under this line (24.52% of the population are poor). In addition, the Brazilian per capita Gini[6] index was 0.543 in 2019, being the 9^{th} highest in a list of 164 countries – the income of 1% the richest population is 33.7 times higher than 50% of the poorest one[7] (IBGE, 2020; World Bank, 2021).

Data from Neri (2018) and (IBGE, 2021) show that the grant rate for the Bolsa Família Program is higher than the amount of drop-out, which considers not only beneficiaries no longer dependent on the Program, but also those who lose the right to benefit. In 2019 (one year before the pandemic situation) 2.51 million families were dropping out of the

4 The current international extreme poverty line is set at US$1.90 a day in terms of Purchasing Power Parity (PPP), which represents the average of the poverty lines in 15 of the poorest countries ranked by consumption/income per capita.

5 The World Bank recommends the use of US$5.50 a day (PPP) line for upper-middle-income countries, a group to which Brazil belongs with another 46 countries

6 The Gini index ranges from zero to one. The closer to zero, the better a country's income distribution, and the closer to one, the more unequal the economy.

7 The portion of workers with the highest income earned R$28,659 per month, on average, while the less favoured 50% earned R$850

Program. In addition, most beneficiaries are on skilled workforce age, and the performance of elementary and high school students is lower when compared to non-beneficiary public school students. It is important to ensure the good results of the Program are maintained so that the effects are lasting, allowing more families to achieve their autonomy, abdicating government transfers. Table 2 shows the Bolsa Família Program data over time.

Table 2 – Benefits and expenses with the Bolsa Família Program (from 2003 to 2021)

Year	**Benefits**[1]	**(%)Population**[2]	**Value**[3]	**(%)GDP**[4]	**Mean Benefit(R$)**
2003*	3.60	5.07%	1.50	0.035%	117.23
2004	6.57	9.12%	8.81	0.194%	162.21
2005	8.70	11.73%	12.50	0.263%	142.20
2006	11.17	14.64%	15.99	0.312%	131.35
2007	11.16	14.08%	18.24	0.329%	138.47
2008	11.13	13.68%	20.38	0.341%	155.71
2009	12.47	14.92%	22.94	0.374%	162.73
2010	12.78	14.89%	25.00	0.370%	165.32
2011	13.36	15.15%	28.36	0.397%	181.07
2012	13.90	15.90%	32.65	0.439%	200.06
2013	14.09	15.14%	36.28	0.467%	219.33
2014	14.20	14.85%	37.24	0.470%	220.99
2015	13.94	14.18%	34.22	0.461%	205.69
2016	13.97	13.82%	33.19	0.455%	200.01
2017	13.83	13.31%	32.85	0.441%	203.27
2018	14.23	13.31%	33.38	0.419%	199.40
2019	14.34	13.50%	32.56	0.420%	196.95
2020* **	14.27	13.34%	32.29	0.437%	189.07

Source: VISDATA (2021), CECAD 2.0 (2021)
* - Estimation; ** - Due the COVID-19 pandemic and the Brazilian, data for Bolsa Família Program value also include the emergency aid.
1 - Total beneficiary families ; 2 - The portion of the Brazilian population that receive Bolsa Família Transfer, considering the mean Brazilian family size; 3 - Total paid to the beneficiary families (R$ bi) – 2021 value; 4 - Portion of GDP expenditures with Bolsa Família

Recently, data from FGV Social (2020) shows, after reaching the maximum number since 2012, the number of beneficiaries has reduced in 2019. In net terms, the Program disconnected about 1.1 million families between May 2019 and January 2020. Thus, the result is the emergence of an average annual queue of 500,000 families that should be being served but are still waiting to be covered by Bolsa Família. Therefore, the main instrument to fight poverty regressed during the economic crisis that started at the end of 2014, which led to a loss of welfare and the growth in the number of Brazilians in situations of extreme social vulnerability.

The COVID-19 pandemic brought unprecedented challenges to the Brazilian social protection system. Informal workers, unemployed and poor families were exposed to the combination of pandemic and recession (PAIVA et al., 2020). Greco et al. (2021) considers that the pandemic has further exposed low-income families to social vulnerabilities.

According to the authors, family income has become even more unstable, affecting the family's quality of life.

The monthly per capita income of Bolsa Família beneficiaries rose from R$ 341 to R$ 352 in 2019, although peaked at R$ 398 in 2014. However, the income of those receiving this benefit is much lower than the income of those who are not beneficiaries of the program (R$1,641). This shows that Bolsa Família is indeed aimed at the poorest part of the Brazilian population (BARROS, 2020).In June 2021 there were 14.64 million Bolsa Família's benefited families, with an average benefit of R$ 83.49 (CECAD 2.0, 2021).

The families from the Northeast are 49.03% of total families in Brazil that receive transfers from Bolsa Família Program in Brazil; Southeast families represent 27.40%; North region represents 12.22%; South region represents 6.52%; and, the Midwest represents 4.83%. The age group that receives the most benefits in Brazil ranges from 16 to 34 years (31%). The educational profile of beneficiary heads of household is low education (VISDATA, 2021). The skill level of Bolsa Família families heads beneficiary can be observed in Figure 1.

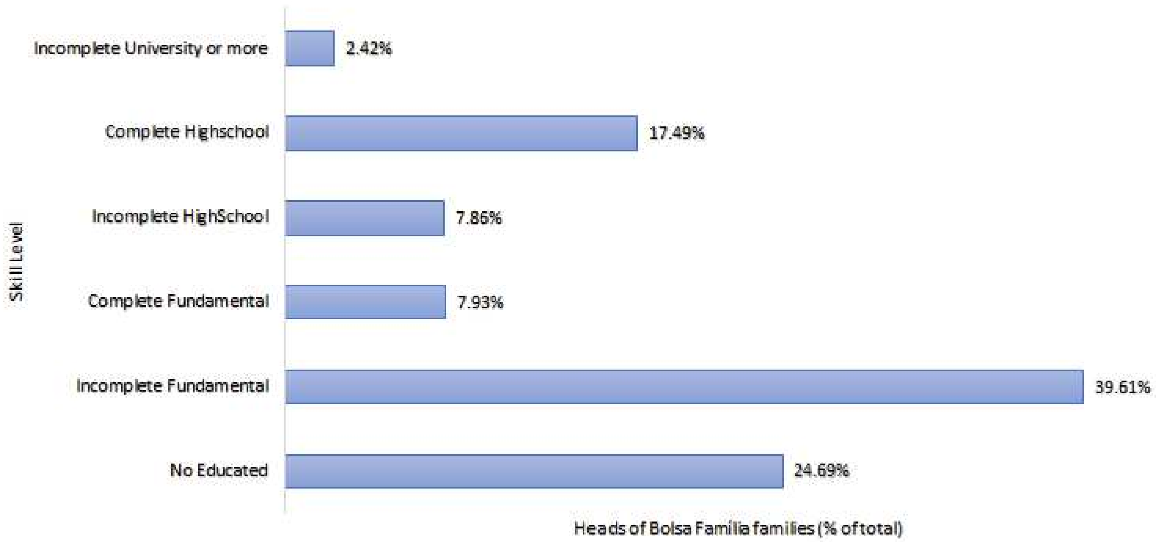


Figure 1 – Skill level of Bolsa Família beneficiaries families heads
Source: CECAD 2.0 (2021), VISDATA (2021)

It is quite clear that most of the heads of families that receive the transfer from Bolsa Família in Brazil present an Incomplete Fundamental skill level (39.61%). However, there are different skill levels among the regions in terms of the population proportion. The proportion of families on incomplete fundamental skill level in North (38.97%, Northeast (38.93%), and Southeast (39.06%) are under the Brazilian aggregated proportion, while South (44.87%) and Midwest (40.34%) are above. The second-highest skill level of Bolsa Família Beneficiaries families heads is the no educated skill. In this skill level, Northeast (27.34%) and North (27.03%) are above the Brazilian aggregated skill level (24.69%), and South (21.19%), Southeast (21.51%) and Midwest (23.93%) are under.

Medeiros, Britto and Soares (2008) consider that the cash transfer programs in Brazil, such as the Bolsa Família, are structured in such a way as to have an “entrance door” but no “exit door”. Such Programs do not have an emancipatory characteristic. More than that, policies targeting the labour force of poor families, would be a definitive solution to fight poverty. Trogiani (2012) and Cassiolato and Garcia (2014) highlight the difficulty of adhesion and keeping the low-income target audience and income transfer programs beneficiaries in programs like PRONATEC[8]. Such a program is designed especially for fast skill improvement, and there are several efforts to incentive the low-income people (and Bolsa Família beneficiaries) in participating in courses.

Among several papers that study income inequality in Brazil, for example, Araújo (2009) and Barros, Foguel and Ulyssea (2006), there were discussions about which elements that make up income were most responsible for its reduction. However, the main hypotheses raised are related to official income transfer programs and the labour market. For Soares et al. (2006), the eradication of poverty and the substantial reduction of inequality levels in Brazil would be difficult to achieve without direct mechanisms of income redistribution.

Moreover, several researchers and segments of society agree that the purposes of public policies for social protection, assistance, and social development (reduce inequality and poverty and contribute to the emancipation of families) will be compromised if the federal government’s action is limited to the transfer of income and assistance to the poor, and not promote an increase in social investment in a whole (MONTEIRO et al., 2008).

There is clear evidence that despite contributing to the improvement of social well-being, the Bolsa Família had not only positive impacts on poverty and inequality. At the first moment, the program improves the poorest families welfare, fulfilling its function of alleviating poverty (ROCHA, 2005; SILVA; FILHO, 2018) Even raising household consumption, the multiplier effects of the transfer on households welfare are small. Thus, the transfer would improve the situation of households, without necessarily moving them above the poverty line. The program’s effects on inequality would be only momentary (ZYLBERBERG, 2008; MUNIZ, 2018).

The positive results of the Bolsa Família Program could be maintained by conditioning the student performance (not just attendance) and mandatory employment for heads of families receiving transfers, besides qualifying heads of families dependent on the Program (via professionalizing/training programs). These kinds of course not only represent a faster and more effective qualification for lower educational levels but also makes it easier to reconcile with employment, so the beneficiary does not have to give up the job market to qualify.

[8] National Program for Access to Technical Education and Employment – see https:/www.educamaisbrasil.com.br/pronatec

1.1 The research problem and its importance

Transfers from the Government to low-income families via Social Cash Transfer programs change their consumption capacity. When the Government transfers more resources to families, the families that receive the resources spend relatively more on more capital-intensive goods (agriculture and manufacturing) than the government (which spends a lot on services). Therefore, the shift of part of government resources to the poorest families generates a relative increase in the price of capital (relative to labor) (WOLF et al., 2018).

In addition to that, it can not be ensured that school attendance conditionally has an isolated positive effect on the Bolsa Família Program performance. There are pieces of evidence that monitoring school attendance reduces the failure of the school year, but does not have sufficiently strong effects on educational indicators to claim that the Program is responsible for altering student achievement. This is because basic education in Brazil is almost universal, disapproval rates are at a very low level, progression is relatively high, and a set of policies to support school attendance has been in place for a long time (PAIVA et al., 2021).

Therefore, it is pertinent to determine the impacts of alternatives that ensure, besides the inclusion of household heads in the labour market, the need for qualification of labour through training, making the income transfer effects lasting, not only momentary. Given the above, the following question is asked: What are the socioeconomic impacts of a government policy that makes the Bolsa Família Program conditional upon the workforce qualification of beneficiary families heads?

By admitting that the increase in the educational level is capable of increasing the worker's salary gain due to the increase in productivity, policies that aim at improving the educational system tend to have a significant impact on income over time. Thus, the increase in the qualification of the labour factor can put the country on a path with higher rates of economic growth throughout this process (FILHO; PESSÔA; VELOSO, 2010).

Given that the educational level of household heads receiving the Bolsa Família Program is predominantly primary education (VISDATA, 2021), a relevant analysis is to consider the labour qualification through training courses, like PRONATEC. Such an alternative is important as it provides a higher income for the heads of these families. The qualification of human capital boosts individual productivity and, consequently, individual salary, and according to Vignoles, Galindo-Rueda and Feinstein (2004), for individuals with low levels of education, training has a better wage impact.

A fact that makes it difficult for the beneficiary families to leave the Bolsa Família Program is that, besides the benefit being a complement to the per capita household income, the adult members of the families do not carry out productive activities, with sufficient remuneration to remove them from the poverty situation. Thus, transfers from the Bolsa Família Program must be linked to labour qualification policies of those who receive the benefit, since less qualified labour tends to receive lower salaries, hindering the ability of families to rise in income class and thus no longer depend on government transfers over time (LEAL, 2012; WOLF et al., 2018).

Throughout Brazil's history, the development and, mainly, from the advent of industrialization, have contributed to creating accentuated conditions of socioeconomic and regional inequalities (FURTADO, 1974). Brazilian regions have profound inequalities that are evidence of an old colonial heritage (CANO, 2000). Therefore, regional analysis is essential, considering the profound social and income distribution differences among the Brazilian regions (see Figure 2 for the Gini index by region in Brazil).

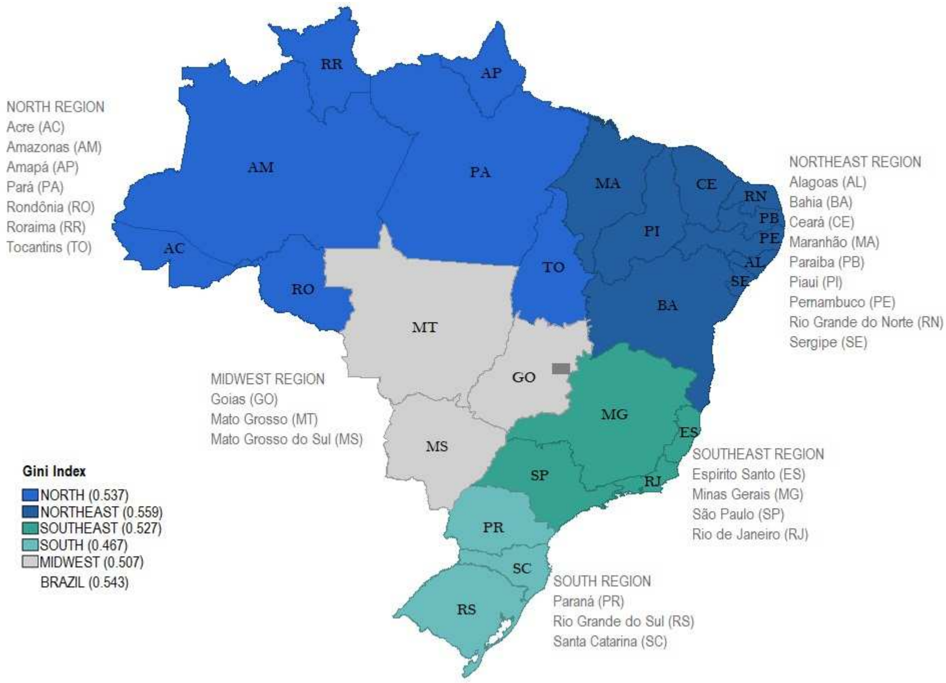


Figure 2 – Gini Index - Brazil and Regions
Source: World Bank (2021); IBGE (2021)

Analyzing the source of family income is relevant because wage labor is the main source for low-income families, while the richest families rely much more on income from capital, comparatively. Thus, policies that increase the wage rate increase the welfare of the most impoverished families. This is the first study proposing skill improvement analysis combined with Bolsa Família Program beneficiaries using the PAEG (General Equilibrium Analysis Project of the Brazilian Economy) database. In addition, it will contribute to the Project database, since it is intended to disaggregate the labour qualification of the families of each income class into the five Brazilian regions.

1.2 Hypotheses

a) Labour skill improvement policies increase the Bolsa Família Program dependent families income;

b) Labour skill improvement policies increase the Bolsa Família Program dependent families consumption;

c) The effects of Bolsa Família Program are lasting when combined with labour skill improvement policies;

1.3 Objectives

1.3.1 General Objective

To assess the economic impacts of a labour skill improvement policy via professionalizing courses for Bolsa Família beneficiary families in Brazilian regions.

1.3.2 Specific Objectives

a) Make the PAEG (General Equilibrium Analysis Project for the Brazilian Economy) model compatible with GEMPACK (General Equilibrium Modeling Package);

b) To disaggregate, in the base data, the educational levels for each income class in the Brazilian regions;

c) To disaggregate, in the base data, the labour force employed in each sector, by income class in the Brazilian regions;

d) To disaggregate, in the base data, the labour force employed in each sector, by educational level in the Brazilian regions;

e) To determine the effects of skill improvement policies associated to Bolsa Família Program on the sectors in the Brazilian economy;

f) To determine the effects of skill improvement policies associated to Bolsa Família Program on families income in Brazilian regions, and;

g) To determine the effects of skill improvement policies associated with the Bolsa Família Program on families consumption in Brazilian regions.

2 THEORETICAL BACKGROUND

The theoretical background session includes a review of the undesirable effects of cash transfer programs (such as Bolsa Família) on beneficiaries. In this way, it will be possible to verify that, among others, there are consequences related to the labor market. Next, the theory of salary gains due to the qualification of labor is presented. This is important, as it guides the formulation of the database and supports the analysis of results.

The third and fourth subsections of this section review technical courses that exist in Brazil and their importance for training (or even raising) the income of those who complete them, highlighting the impacts on the poorest families. Like the first chapters of the theoretical framework, these chapters are intended to provide a basis for analysis and the database.

Finally, a theoretical framework is presented on the computable general equilibrium methodology, highlighting the impacts, in theoretical terms, of government interference in the economy, through labor qualification. In addition to presenting the concepts of the adopted methodology, this session is important to understand the behavior of the model developed for this thesis.

2.1 Unintended consequences of the Bolsa Família Program

The Bolsa Família Program is characterized as a Conditional Cash Transfer Program due to the conditions required to receive the benefits. These conditionally involve measures of children human capital development, related to education, health, and social assistance. The reason for the conditionality is that they would break the poverty cycle. The program has significant impacts on extreme poverty in Brazil and reached practically all eligible people. However, the long-term objectives to combat the poverty trap are uncertain (RASELLA et al., 2013).

Such authors as Besley and Coate (1992) believe in adult beneficiary dependence possibility of Conditional Cash Transfer Programs. This dependence results in a poverty trap, since, according to Tavares (2010), the income eligibility criteria would create a double effect in the adult population: withdrawing from the labour force and entering informality. Gasparini and Furtado (2014) believe that cash transfer beneficiaries prefer the informality, once this option because it makes it more difficult to monitor potential income, avoiding the termination of the benefit.

The longer an individual stays away from the labour market, the more likely it is not to find an acceptable position (with higher earnings) and the worse the quality of employment since the individual's human capital is depreciated. Blundell (2000) states that any program that aims at poverty alleviation has a potential disincentive for the welfare trap. The author argues that typically these programs withdraw the benefit as the family's income rises, and this leads to disincentives for participation in the labour market.

Blundell (2000), citing examples from the Canadian Self Sufficiency Experiment and the Earned Income Tax Credit, emphasizes that benefits should remain as individuals enter the labour market, and reduce as wages increase. However, the incentives in skill training of the labour force of less-skilled workers are typically reduced in this benefit system, and if wages are relatively low (due to low skill) the individual's choice is to be held hostage to benefits to stay in this "welfare system".

Even with incentives for adults who benefit from cash transfer programs to remain in the labour market, there comes a time when the individual chooses to remain in the welfare trap, due to the salary reduction. This is explained by the reduction in incentives for professional training and qualification. Therefore, it is plausible to believe that labour qualification conditionality is an efficient way to increase wages, and thus encourage the exit from the welfare trap, by increasing the possibility of an acceptable placement in the labour market.

Soares, Ribas and Osorio (2007) believe that much attention is given to analyzing compliance with Bolsa Família Program conditionalities regarding children's education (school attendance[9]), child labour, nutritional issues, and health monitoring. Little note is made of the fact that no requirements on labour supply of the adults in the families. The authors find results of disincentive for the participation of the main families source of income (labour) in the formal employment sector in metropolitan areas, but not in rural regions. Thus, the hypothesis that the Bolsa Família Program causes dependency in the beneficiary families is not rejected.

Brauw et al. (2015) disagree that the Bolsa Família Program reduces the participation of beneficiaries in the labour market. However, they report a substitution between formal and informal work (eight additional hours in informal jobs), and a reduction of the same amount of hours in formal work per household member in families receiving government transfers in the urban area. As for rural areas, there is evidence of a reduction in women's and positive impacts on men's workforce.

Vieira (2017) refutes the hypothesis that there is a "laziness effect[10]" in families dependent on the Bolsa Família Program. There is, however, evidence that the patterns of the Program encourage the under-declaration of income of the beneficiaries, an increase in informality, and a disincentive to look for work. This fact can be explained, besides what has already been raised, also by the low qualification of the dependents of the Program, since people with low qualifications have to accept less advantageous positions in the labour market, or simply accept unemployment and informality.

Bugarin (2015) simulate 4 scenarios on different information and incentive with strategic income reduction to evaluate the reach and accuracy of the Bolsa Família Program.

[9] An interesting question may arise about this conditionality: is the requirement only that children be present in school, and little attention to performance, sufficient to accumulate human capital and break the poverty cycle?

[10] Regarding to the reduction in the demand for employment

In the study, even with the possibility of the government determining the income of each individual (unrealistic situation), the minimum income condition can generate a moral hazard effect on the beneficiaries. The most productive citizens, with the possibility of establishing themselves above the poverty line used to determine entry into the Bolsa Família Program, can reduce their income (hours worked) in a way that guarantees the receiving of the benefit. The authors consider that, in this case, the Program's reach is reduced since the target audience will be expanded without an immediate increase in the budget.

In a scenario where the government cannot observe the income of the applicants perfectly (more realistically), Bugarin (2015) believe that, in addition to the moral hazard problem, the adverse selection effect arises, since even with a high income the individual has the incentive to request the benefit in the hope that the government will not observe this income. The coexistence of these two problems reduces both the reach and the accuracy of the Bolsa Família Program, preventing scarce public resources from not reaching the really poor families for whom they are intended because they are benefiting individuals who should not be receiving the benefit. Mendes and Sampaio (2008) corroborate the view that the policy adopted by the government encourages fraud, and considers that the asymmetry of information increases the costs of the Program.

Simoes and Sabates (2014) alert to the fact that considering fourth-graders, there is only a short-term substitution effect between the value of the Bolsa Família Program transfers and educational performance. According to the authors, it is necessary to take into account the progression and performance of students. Camargo and Pazello (2014), analyzing performance in Portuguese and Mathematics, argue that the effects of school attendance alone are weak on student performance. The fact is that, according to Ribeiro, Shikida and Hillbrecht (2017), there is little evidence of the school performance of children from Bolsa Família Program beneficiary families.

Junior and Mendes (2012) warn about the weak Government evaluation power on the effort of students who, even if they are fulfilling their obligation to attend school, may not be generating a human capital accumulation. The authors believe that the asymmetry of information, in this case, appears because the Government assumes as a proxy for human capital formation, student attendance, and that the correlation between what is required (school attendance) and the effort (which generates human capital, and which is not observed) made may not be perfect.

The results of Junior and Mendes (2012) study emphasize that the present Government incentive system generates the minimum effort of the students dependent on the Bolsa Família Program. Therefore, there is currently a suboptimal Nash equilibrium for two reasons: the maximum effort of the student depends on the Government transfers, and; the student maintains the minimum effort. The authors consider that another incentive system should be considered so that the transfers are conditional on observable variables.

Bichir (2010) highlights the importance of cash transfer programs having "exit doors" for beneficiaries and cites the example of the Chile Solidario program, where the beneficiary receives the benefit for a certain time (3 years). In the case of a time limit, it would be up to the families themselves to seek positions capable of guaranteeing not to receive government transfers. The government must, therefore, assume the role of guaranteeing that the dependent of the social cash transfer programs can, on their own, after the emergency measures of the Bolsa Família Program, guarantee an income that places them above the situation of vulnerability.

Chitolina et al. (2014) highlight the importance of cash transfer programs in providing immediate relief from poverty. Soares and Sátyro (2009) believe that the Brazilian government rejects the idea of an "exit door" to the beneficiaries of the Bolsa Família Program, creating articulations with other social policies and complementary programs. Therefore, the Bolsa Família Program would be a way to cool the impacts of poverty, but by itself, it is not enough to break the cycle of poverty, and even if it does, it would take a considerable time for the effects of the care to be felt on the children and adolescents of the families and not directly on the adults (current labour force).

A widely debated problem is the incentive for families to have more children (increasing the fertility of women in beneficiary families) since the benefit received is variable according to the number of children and would stimulate families, who are already poor, to have more children, which could create a poverty trap. Rocha (2018) finds no robust evidence that this hypothesis is true. Cechin et al. (2015) consider that, in general, the Bolsa Família Program generates little incentive to the generation of the second child in the beneficiaries, and the Northeast and Midwest regions are those that present the greatest impacts.

Alves and Cavenaghi (2015) argue that in the last decade even the low-income population has shown a reduction in the average number of children as they urbanization and due to access to public policies on education, health, among others. The authors emphasize that women, in general, want to have fewer children than their mothers, and have a high rate of unplanned pregnancies. Predominantly, women join the Bolsa Família Program because they have children, and not the other way around (having more children to receive more benefits, or to join the Bolsa Família Program). However, the design of the Bolsa Família Program can be considered "pro-born", but the value of the variable part of the benefit is very low and with low impact power to change the average trend of decline in fertility rates in Brazil.

It is also relevant to cite the "snake effect", a situation where the policies adopted end up worsening the problem instead of solving it (in the case of the Bolsa Família Program, the poverty and vulnerability situation) (MARTINS, 2020). The Bolsa Família Program is effective in reducing the effects of poverty in an emergency way. However, several distortions, such as the control of conditionality, can cause adverse effects on families, many of them referring to permanence in poverty. While families are assisted by government transfers, they are in a better situation, but in the long run, they have no effective way out of poverty.

2.2 Skill improvement and salary gains

Human capital consists of accumulated training and education throughout the life of each individual. Workforce quality is an essential component of wealth generation (YANG; PAN, 2020). The abundance of skilled people, according to Barro and Lee (2013), increases labour productivity in the economy, also implying more skilled workers who can influence social development, improving income distribution. Investment in human capital to Schultz (1960) is a way to increase productivity as well as wages, and significantly explain the growth of national income.

Education, therefore, plays a key role in wage formation. Mincer (1958) develops a model where the only difference between workers is the educational level, with no uncertainty about future earnings and assuming the skill tables among individuals (thus, there are no unobservable characteristics that influence the salaries of different individuals). Considering wage $w(s)$ fixed for each year of study (s), the present value, $V(s)$ of earnings over working time T, where the interest rate is r, is given by:

$$V(s) = w(s) \int_{s}^{T} e^{-rt} dt = \frac{w(s)}{r}(e^{-rs} - e^{-rT}) \tag{1}$$

Taking the wage logarithm, the difference between a person with s schooling years and another with no education is given by:

$$ln w(s) = ln w(0) + ln\left(\frac{1-e-rt}{1-e^{-r(T-s)}}\right) + rs \tag{2}$$

Equation (2) explains the fact that education increases wages and the longer the time for retirement, the greater the return on education. Becker (1962) believes that labour training, which is a professional qualification, presents a considerable and important effect on the income profile over time. The following are the concepts addressed by the author.

Figure 3 shows the wage trajectories of skilled workers (TT) and unskilled workers (UU) over time. The author suggests that, at first, a worker who is not qualifying receives a higher salary than the one who is qualifying. Assuming the workers are already employed, those being qualified would have part of their “appropriate” salary from the company to cover the qualification, and after that period will receive more than the unskilled worker.

Workers are paid according to productivity, and the initial reduction in skilled workers wages is due to the generality of training, thus having two specifications for the type of labour qualification: generic training and specific training. In generic qualification, the firm could benefit from increased productivity by hiring an already trained employee, but not from it, so skills acquired by a worker in a given firm could contribute to another

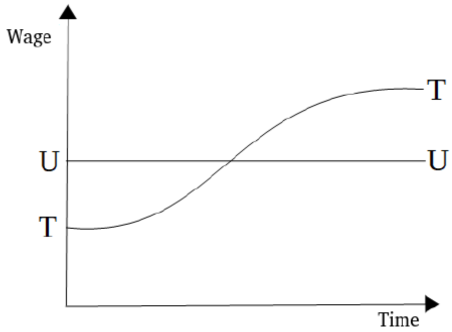


Figure 3 – The relation between salary and time (qualification)
Source: Becker (1962)

firms increased productivity in the case of dismissal of the worker. In specific training, the skills acquired by the worker would be able to increase to a greater degree the productivity of the company that needs this labour compared to other firms that could employ it.

In a generic training scenario, it could be that the company would not get any kind of return after qualifying the worker, as it could transfer from the company that trained it to another, as the lessons learned by the worker could easily be employed. in any company. The Firms would then agree to offer generic training if they did not have to pay any kind of cost. The Workers would be willing to bear the costs of labour qualification provided there is a possibility of wage increases.

Thus, it would be the workers themselves, who, looking for higher wages, would be willing to qualify their labour, temporarily earmarking a portion of their wage for this purpose, would later be raising the wage, and companies would gain in terms of productivity. When it comes to specific training, workers would get a lower and even non-existent discount on their salaries. Figure 4 shows, on the `T’T’` line, the wage behaviour for a specifically skilled workforce.

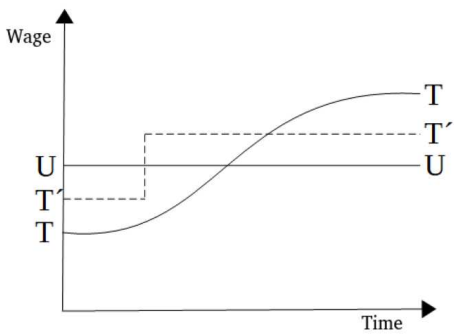


Figure 4 – The relation between salary and time (specific qualification)
Source: Becker (1962)

A worker who is already employed would have no motivation to pay for a specific qualification for a particular firm, as this would reduce his chances of returning to a limited number of firms, so the firm should finance part of the qualification, absorbing in the future part of the return. The trajectory of a person who received specific training would be represented by the `T’T’` curve, higher than `TT` and less sloping over time.

Throughout his career, the most qualified worker will receive a higher salary than the unskilled, because the former is more productive. The difference between curve inclinations will depend on the cost and return of the training. The concavity of the TT curve is linked to the rate of return on investment, which is higher at older ages because an individuals skills only develop fully after a certain time and, as a result, return on investment only will occur after a trial period.

Following the reasoning, one can then analyze that skilled labour is synonymous with higher pay for the worker. The author analyzes two qualification specifications: a scenario in which the employee is willing to bear the costs of qualification and another scenario in which the firm has incentives to qualify the employee. So if the government is introduced into the analysis (Figure 5) there is the possibility of a higher curve pay rise, directly, without somehow exhausting what the worker already receives.

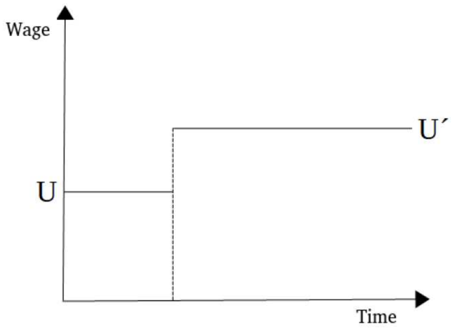


Figure 5 – The relation between salary and time (qualification with the government)
Source: adaptado de Becker (1962)

When the worker takes the initiative to specialize, he loses part of his salary to increase over time; When this initiative starts from the company itself, the employee loses part of this salary to split the cost of the qualification. Considering that the salary increase follows a logic that the higher the productivity, the more the worker receives, when this qualification comes from the Government, the company and worker himself do not bear the costs of the qualification, thus, the result is higher productivity and higher productivity, the company raises the remuneration of the work.

Becker (1964) investigates investments and returns of human capital at different times of life and considers that the educational gains of the older strata are greater than those of the early strata. The author also considers that less qualified people reach the maximum of the remuneration before the qualified ones.

Becker and Chiswick (1966) consider that the individual total income after investment in human capital (RT_i) is equal to the sum of the returns on his investments and the gains from his previously acquired ("original") human capital. If returns could be treated as constants for an indefinitely long period, this relationship would be:

$$RT_i = X_i + \sum_{j=1}^{m} r_{ij} C_{ij} \tag{3}$$

where C_{ij} is the amount spent by i^{th} person on j^{th} investment, r_{ij} is the rate of return on this investment and X_i is the effect of original capital. It is noted that the analysis applies directly to earnings, which is only a part, although dominant, of total income.

The authors assume that the amount invested in human capital results from worker optimization, and each person should invest a value that maximizes their economic welfare. The approach considers excessive data availability, although the authors consider data on formal education to be accurate, data on other types of human capital are limited, separating formal education from other types of human capital:

$$log RT_i = \alpha + \sum_{j=1}^{q_i} \overline{r}_j^{'} S_j^{+} v_i^{'} \tag{4}$$

where $\overline{r}_j^{'}$ is the adjusted rate of return for each of the S_j years of formal study, so $S_i = \sum_1^{qi} S_j$ represents the total of years of formal study of every i^{th} person, and

$$v_i^{'} = v_i + \sum \overline{r}_k^{'} T_k \tag{5}$$

includes the effect of other sources of human capital. Where: $\overline{r}_k'$ is the adjusted rate of return for each of the T_k years from other sources of human capital.

Expanding the Becker (1964) and Becker and Chiswick (1966), Mincer (1974) analyzes the influence of the worker's life cycle on wages, analyzing the influence of both increases in years of schooling and experience. The author presented the concept of wage return in which earnings distributions and investments in human capital are related. The equation, at first, is as follows:

$$ln W_{si} = ln \beta_0 + \beta_1 S_i + \varepsilon_i \tag{6}$$

where W_{si} are annual i earnings with S years of schooling, and $ln\beta_0$ is the gain of an unschooled worker, β_1 is the gain additional income that is occasioned by an additional year of study.

The author, assuming that the only cost of attending school one year more is the student's opportunity time cost and that the commensurate increase in earnings from that additional year of schooling is constant throughout his or her life, concludes that the wage return logarithm is a linear time function invested in school and that the additional income gain caused by one additional year of study can be interpreted as the rate of return on schooling investment.

The salary gain that a person would receive after the completion of the (W_s) qualification implies that no further human capital investments will occur afterward, which is often unusual. Thus, a model of education that is closer to reality must admit that the rates of return on education are similar to the rates of return on investments made after the school cycle and that the individual income stream is constant over time. The equation of Mincerian wage returns is, therefore:

$$lnWs_i = \beta_0 + \beta_1 S_i + \beta_2 t_i + \beta_3 t_1^2 + \varepsilon_i \tag{7}$$

where W_{si} is the the salary of the individual i with S years of schooling, t is the experience. The β_1 coefficient indicates the one-year marginal gain in education, the return on education. Experiment returns are positive for β_2. $\beta_3$measures the decrease in human capital investments in the labour market (negative). The return on experience grows and peaks maximum throughout life.

Ferreira (2003), sophisticate the function and production from Mankiw, Romer e Weil[11] using the equation of Mincer(1974), resulting in an alternative production function for macroeconomic growth analysis bringing human capital in exponential form:

$$\mathtt{Y_{it}} = \mathtt{A_{it}K_{it}^{\alpha}(exp(\phi h_{it}).L_{it}exp(g.t))^{\beta}} \tag{8}$$

where the parameter $\mathtt{exp(\phi h_{it}}$) expresses the percentage increase in income caused by one additional year of schooling. Adjusting the equation for effective units of labour and applying logarithm, we have:

$$ln\mathtt{y_{it}} = ln\mathtt{A_{it}} + \alpha ln\mathtt{k_{it}} + \beta\phi\mathtt{h_{it}} + (\alpha + \beta - 1).ln\mathtt{L_{it}} + \beta(\mathtt{g.t}) + \varepsilon_{\mathtt{it}} \tag{9}$$

the coefficient β measures the proportional change in income given an absolute change in the value of human capital.

2.3 Training courses in Brazil

The INEP (Intituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira) defines three levels of professional education. Basic level courses do not require schooling prerequisites, they are continuing education courses, have a variable duration, and are offered by several organizations besides the government (such as NGOs, churches, unions). The technical medium level is the second level course, which has a high school education as a minimum requirement (it can be done concomitantly), and is offered by institutions accredited by the government. Finally, there are the higher-level professional courses, called technological graduation courses (FILHO; COSTA, 2017).

The inclusive character and professional certification of vocational education in Brazil emerges in 1996 with Law 3.394/1996. It came to be considered an educational level (a modality of education accepted in the dimensions of work, science, and technology) in 2008 [12], the levels of professional, technical high school education, youth, and adult education, and technology courses are institutionalized. In 2007, the second phase of the Expansion Plan for the Federal Network of Professional and Technological Education began,

[11] $Y_{it} = A_{it}K_{it}^{\alpha}H_{it}^{\phi}(L_{it}exp(g.t))^{\beta}$
[12] Lei Nº11.741/2008

intending to cover all Brazilian regions, offer qualification, technical and technological education courses, to supply the needs of local and regional development (MEC, 2007).

The year 2011 marks the beginning of the National Program for Access to Technical Education and Employment[13] to expand the offer of Professional and Technological Education courses, through programs, projects, and technical and financial assistance actions. The target public of the Program includes among other individuals those who receive benefits from federal income transfer programs (BRASIL, 2011).

The professional qualification of people registered in the Unified Registry via Pronatec is part of the plans of Brazil Without Extreme Poverty program and aims at the productive inclusion of the individual, not only the guarantee of income for immediate poverty alleviation (income from social programs). The target audience is beneficiaries of social programs and people living in extreme poverty, for which there is the "Bolsa-Formação", which is passed on to the institutions that teach the courses (Federal Network Institutions; State and Municipal Networks; National Learning Services; Public Universities and Foundations and Private Institutions of Higher Education and Professional and Technological Education) (SETEC, 2020).

Through the Bolsa Formação Program the Department of Professional and Technological Education supports institutions linked to the various education networks in the country in offering free places in secondary-level technical professional education courses and initial and continuing education or professional qualification courses, at the cost of the opening of vacancies. The National Catalog of Technical Courses (CNTC, 2021) considers as technological axes: environment and health, industrial control and processes, educational and social development, management and business, information and communication, infrastructure, military, food production, cultural production and design, industrial production, natural resources, safety, tourism, hospitality, and leisure.

It is observed that professional and technological education in Brazil is treated as a public policy to combat the cycle of poverty, improving (qualifying) the supply of labour, seeking the insertion in the labour market (or a better position) of, mainly, individuals assisted by other social programs or in poverty. Goals to expand the education modalities offered by Pronatec are included in the National Education Plan 2014-2024 (MONTAGNER; MULLER, 2015; BRASIL, 2014).

Data from the Ministry of Social Development and Fight Against Hunger and the Ministry of Education indicate that, in 2014, 33% of the Bolsa Formação students enrolled in Pronatec were beneficiaries of the Bolsa Família Program, with a dropout rate of 19.7% and a failure rate of 12.3%. Neri (2010) believes that vocational courses have the relative advantages of requiring less time to complete, offering easier reconciliation between studies and work, and being directly oriented to the needs of the demand for labour.

In addition, as Vieira and Júnior (2016) note, professional and technological

[13] Lei Nº12.513/2011

education in Brazil assumes a strategic role in the development of the country, serving diverse audiences in different areas of production. There are also several studies that indicate positive effects of vocational courses on the probability of employment and labour income, such as: Vasconcellos, Lima and Menezes-Filho (2010); Severnini and Orellano (2010); Oliva, Ribeiro and Souza (2015); Oliva et al. (2014); Mariano and Arraes (2018). Thus, this labour qualification modality can be a less costly alternative from an individual point of view and with possibly positive returns to the labour market.

Vasconcellos, Lima and Menezes-Filho (2010) find positive results on labour income among 12% e 37% for high school technical education.Oliva, Ribeiro and Souza (2015) e Oliva et al. (2014) find positive effects for professional education on wages and occupations. The Nilo Peçanha Platform (MEC, 2019) shows that in 2018, the Federal Network of Professional, Scientific and Technological Education recorded 1,031,798 enrollments at all levels, of which 564,095 (54,67%), in medium-level technical courses, 261,181 (25,31%) in Undergraduate courses, with outstanding performance also in Professional Qualification and Post-Graduation, with 106 Masters and 07 Doctorate courses, emphasizing that there has been a substantial expansion in attendance at all levels.

2.4 The effects of qualification for low-income people and beneficiaries of income transfer programs

In the human capital theory, it is usual to consider that more schooling generates higher income in a decreasing manner, the lower increments wages are received the higher the schooling (PATRINOS, 2016). Considering this characteristic, and considering that the schooling of the poorest tends to be lower than the richest, it is inferred that the marginal returns to education are distinct for rich and poor. The return of the poor (low human capital) for an additional year of study should be higher than the return of the rich.

Rosenzweig and Wolpin (1994) investigate whether preschool increases human capital production in children, and suggests that completing preschool improves all human capital generation thereafter. Thus, the investments made at the beginning are very powerful, there are increasing returns to the early educational levels. The educational levels of extremely poor families tend to be low and are the levels of the highest educational returns, investments to increase the schooling of the poor with low schooling would represent a high private return.

Positive returns for the individual are even more positive for society. Moretti (2004) argues that the effect of a general increase in human capital has larger effects on productivity than the individual effect, there are spillovers. Acemoglu and Angrist (2000) measure these spillovers to society and conclude that, aggregating the individuals, represents the overall effect.

Psacharopoulos and Patrinos (2004) consider that the return for the already highly educated individual is lower than the return for the poorly educated. Psacharopoulos (1985) shows that the social returns of regions with low per-capita incomes are higher than those of regions with high per-capita incomes. Furthermore, Psacharopoulos and Patrinos (2018) find that the social returns to investment in education average 17.5%, 11.8%, and 10.5% for primary, secondary, and tertiary education, respectively, while for poor regions it is 22.1%, 18.1%, and 13.2%.

Cruz, Teixeira and Braga (2010) consider that, in the Brazilian case, investment in education is effective in promoting “pro-poor” growth. The Conditional Cash Transfer Programs, according to Simoes and Sabates (2014), present mechanisms for immediate poverty alleviation and should promote the accumulation of human capital in the long term, safeguarding future generations from the poverty trap. Carneiro and Heckman (2003) suggest, citing as an example the Perry Preschool and Sure Start programs, investment in parents prolongs the effects of interventions on children. In other words, the conditionalities of children’s education, by themselves, do not guarantee the accumulation of human capital, the effects can be greater with educational policies aimed at parents.

It is common for studies on income distribution to highlight the effect of inequality of study opportunity in generating the high level of income concentration in Brazil. Neves (2016) considers that access to a professional qualification course appears for a class that was previously distant from access to public policies, and is intended to contribute to the entry of individuals into the formal labour market, stimulating and raising their schooling, aiming, above all, to overcome the situation of social vulnerability.

Langoni (1973) and Fishlow (1973) point to a tendency for individuals from poor families to enter the labour market earlier and study less. Pires (2013) argues that this situation creates a vicious circle, as the poor, who would enter the labour market earlier, would decrease their schooling and reduce their chances of getting out of poverty as adults. The authors go on to argue that, to break the cycle of “intergenerational transmission” of poverty, it is necessary to guarantee a family income compatible with the increase generated by child labour, increase children’s schooling, and increase their chances of leaving poverty as adults.

However, Kerstenetzky (2009) states that children from families dependent on cash transfer programs have a "cognitive malnutrition" that is also responsible for generating future inequalities and that this intergenerational poverty can be avoided with investments in education that ensure interaction with better educational levels. Barros, Henriques and Mendonça (2001) corroborate the argument, stating that environments with low educational levels, through a mechanism of unequal educational opportunity, have parents with low levels of schooling and income, and are more likely to have, in the future, adults with low educational performance and, consequently, low income.

Arruda and Dias (2008) argues that economic growth alone is not capable of reducing extreme poverty rates, while investment in human capital does. The authors consider that, in Brazil, educational investments (increase in human capital) and the increase in the average schooling of the population contribute more to the reduction of the poverty index and would have a direct impact on the families that receive poverty cash transfers, such as the Bolsa Família Program.

Some authors, Alzúa, Cruces and Lopez (2016), Attanasio, Kugler and Meghir (2011), Diaz and Rosas (2016), analyze the impacts of professional qualification courses for low-income youth (aged 15 to 29) and find interesting results for Argentina, Colombia and Peru. The average effect, considering the three studies, on the increase in formal employment is 6.3%. The increase in the average income is 35.13%, representing an increase in monthly income that reaches US$83, in a maximum period of 36 months after the conclusion of the course.

2.5 Applied Computable General Equilibrium Models

A computable general equilibrium model can be defined as a numerical representation of the equilibrium conditions of an economy, promoted by economic agents represented by behavioral equations. Its purpose is to convert the theoretical conception of Walrasian general equilibrium into models applied to the real economy. Thus, general equilibrium models could be used to assess concrete policy options, as they provide an ideal framework for analyzing the effects of policy changes on resource allocation (SHOVEN; WHALLEY, 1992)

Acemoglu (2010) considers that, depending on the magnitudes of various effects, General Equilibrium methodology can find different results compared with partial equilibrium conclusions. Nevertheless, most empirical strategies do not consider estimating general equilibrium effects. Economic theory provides some guidance in assessing the importance of general equilibrium effects.

According to the author, three types of general equilibrium effects, not generally estimated in partial equilibrium comparisons, are potentially important:

- in response to large interventions or policy shocks, imperfect substitution between factors and diminishing returns imply productivities of factors and prices will change;
- the same policy interventions or shocks can lead to endogenous technological responses;
- there may be compositional effects resulting from the equilibrium substitution of some factors or products by others (where the composition of micro-units changes differently in response to different types of interventions);

The theory generally implies that the first and third effects tend to partially offset or even reverse direct partial equilibrium effects, whereas endogenous technology responses may attenuate or enhance them.

According to Najberg et al. (1995) Applied General Equilibrium (AGE) Models aim to capture all existing relationships in the economic system. Such models have the ability to portray the direct and indirect effects caused by changes in economic policies, as well as technological changes, income distribution, taxes, subsidies, etc. Consequently, the use of this model allows for the variation in the entire economy caused by government policy.

According to Gurgel and Campos (2006), the Applied General Equilibrium (AGE) Models propose to portray the functioning of an economy, unlike partial equilibrium models, which consider the impact of a policy only in the sector in which it was implemented, disregarding other sectors of the economy, and can, therefore, obtain erroneous estimates.

Computable General Equilibrium (CGE) models use real economic data to simulate how economic conditions are affected by policy changes or other factors. Unlike partial analysis, which focuses on specific goods or services, a CGE model describes all sectors' economic activities (industries, government, and families). These models consist of equations that describe the model and a database consistent with the equations (MATSUMOTO; FUJIMORI, 2019).

Pearson et al. (2014) consider General Equilibrium as an essential tool that allows us to understand the economy as a complete interdependent system (i.e., changes in any component of the economy has an impact on all the others), and knowing how to understand this unfolding is of fundamental for the analysis. By Applied Models (provide a more realistic representation of economies than is typical of stylized models), it is understood that the primary objective is to provide a quantitative analysis of the problems encountered in the economy.

Consequently, as well as a robust theoretical framework, a structure that allows solutions to numerical models is needed. However, the challenges are different between the approaches (i.e., it is necessary to consider the different closures). Devarajan and Robinson (2005) argues that such models must be structural for understanding the mechanisms through which policies affect the economy is the whole purpose of the exercise. In policy analysis, the models have been used to explore different scenarios where policies are changed, and then the model is solved to see how the changes modify the economy.

Although static CGE models can simulate future effects of policy changes, they are not a forecasting tool. Policies are evaluated by comparing the economy between two states of the economy. The pre-policy baseline is generated from the base year data, and the impact of a policy is estimated by measuring deviations from the baseline due to the policy change (PRATT; BLAKE; SWANN, 2013). Instead, according to Devarajan and Robinson (2005), they are meant to inform policymakers about the relative strength of policy changes' potential impacts.

A theoretical structure of a static Applied General Equilibrium Model consists of equations describing, for some period at the time (HORRIDGE, 2003):

- producers' demands for produced inputs and primary factors;
- producers' supplies of commodities;
- demands for inputs to capital formation;
- household demands;
- export demands;
- government demands;
- the relationship of basic values to production costs and to purchasers' prices;
- market-clearing conditions for commodities and primary factors, and;
- numerous macroeconomic variables and price indices.

Demand and supply equations for private-sector agents are derived from the agents' optimization problems and assumed to underlie the behaviour of the agents in conventional neoclassical microeconomics. The agents are assumed to be price-takers, with producers operating in competitive markets which (preventing the earning of pure profits).

The general equilibrium analysis determines simultaneous prices and quantities in all markets and explicitly takes into account the feedback effects. The feedback effect is the adjustment of prices or quantities in a given market caused by price or quantity adjustments in related markets (DIXIT; DIXIT; PINDYCK, 1994).

Figure 6 shows the operation of a general equilibrium model considering a multi-sectoral open economy. This economy is divided into three sectors: foreign, domestic, and government. Through this diagram, it is possible to verify the behaviour and interrelationships of the sectors in the economy. The model represents a system of simultaneous relationships that express the decisions of agents.

From a per capita utility Cobb-Douglas function, the agents income in the economy is exhausted in three forms of final demand: household spending (consumption), government spending (consumption), and savings. Each component of final demand maintains a constant share of total regional income, so an increase in regional income causes a commensurate change in private spending, government spending, and savings. Firms and the regional household (government and households), together with the three components of final demand, form a closed economy

The technology considers constant returns to scale, and each sector produces a single product. There is a rigidity in technology allocation between factors. Firms maximize profit, so the substitution elasticity between primary factors and different intermediate factors is equal. Primary factors are employed in the economy's activities according to the elasticity of substitution $\sigma_{\mathtt{q}}$.

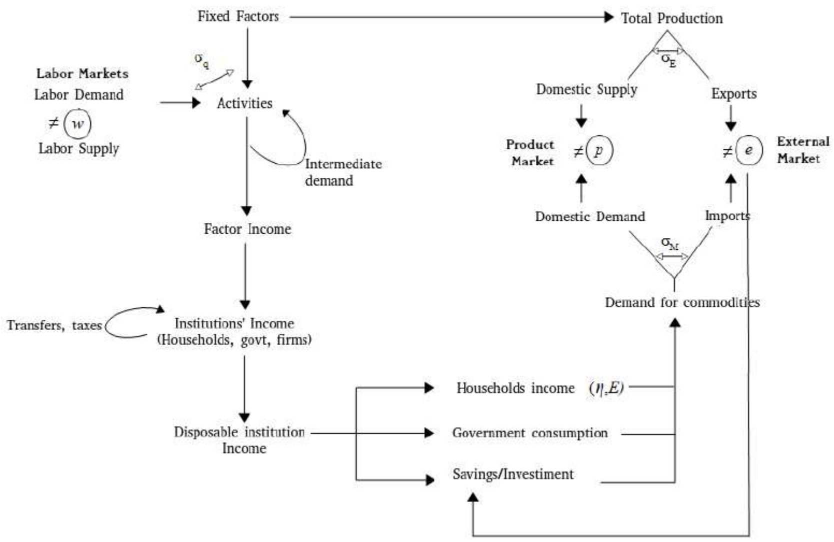


Figure 6 – A multisectoral general equilibrium model
Source: Sadoulet and Janvry (1995) e Brokmeier (2001)

Factors can be distinguished between perfectly moving and slow to adapt. In the first case, the factor earns the same market return regardless of where it is employed. For slow factors, equilibrium returns may differ across sectors. Since the model can only be solved by N-1 prices, the reference price is set exogenously, and all other prices are valued against this cash.

Considering that the profit maximization behaviour determines the demand for labour, given prices and wages. In a perfect job market, wages, labour supply, and demand for work will adjust until they reach full employment. The income generated by the activities is distributed among families (compensation of labour), firms (compensation of goods and services), and the government.

In addition to supply and demand activities, governmental interventions occur throughout the economy. Figure 7 shows the value streams that arise from government intervention in the model. Transfers between institutions, such as taxes, profit distribution, and transfers from government to households and firms, modify initial income and define new disposable income for institutions, i.e. any change in transfers/taxes primarily influences disposable income from agents (firms, families, and government) to then influence the entire economic system.

All taxes are always reverted to the regional economy, so the regional income is reformulated, becoming the value of production of firms plus the values of taxes and transfers (subsidies), resulting from state intervention in the economy, giving rise to a new disposable income in the economy. Private and government consumption now not only spend their disposable income on consumer goods but also pay taxes to the regional household. Taxes (subsidies) are imposed on firms (producers), therefore, on the purchase of intermediate inputs and primary factors.

It can be observed that a new income is generated only after government interference

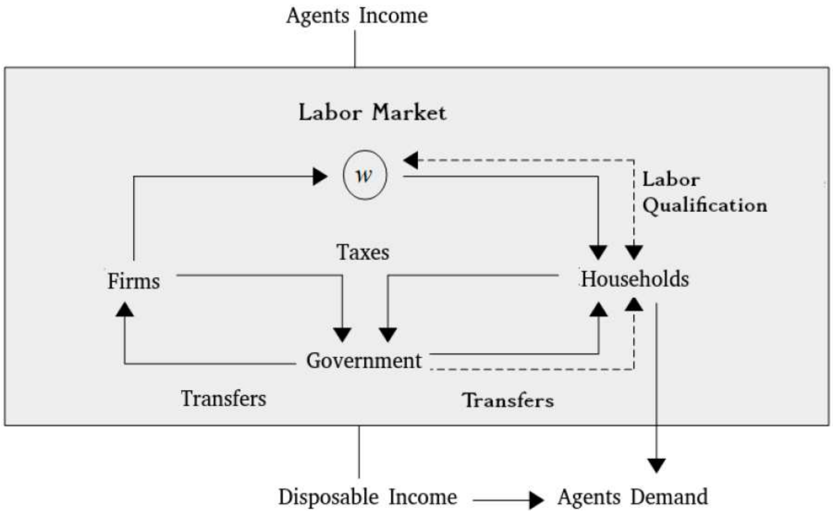


Figure 7 – Government intervention in a general equilibrium model
Source: Sadoulet and Janvry (1995) e Brokmeier (2001)

when it receives taxes and distributes income in the economy. Thus, the skill improvement of household labour would directly influence the labour factor value (wage) in the labour market. Social income transfer programs are included via transfers between government and households, and since government transfers income to poorer households, this policy has a direct impact on the demand (consumption) of households in the model and, by representing a " complementary income" for these households would also have the ability to influence the savings/investment of the beneficiary households.

Neri, Vaz and Souza (2013) consider that leaks (flows from endogenous to exogenous accounts) restore the initial equilibrium after the first impulse given by an autonomous expenditure, being crucial to establishing the multiplier effect of a given impulse. Figure 8 presents the simplified circular flow resulting from government participation in the economy, simplifying the impacts that income transfer and labour skills programs would have on the economy.

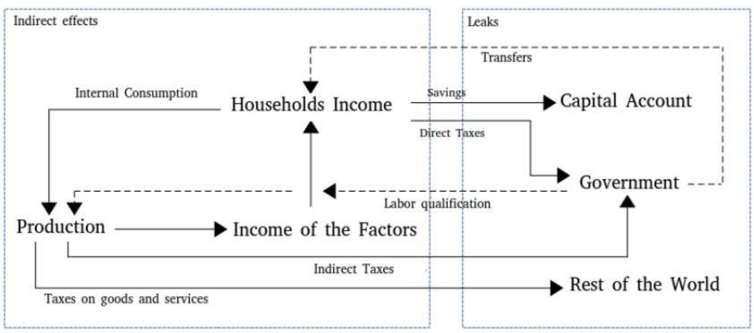


Figure 8 – Income circular flow after government intervention
Source: Neri, Vaz and Souza (2013)

A direct transfer from the government to poorer households has a first (direct) effect of increasing household income, as well as a skilled labour force (which also affects production, since labour is an input for firms), and part of this increase in income is transformed into consumption, the other part households save and pay taxes on. The increase in household welfare (higher consumption) generates indirect benefits for the economy, stimulating production, becoming factor income, and heating the economy.

The combination of labour qualification and income transfer policies has a direct impact on income elasticity, η, and price elasticity, $\mathtt{E}$. It is important to note that, at the end of each cycle of indirect effects, household income increases are lower than additional domestic consumption, since part of the resources leaks during the production process in the form of imports and the payment of direct taxes.

Combining the regional economy with the rest of the world, we have a multi-regional general equilibrium model, representing an open economy. Firms derive additional export revenues. On the other hand, producers revenues now consist of imported intermediate inputs in addition to the primary factors and internally produced intermediate inputs. In addition, companies have to pay an additional excise tax on imported inputs. Goods are considered to be perfect substitutes.

The choice between consumption and saving of the model agents occurs as follows: for the government, it occurs via explicit policies; firms usually aim to consume all residual income; households have constant savings/investment, however, and consumption is based on maximizing utility. Consumer prices will be defined by reference to domestic prices, import prices, and the elasticity between import and domestic goods, $\sigma_{\mathtt{M}}$. The distribution of domestic demand between imports and domestic goods is defined by relative prices and elasticity.

3 METHODOLOGY

3.1 DAYANE Model Description

The development of the model is based on the database of the General Equilibrium Analysis Project of the Brazilian Economy (PAEG) (TEIXEIRA; PEREIRA; GURGEL, 2013; GURGEL; LIMA; PINTO, 2020), regionalized for the Brazilian economy for the year 2014, compatible with the database 10 of the Global Trade Analysis Project (GTAP) (AGUIAR; CORONG; MCDOUGALL, 2019; AGUIAR et al., 2019). Unlike PAEG, which is developed in MPSGE (RUTHERFORD, 1999) and GAMS[14], the model used in this study is modeled in TABLO language using the GEMPACK (CODSI; PEARSON, 1988; HARRISON et al., 2014), based on version 6 the GTAPinGEMPACK code (PEARSON; HORRIDGE; CORONG, 2004; CORONG et al., 2017; MENSBRUGGHE, 2018).

Since there are subtle differences between the Brazilian Economy Analysis Project (PAEG) model and the one that will be described in the methodology section, I will treat it as an "extension" and call it DAYANE[15] model. The model was developed by me and Mark Horridge, during my sandwich period, as a visiting researcher at the Center of Policy Studies - CoPS, at Victoria University, Melbourne - Australia.

The model is designed for comparative-static simulations. Its assumption, equations, and variables all refer implicitly to the economy at some future period. This interpretation is illustrated in Figure 9.

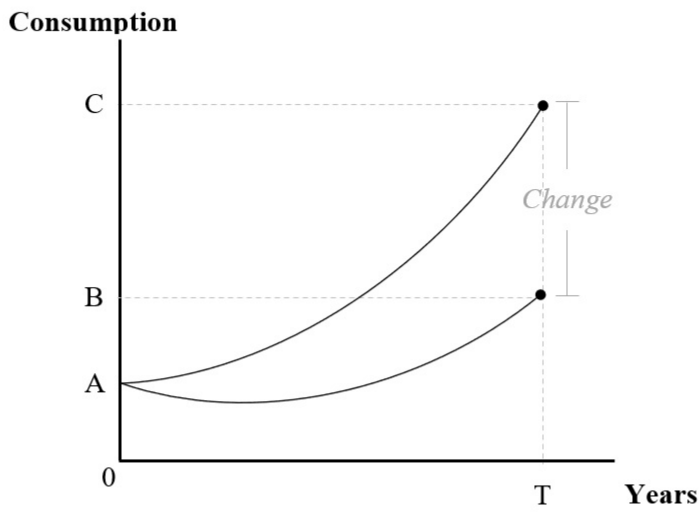


Figure 9 – Static-comparative interpretation of results

The Figure shows values of any variable (consumption, for example) over time. `A` is the level of consumption in the base period (period 0) and `B` is the level of consumption that would be obtained in `T` years if any policy (tax reduction, for example) was not implemented. With the change only in the tariff, consumption would reach `C`. In a static-

[14] http://www.mpsge.org/gtap6/
[15] I'll follow Dixon (1982) example and pay tribute to an important person

comparative simulation the change in consumption will be given by `100(C-B)/B`, showing how consumption would be affected by the change in tariff, in `T`. It is assumed, as a static-comparative model, that the shock alters the initial equilibrium and calculates the differences between after and before the shock, with the before being the model's initial equilibrium database.

3.2 The model database

In the present study, the original region and sectors aggregation of the PAEG model will be maintained - with 19 sectors and 21 regions, including the 5 Brazilian macro-regions. Table 3 shows the aggregation between regions and sectors considered in both models. There is the flexibility to obtain different aggregations of countries and products, according to the research objectives.

The families aggregation on Brazilian regions is also the same from PAEG - 10 income and consumption classes. Regarding the factors aggregation, while the standard PAEG considers the factors: skilled labor, unskilled labor, capital, land and natural resources, the model used here will split the labor factor into 12 different levels. Another important difference is that on DAYANE model the families income include disaggregated transfers and income tax payment to the Government.

Table 3 – Sectors and Regions of the Model

Sectors	Regions
Agriculture	Brazil - North (NOR)
Paddy rice (pdr)	Brazil - Northeast (NDE)
Cereal grains (gro)	Brazil - Midwest (COE)
Oil seeds (osd)	Brazil - Southeast (SDE)
Sugar cane; sugar industry (c_b)	Brazil - South (SUL)
Animal products (oap)	Rest of Mercosur
Milk and dairy products (rmk)	United States of America
Other agricultural products (agr)	Canada
Industry	Rest of Americas
Food products (foo)	Mexico
Textiles (tex)	European Union
Wearing apparel leather products (wap)	Rest of Europe
Wood products (lum)	Japan
Paper products publishing (ppp)	Russia
Chemical rubber plastic prods (crp)	China
Other manufacturing (man)	India
Services	Australia and New Zealand
Electricity, gas, water distribution (siu)	Fast development Asia
Construction (cns)	Africa
Trade (trd)	Middle East
Transport (otp)	Rest of Asia
Services (ser)	

Source: Gurgel, Lima e Pinto (2020)

The disaggregation of Brazilian households in the model makes it possible to assess the distributive impacts of different policies, not just the aggregate effects. The income classes are presented on the model considering the 2014 minimum wage (MW), in US$ dollars:

1^{st} class - until 1 MW;
2^{nd} class - more than 1 MW until 2.5 MW;
3^{rd} class - more than 2.5 MW until 4 MW;
4^{th} class - more than 4 MW until 5 MW;
5^{th} class - more than 5 MW until 6 MW;
6^{th} class - more than 6 MW until 7 MW;
7^{th} class - more than 7 MW until 8 MW;
8^{th} class - more than 8 MW until 10 MW;
9^{th} class - more than 10 MW until 12 MW;
10^{th} class - more than 12 MW;

Factor income of Brazilian families was broken down into labor income, capital income, and land income based on the Family Budget Survey - POF 2017/2018 (IBGE, 2019). Since the base year of the computable general equilibrium model is 2014, the 2017/2018 POF values were deflated (based on the IPCA) and converted to 2014 dollars. The model considers that factor remuneration (by firms) is fully owned by families, and is distributed according to the shares of each income class in the total receipt of each factor. The strategy used to distribute the families' income was:

a. aggregate the remuneration of factors (labor, capital and land)[16] in the PAEG;

b. calculate, based on the POF, the income share of each family within each region, for each factor;

c. to distribute the aggregate PAEG income in each income class, based on the shares in step b.;

In addition to factor remuneration, the model considers government transfers (Bolsa Família Program, other social programs, income tax refunds, and other transfers and retirement) and family transfers to the Government (tax income). As the total received by each income class must equal the total consumed, the savings for each income class are calculated considering the difference between total income and total consumption.

Once the household incomes are added to the model, the labor factor income must be distributed at different levels. The breakdown of work in each income class was calculated based on the 2014 National Household Sample Survey. For the breakdown, the hourly wages of household heads in each sector of the model were considered. The skill levels were split among sectors:

[16] Labour = skilled + unskilled labour; capital = capital + natural resources

S1 - No Instruction;
S2 - Incomplete Basics;
S3 - Complete Basics;
S4 - Incomplete Fundamental;
S5 - Qualified Basics;
S6 - Complete Fundamental;
S7 - Incomplete High School;
S8 - Qualified Fundamental;
S9 - Complete High School;
S10 - Qualified High School;
S11 - Incomplete College;
S12 - Complete College;

To represent the labour market in the model, workers in the formal and informal market were considered, excluding civil servants and military personnel from the sample[17]; the age range considered is from 18 to 65 years old; incomes of less than R$1 per hour and R$100 per hour were disregarded. The weights of people from the surveys (POF and PNAD) were used to expand the data. To match labour market data, a `scalar` was calculated for the PNAD data to represent the POF data[18].

The labour market data in the model, it should be considered that the data previously extracted from the PNAD/POF, the wages of each level of education must equal the value of the labour factor received by the families in the model (and thus, respecting the values from the database)[19], and at the same time be distributed across sectors of the economy. Thus, the RAS method was applied to obtain a matrix with dimension `Sector X Income Class X Region X Skill`. In this way, it is possible to simulate changes in the labour market and the implications for the entire economy represented in the model.

Household consumption was extracted from the 2017-2018 POF for each region in the format of 110 products aggregated for the sectors in the model and then distributed among the different income classes. To disaggregate household consumption, in order not to change the original data on total consumption by region, the alternative adopted was to calculate, based on data extracted from the POF, the share of each household's consumption in the total consumed in each sector, in the Brazilian regions. This participation was applied to the value of household consumption in the original PAEG database.

There is one more relevant aspect on base-data, PAEG model represents the flows using the market prices, to run the model on GEMPACK code we have to calculate the agents price for some flows[20]. For others (those used on the present model in market price) it's not necessary to calculate a new value. In Agents prices, it is necessary to consider

[17] This is necessary because these occupations salary do not follow the market labour price formation
[18] $\texttt{Scalar} = \frac{\texttt{POFValue}}{\texttt{PNADValue}}$
[19] It is important to realize that PNAD must follow POF data, and POF must follow VFM (I-O tables data)
[20] The GEMPACK approach considers the power of the tax, i.e., `1 + ad valorem tax rate`

the taxes on flow value. The process used to create the new database (mix of softwares used) and how the new flows were calculated can be observed in Appendix B.

3.2.1 SAM Transactions

The model base data can be expressed in a Social Accounting Matrix, presented in the Figure 10[21]. Thus, the sum of each column (in rows) represents the total expense of each agent; and the sum of the lines (in columns) represents the total revenue; the sum total of the expenses must be the same of the resource (income)[22].

The SAM reports the Agents in the economy that demand commodities: Activities, Private Households, Government, Investment, Transport Services, and Foreign Region (rest of the world). Flows are presented at market price (i.e., not considering taxes). The price paid by the agent, or the final price paid, can be found by adding the respective rate to the market value.

EXPENSES

RESOURCES	Imported Comm.	Domestic Comm.	Activities	Factors	Priv. Household	Government	Trade Taxes	Imp. Sales Taxes	Domestic Sales Taxes	Factor Taxes	Production Tax	Direct Taxes	Import Margins	Export Margins	Investiment	Rest of World	Totals
Imported Comm.			VIFM		VIPM	VIGM									VIFM("CGDS")		IMPRES
Domestic Comm.			VDFM		VDPM	VDGM								VST	VDFM("CGDS")	VXWD	DOMRES
Activities		VOM															ACTRES
Factors			VFM														FACRES
Priv. Households				VOM		TRANSF											PRIVRES
Government							TIM + TEX	IFTAX + IPTAX + IGTAX	DFTAX + DPTAX + DGTAX	TFU	TOUT	ITAX					GOVRES
Trade Taxes	TIM	TEX															TTXRES
Imp. Sales Taxes			IFTAX		IPTAX	IGTAX									IFTAX("CGDS")		ITXRES
Domestic Sales Taxes			DFTAX		DPTAX	DGTAX									DFTAX("CGDS")		DTXRES
Factor Taxes			TFU														FTXRES
Production Tax			PTAX														PTXRES
Direct Taxes					ITAX												DIRRES
Import Margins	VTWR																IMGRES
Export Margins													VTWR				EMGRES
Investiment					PSAVE	GSAVE								VTWR - VST			INVRES
Rest of World	VIWS - VTWR																ROWRES
Totals	IMPEXP	DOMEXP	ACTEXP	FACEXP	PRIVEXP	GOVEXP	TTXEXP	ITXREEXPr)	DTXEXP(r)	FTXEXP(r)	PTXEXP(r)	DIREXP	IMGEXP	EMGEXP	INVEXP	ROWEXP	**RES = EXP**

Figure 10 – Aggregated Social Account Matrix

For domestically produced commodities market prices are the prices received by domestic activities. Hence, export taxes are considered expenditures on domestic commodity accounts. Domestic prices are derived from the production costs (made up of the costs of intermediate inputs plus the sales taxes, plus expenditure on primary factors usage and production taxes). The model considers the Neoclassical approach where total investments equal domestic savings.

Exports at F.O.B. valued at prices (`VXWD`) considers the exports valued at market prices (`VXMD`) added the export taxes (`TEX`). Expenses on imported commodities valued

[21] The regional economic structure can be observed in Appendix C
[22] To understand the SAM interpretation see McDonald and Thierfelder (2019)

at C.I.F. prices (VIWS) considers exports at F.O.B. prices and payment for international transport (VTWR). Revenues on imported commodities depend on the consumption of agents (VIFM; VIPM; VIGM), including imported investment goods (VIFM("cgds")). Imports valued at market prices (VIMS) consider the values of imports at world prices (C.I.F.) added the taxes on imports (TIM).

The link between imports and exports on the international market is:

$$\text{VXMD + TEX = VXWD} \tag{10}$$

$$\text{VXWD + VTWR = VIWS} \tag{11}$$

$$\text{VIWS + TIM = VIMS} \tag{12}$$

The global transport sector corresponds to the difference between the F.O.B. and C.I.F. for a particular commodity shipped along a specific route: VTWR = VIWS - VXWD. The sum of all commodity routes is equal to the total demand for international transport that is provided by individual regional economies, which export them to the global transport sector (VST), transport supply.

The Value of Firms consumption at Agent's prices (VFA) includes: Value of Domestic Consumption of Firms at Market prices (VDFM) and imported intermediate consumption - Value of Imported Consumption of Firms (VIFM); the payment of factors at market prices - Value of Factor at Market prices (VFM); tariffs on imported intermediate consumption (IFTAX), and domestic (DFAX); payment of fees on the use of factors (TFU); and tariffs on production (PTAX).

Combining intermediate consumption at market prices (VDFM and VIFM) and use of factors at market prices (VFM), firms produce the output (VOM). Let VIFA be the Value of intermediate consumption Imported at Agent prices; VDFA Value as Domestic Intermediate Consumption at Agent prices , and; (VFA_{fact}) the Value paid by firms for the use of Factors at Agent prices:

$$\text{VIFM + IFTAX = VIFA} \tag{13}$$

$$\text{VDFM + DFTAX = VDFA} \tag{14}$$

$$\text{VFM}_{\text{fact}} + \text{TFU} = \text{VFA}_{\text{fact}} \tag{15}$$

$$\text{VOM = VIFM + VDFM + VFM} \tag{16}$$

$$\text{VOA} = \text{VIFA + VDFA} + \text{VFA}_{\text{fact}} \tag{17}$$

$$\text{VOM + PTAX = VOA} \tag{18}$$

Exports are accounted for as part of the domestic accounts. Therefore, the domestic supply must consider both domestic consumption and exports. Thus, the output value (VOM) must equal the total demanded internally; government and private agent (VDFM + VDGM + VDPM) and the value of exports at market price (VXMD), and the Value of

Supplied Transport at market price (VST), in addition to domestic investments (VDIM = VDFM("cgds")):

$$\mathtt{VOM = VDFM + VDPM + VDGM + VDIM + VXMD + VST} \tag{19}$$

The Value of Private consumption at Agent prices (VPA) includes the Value of Domestic Private consumption at Market prices (VDPM), and Imported consumption at Market prices (VIPM); in addition to Domestic Private Taxes on consumption (DPTAX) and on Imported consumption (IPTAX). The model considers that firms remunerate private agents, thus, representative agents receive the Output Value at Market prices of the use of the factors ($\mathtt{VOM_{fact}}$). The difference between total consumption and total income is considered private savings (PSAVE):

$$\mathtt{VIPM + IPTAX = VIPA} \tag{20}$$

$$\mathtt{VDPM + DPTAX = VDPA} \tag{21}$$

$$\mathtt{VOM_{fact} = VIPA + VDPA} \tag{22}$$

$$\mathtt{PSAVE = [VOM_{fact}] - [VIPA+VDPA]} \tag{23}$$

In the case of Brazilian regions, household expenses still consider Income Taxes (ITAX), and government Transfers (TRANSF) as income:

$$\mathtt{VOM_{BRA_{fact}} - ITAX_{BRA} + TRANSF_{BRA} = VIPA_{BRA} + VDPA_{BRA}} \tag{24}$$

$$\mathtt{PSAVE_{BRA} = [VOM_{BRA_{fact}} - ITAX_{BRA} + TRANSF_{BRA}] - [VIPA_{BRA} + VDPA_{BRA}]} \tag{25}$$

The Value of Government consumption at Agent prices (VGA = VDGA + VIGA) considers domestic (VDGM) and imported (VIGM) consumption; tariffs on domestic (DGTAX) and imported (IGTAX) consumption. Government revenue includes indirect taxes (INDTAX = IFTAX + IPTAX + IGTAX + DFAX + DPTAX + DGTAX + TFU + TOUT), and income taxes (ITAX). Government collections must equal the total spent, the difference is considered savings (GSAVE):

$$\mathtt{VIGM + IGTAX = VIGA} \tag{26}$$

$$\mathtt{VDGM + DGTAX = VDGA} \tag{27}$$

$$\mathtt{INDTAX + ITAX = VIGA + VDGA} \tag{28}$$

$$\mathtt{GSAVE = [INDTAX + ITAX] - [VIGA + VGA]} \tag{29}$$

In the case of Brazil, government spending must include transfers to families:

$$\mathtt{INDTAX_{BRA} + ITAX_{RBA} - TRANSF_{BRA} = VIGA_{BRA} + VDGA_{BRA}} \tag{30}$$

$$\mathtt{GSAVE_{BRA}[= INDTAX_{BRA} + ITAX_{RBA} - TRANSF_{BRA}] - [VIGA_{BRA} + VDGA_{BRA}]} \tag{31}$$

3.3 Price and quantity linkages

In the DAYANE model, as in the GTAP, there is a set of prices that end up determining all the prices in the system - the market prices, for both goods and factors. Prices are what balance supply and demand in the model. Figure 11 shows the links between the different prices and taxes.

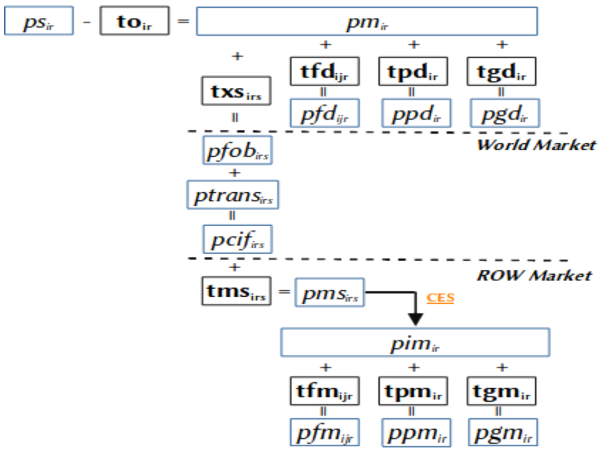


Figure 11 – The prices linkages on the model
ROW – Rest of the World; **CES** – Constant Elasticity Substitution;
$\mathbf{ps_{ir}}$ – supply price of good i in region r; $\mathbf{pm_{ir}}$ – market price of good i in region r; $\mathbf{pfd_{ijr}}$ – price index for domestic purchases of good i by sector j in region s; $\mathbf{ppd_{ir}}$ – price of domestic good i to private households in region r; $\mathbf{pgd_{ir}}$ – price of domestic good i in government consumption in region r; **pfob** – free on board price of good i supplied from region r to region s $_{\mathbf{irs}}$; $\mathbf{ptrans_{irs}}$ – cost index for international transport of commodity i from region r to region s ; $\mathbf{pcif_{irs}}$ – cost, insurance and freight (world) price of good i supplied from region r to region s; $\mathbf{pms_{irs}}$ – domestic price for good i supplied from region r to region s; $\mathbf{pim_{ir}}$ – market price of composite import i in region r; $\mathbf{pfm_{ijr}}$ – price index for imports of good i by sector j in region r; $\mathbf{ppm_{ir}}$ – price of imports of good i by private households in region r ; $\mathbf{pgm_{ir}}$ – price of imports of good i in government consumption in region r; $\mathbf{to_{ir}}$ – output tax in region r; $\mathbf{txs_{irs}}$ – destination specific change in subsidy on exports of good i from region r to region s; $\mathbf{tfd_{ijr}}$ – tax on domestic good i purchased by sector j in region r; $\mathbf{tpd_{ir}}$ – tax on domestic good i purchased by private household in region r; $\mathbf{tgd_{ir}}$ – tax on domestic good i purchased by government in region r; $\mathbf{tms_{irs}}$ – source-specific change in tax on imports of good i from region r to region s; $\mathbf{tfm_{ijr}}$ – tax on imported good i purchased by sector j in region r; $\mathbf{tpm_{ir}}$ – tax on imported good i purchased by private household in region r; $\mathbf{tgm_{ir}}$ – tax on imported good i purchased by government in region r;

From top to bottom, starting from the supply price $\mathtt{ps_{ir}}$, of good `i`, in the region `r`. The market price, $\mathtt{pm}_{ir}$, of good `i` in the `r` region is the offer price plus the rate/subsidy to production $\mathtt{to_{ir}}$ – note `to > 1` indicates a fee, and a subsidy otherwise. All fees are implemented in the model as tax power, instead of `ad valorem` tax. To guarantee the zero profit condition, the prices received must equal the supply price.

Domestic supply is distributed between domestic consumption and exports. Domestic commodity prices are priced by $\mathtt{pm_{ir}}$. The price in foreign trade is $\mathtt{pm_{ir}} + \mathtt{txs_{irs}} = \mathtt{pfob_{irs}}$, hence the price of export to the international market does not consider prices with transport and insurance – Free On Board price. Export indices reflect demand (not supply of goods for export).

To form the price of imports, add the transport price for the destination region, $\mathtt{ptrans_{irs}}$, to form the Cost, Insurance and Freight price – considering costs of transportation and insurance included: $\texttt{pcif}_{\texttt{irs}}$ = $\texttt{pfob}_{\texttt{irs}}$ + $\texttt{ptrans}_{\texttt{irs}}$. To pcif is add the import tax, $\texttt{tms}_{\texttt{irs}}$, to generate the market prices of imported products, $\texttt{pms}_{\texttt{isd}}$. The imported goods constitute an aggregate import price for each region, $\texttt{pim}_{ir}$. The tms variable captures changes in the power of the import tariff. Each agent (firms, households, and government) accesses aggregated imports (these imports compete with domestically produced goods).

However, it is necessary to add the specific rates for each agent in the economy to find the price paid for them: government consumption of imported goods is priced as: $\texttt{pgm}_{\texttt{ir}}$ = $\texttt{pim}_{\texttt{ir}}$ + $\texttt{tgm}_{\texttt{ir}}$; the imported aggregate household consumption is priced as: $\texttt{ppm}_{\texttt{irs}}$ = $\texttt{pim}_{\texttt{ir}}$ + $\texttt{tpm}_{\texttt{ir}}$ and the price paid by firms for imported goods is given by: $\texttt{pfm}_{\texttt{ijr}}$ = $\texttt{pim}_{\texttt{ir}}$ + $\texttt{tfm}_{\texttt{ijr}}$.

For prices paid by agents in the domestic market, those are defined as, for the government: $\texttt{pgd}_{\texttt{ir}}$ = $\texttt{pm}_{\texttt{ir}}$ + $\texttt{tgd}_{\texttt{ir}}$; for firms: $\texttt{pfd}_{\texttt{ijr}}$ = $\texttt{pm}_{\texttt{ir}}$ + $\texttt{tfd}_{\texttt{ijr}}$; and for the representative agents: $\texttt{ppd}_{\texttt{ir}}$ = $\texttt{pm}_{\texttt{ir}}$ + $\texttt{tpd}_{i,r}$. The aggregate prices, considering the consumption of an imported and domestically produced good, are: $\texttt{pf}_{\texttt{ijr}}$, for firms; $\texttt{pg}_{\texttt{ir}}$, for the government, and; $\texttt{pp}_{\texttt{ir}}$, for private agents. The quantity linkages can be observed in Figure 12.

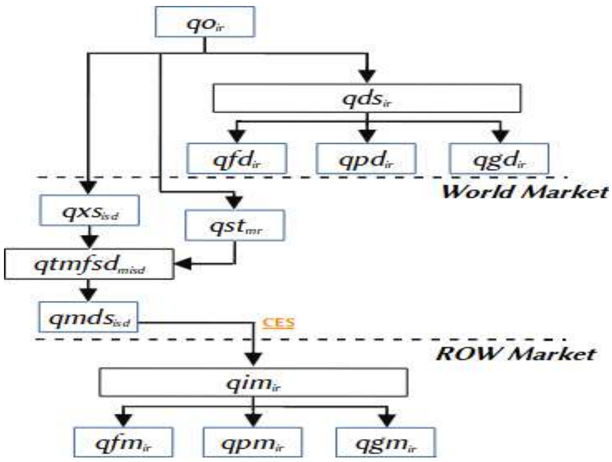


Figure 12 – The quantity linkages on the model
ROW – Rest of the World; **CES** – Constant Elasticity Substitution;
$\mathbf{qo_{ir}}$ – industry output of good i in region r; $\mathbf{qds_{ir}}$ – domestic sales of good i in region r; $\mathbf{qfd_{ijr}}$ – domestic good i demanded by industry j in region r; $\mathbf{qpd_{ir}}$ – private household demand for domestic good i in region r; $\mathbf{qgd_{ir}}$ – government demand for domestic good i in region r; $\mathbf{qxs_{irs}}$ – export sales of good i from region r to region s; $\mathbf{qst_{mr}}$ – sales of margin from region r to international transport; $\mathbf{qtmfsd_{mirs}}$ – international usage margin m on good i from region r to region s; $\mathbf{qmds_{irs}}$ – total exports considering transport of good i from region r to region s; $\mathbf{qim_{ir}}$ – aggregate imports of good i in region r, market price weights; $\mathbf{qfm_{ijr}}$ – aggregate imports of good i from sector j in region r, market price weights;

Regarding the quantity linkages, the interpretation in pretty much similar to the prices one. There is a quantity that ends to determine all quantities in the model. The domestic supply of commodity i in region r, $\texttt{qo}_{\texttt{ir}}$ must equal demand quantity $\texttt{qds}_{\texttt{ir}}$ for commodity, exports $\texttt{qxs}_{\texttt{irs}}$ and transport supply $\texttt{qst}_{\texttt{ir}}$ - the supplied transport must sum demanded $\texttt{qtmfsd}_{\texttt{mirs}}$. The exported quantity plus transport is equal aggregated imports

$\mathtt{qim}_{ir}$.

The demanded quantity, $\mathtt{qds}_{ir}$, will be divided into the model agents: firms (intermediate consumption), $\mathtt{qfd}_{ijr}$ – including $\mathtt{qfd}_{i"cgds"r}$ –, private representative agent, $\mathtt{qpd}_{ir}$ and government, $\mathtt{qgd}_{ir}$. On the other hand, aggregated imports, $\mathtt{qim}_{ir}$ is shared among agents, as well, being: $\mathtt{qfm}_{ir}$ the intermediate imported quantity; $\mathtt{qpm}_{ir}$ the private imported demand; and, $\mathtt{qqm}_{ir}$ the imported government demand. Thus, the equilibrium condition for quantity, in levels is:

$$\mathtt{QDS}_{i,r} = \sum_{j} \mathtt{QFD}_{i,j,r} + \mathtt{QINV}_{i,r} + \mathtt{QPD}_{i,r} + \mathtt{QGD}_{i,r} \tag{32}$$

$$\mathtt{QO}_{i,r} = + \mathtt{QDS}_{i,r} + \mathtt{QST}_{i,r} + \sum_{r} \mathtt{QXS}_{i,r,s} \tag{33}$$

3.4 Firms Behaviour

The model assumes that each industry produces only one commodity. To produce the total supply, each industry uses as input domestic and imported commodities, labour (disaggregated at different levels in Brazil), land (specific sectors), capital, and natural resources (specific sectors). Firms, therefore, produce for domestic consumption and export. Production is made explicit by a series of separability assumptions. The input-output separability assumption implies the generalized production function for one industry:

$$\mathtt{F}_{\mathtt{input,\ output}} = 0 \tag{34}$$

can be write as (at agents price):

$$\mathtt{G}_{\mathtt{inputs}} = \mathtt{VOA}_{j,r} = \mathtt{H}_{\mathtt{outputs}}$$

where $\mathtt{VOA}_{j,r}$ is the commodity $\mathtt{j}$ produced in region $\mathtt{sr}$.

The production function $\mathtt{G}$ is divided into different nests levels. Each producing activity combines a set of intermediate goods and factors to produce output. The production structure is based on a sequence of nested Constant Elasticity of Substitution (CES) functions that aims to re-produce the substitution possibilities across the full set of inputs. The nested structure is depicted in Figure 13.

In the top nest, commodities (intermediate consumption of firms) and production factors are combined through a Leontief function, that is, in fixed proportions. Each commodity compound is a Constant Substitution Function (CES), which determines substitution between domestic and imported goods. In Brazil, the labor factor is combined between different levels through a CES.

In this representation of production, we allow for technological change. All technical change variables are given the first letter in place of the relevant quantity upon which they operate. These technological change variables operate in three ways: (1) reducing

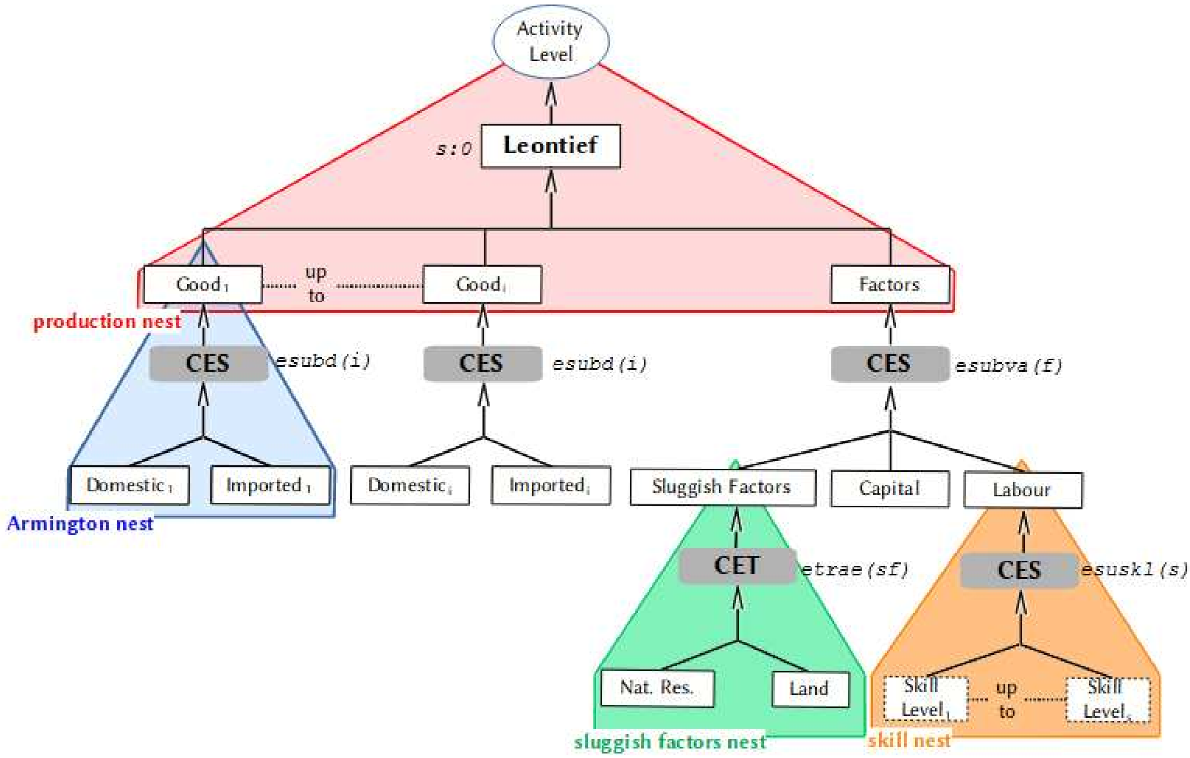


Figure 13 – Production structure
esubd(i) – region-generic elasticity of substitution between domestic and imported good i for all agent
esubva(f) – elasticity of substitution between factors (capital/labor/land), in production of value added in sector j
etrae(sf) – elasticity of transformation for sluggish primary factor endowments
esuskl(s) – elasticity of substitution between different s skill types

the input required for the augmented factor, (2) modifying the effective price of the input, and (3) altering the unit cost of production, and hence, through the zero profits condition, output price.

3.4.1 Top production nest

The top level nest is composed of two aggregate composite bundles: intermediate demand and value added. The second level nests decompose each of the two aggregate nests into their components: on the one hand demand for intermediate goods and demand for individual factors. The composite index of output from activity `j`, represented by $\texttt{qo}_{\texttt{j,r}}$, is a combination of an intermediate demand bundle, $\texttt{qf}_{\texttt{i,j,r}}$, with the value added bundle, $\texttt{qva}_{\texttt{j,r}}$.

Equations `(35)` and `(36)` define the demand for the two top level bundles where the key substitution elasticity is $\texttt{ESUBT}_{\texttt{j}}$`( = 0 )`. Equation `(37)`, presented as a levels equation, represents the clearing (zero-profit) condition for `j` – the total revenue of this sector must be equal to the sum of all the input costs. Equation `(37)` can be totally

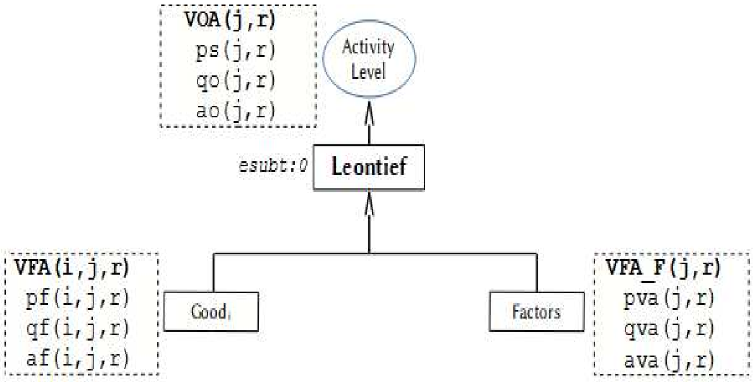


Figure 14 – Top Production Nest

VFA(i,j,r) – producer expenditure on good *i* by sector *j* in region *r* valued at agent's prices; **VFA__F(j,r)** – producer expenditure on good *i* by sectorj in region *r* valued at agent's prices summed over factors;**VOA(j,r)** – value of good *i* output in region *r* at agent's prices;
ps(i,r) – Supply price of commodity i in region r; **pf(i,j,r)** – firms' price for good *i* for use by sector *j* in *r*; **pva(j,r)** – firms' price of value added in industry *j* of region *r*;
qo(i,r) – industry output of good *i* in region *r*; **qf(i,j,r)** – demand for good *i* for use by industry *j* in region *r*; **qva(j,r)** – value added in industry j of region r;
ao(j,r) – output augmenting technical change in sector *j* of region *r*; **af(i,j,r)** – composite intermediary input *i* augmenting technical change by sector *j* of region *r*; **ava(j,r)** – value added augmenting technical change in sector i of r ;
esubt – elasticity of substitution among composite intermediate inputs in production.

differentiated to give (37').

$$\mathtt{qf}_{\mathtt{i,j,r}} = \mathtt{qo}_{\mathtt{j,r}} - \mathtt{af}_{\mathtt{i,j,r}} - \mathtt{ao}_{\mathtt{j,r}} - \mathtt{ESUBT}_{\mathtt{j}}\,.\,[\mathtt{pf}_{\mathtt{i,j,r}} - \mathtt{af}_{\mathtt{i,j,r}} - \mathtt{ps}_{\mathtt{j,r}} - \mathtt{ao}_{\mathtt{j,r}}] \quad (35)$$

$$\mathtt{qva}_{\mathtt{j,r}} = \mathtt{qo}_{\mathtt{j,r}} - \mathtt{ava}_{\mathtt{i,j,r}} - \mathtt{ao}_{\mathtt{j,r}} - \mathtt{ESUBT}_{\mathtt{j}}\,.\,[\mathtt{pva}_{\mathtt{j,r}} - \mathtt{ava}_{\mathtt{j,r}} - \mathtt{ps}_{\mathtt{j,r}} - \mathtt{ao}_{\mathtt{j,r}}] \quad (36)$$

$$\mathtt{PS}_{\mathtt{j,r}}\,.\,\mathtt{QO}_{\mathtt{j,r}} = \mathtt{PF}_{\mathtt{i,j,r}}\,.\,\mathtt{QF}_{\mathtt{i,j,r}} + \mathtt{PVA}_{\mathtt{j,r}}\,.\,\mathtt{QVA}_{\mathtt{j,r}} \quad (37)$$

$$\mathtt{ps}_{\mathtt{j,r}} = \sum_{\mathtt{e}} \mathtt{STC}_{\mathtt{e,j,r}}\,.\,[\mathtt{pfe}_{\mathtt{e,j,r}} - \mathtt{afe}_{\mathtt{e,j,r}} - \mathtt{ava}_{\mathtt{j,r}}] + \sum_{\mathtt{i}} \mathtt{STC}_{\mathtt{i,j,r}}\,.\,[\mathtt{pf}_{\mathtt{i,j,r}} - \mathtt{af}_{\mathtt{i,j,r}} - \mathtt{ava}_{\mathtt{j,r}}] - \mathtt{ao}_{\mathtt{j,r}} \quad (37')$$

where $\mathtt{STC}_{\mathtt{k,j,r}} = \dfrac{\mathtt{VFA}_{\mathtt{k,j,r}}}{\sum_{\mathtt{i}} \mathtt{VFA}_{\mathtt{k,j,r}}}$, $\mathtt{k} \in \mathtt{DEMD\_COMM}$[23], is the share of i in total costs of j in r.

3.4.2 Intermediate Consumption Composite Nest

At this point, the intermediate nest describes the composition of the commodity bundle – imported and domestic produced i, $\mathtt{qf}_{\mathtt{i,j,r}}$. Domestic inputs are represented by $\mathtt{qfd}_{\mathtt{i,j,r}}$ and imported by $\mathtt{qfm}_{\mathtt{i,j,r}}$.

Equations (38) and (39) determine firms demand for domestically produced goods and the composite import good. The key substitution elasticity is $\mathtt{ESUBD}_{\mathtt{i}}$ – the Armington elasticity that determines the degree of substitutability between domestic and imported goods (is used in the Goverment Household, Private Household, and Firms). Equation (40) defines the price of the composite and (40') gives the percentage change form of

[23] See Appendix E

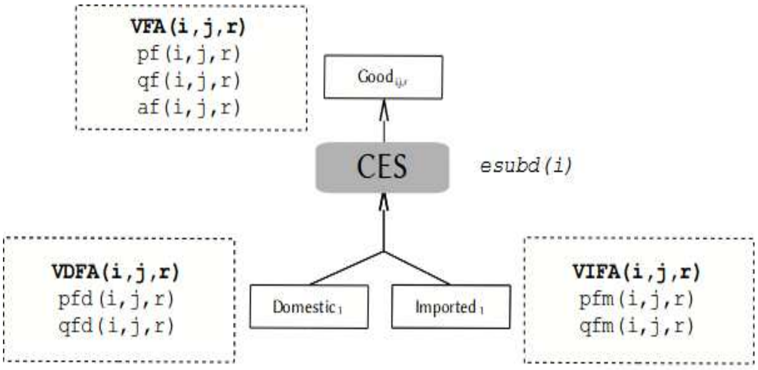


Figure 15 – Intermediate Consumption Composite Nest
VDFA(i,j,r) – purchases of domestic *i* for use by *j* in region *r* ; **VIFA(i,j,r)** – purchases of imported *i* for use by *j* in region *r*; **VFA(i,j,r)** – producer expenditure on good *i* by sector *j* in region *r* valued at agent's prices; **pf(i,j,r)** – firms' price for good *i* for use by sector *j* in *r*; **pfd(i,j,r)** – price index for domestic purchases of good *i* by sector *j* in region *r*; **pfm(i,j,r)** – price index for imports of good *i* by *j* in region *r*; **qf(i,j,r)** – demand for good *i* for use by industry *j* in region *r*; **qfd(i,j,r)** – domestic good *i* demanded by industry *j* in region *r* ; **qfm(i,j,r)** – demand for *i* by industry *j* in region *r*; **af(i,j,r)** – composite intermediary input*i* augmenting technical change by *j* of *r*; **esubd(i)** – region-generic elasticity of substitution between domestic and imported good *i* for all agent.

$\mathtt{pf}_{\mathtt{i,j,r}}$, the price index for domestic purchases of i by j in region r.

$$\mathtt{qfm}_{\mathtt{i,j,r}} = \mathtt{qf}_{\mathtt{i,j,r}} - \mathtt{ESUBD}_{\mathtt{i}}.[\mathtt{pfm}_{\mathtt{i,j,r}} - \mathtt{pf}_{\mathtt{i,j,r}}] \tag{38}$$

$$\mathtt{qfd}_{\mathtt{i,j,r}} = \mathtt{qf}_{\mathtt{i,j,r}} - \mathtt{ESUBD}_{\mathtt{i}}.[\mathtt{pfd}_{\mathtt{i,j,r}} - \mathtt{pf}_{\mathtt{i,j,r}}] \tag{39}$$

$$\mathtt{PF}_{\mathtt{i,j,r}}.\mathtt{QF}_{\mathtt{i,j,r}} = \mathtt{PFD}_{\mathtt{i,j,r}}.\mathtt{QFD}_{\mathtt{i,j,r}} + \mathtt{PFM}_{\mathtt{i,j,r}}.\mathtt{QFM}_{\mathtt{i,j,r}} \tag{40}$$

$$\mathtt{pf}_{\mathtt{i,j,r}} = [\mathtt{FMSHR}_{\mathtt{i,j,r}}.\mathtt{pfm}_{\mathtt{i,j,r}}] + [(1 - \mathtt{FMSHR}_{\mathtt{i,j,r}}.\mathtt{pfd}_{\mathtt{i,j,r}})] \tag{40'}$$

where $\mathtt{FMSHR}_{\mathtt{i,j,r}} = \frac{\mathtt{VIFA}_{\mathtt{i,j,r}}}{\sum_{\mathtt{i}} \mathtt{VFA}_{\mathtt{i,j,r}}}$, $\mathtt{i} \in \mathtt{COMM}$, is the share of firms' imports in domestic composite at agent's prices.

3.4.3 Value Added Nest

The next technology tree explains the composition of demand for production factors, that is, the added value. In each region, the sectors will seek to minimize costs with the primary factors of production according to function:

$$\mathtt{VFA\_F}_{\mathtt{j,r}} = \mathtt{CES}\left[\frac{\mathtt{VFA}_{\mathtt{"sf",j,r}}}{\mathtt{AFE}_{\mathtt{"sf",j,r}}}, \frac{\mathtt{VFA}_{\mathtt{"lab",j,r}}}{\mathtt{AFE}_{\mathtt{"lab",j,r}}}, \frac{\mathtt{VFA}_{\mathtt{"cap",j,r}}}{\mathtt{AFE}_{\mathtt{"cap",j,r}}}\right]$$

Tthe value added bundle, $\mathtt{qva}_{\mathtt{j,r}}$, is a CES aggregation of $\mathtt{qfe}_{\mathtt{i,j,r}}$, where i its de endowment (sluggish, sf, or mobile factors – cap; lab), as given in equation (41).

The key substitution elasticity is $\mathtt{ESUBVA}_{\mathtt{j}}$ which is differentiated by produced commodity. The price of the value-added bundle, $\mathtt{PVA}_{\mathtt{j,r}}$ is given by equation (42), where

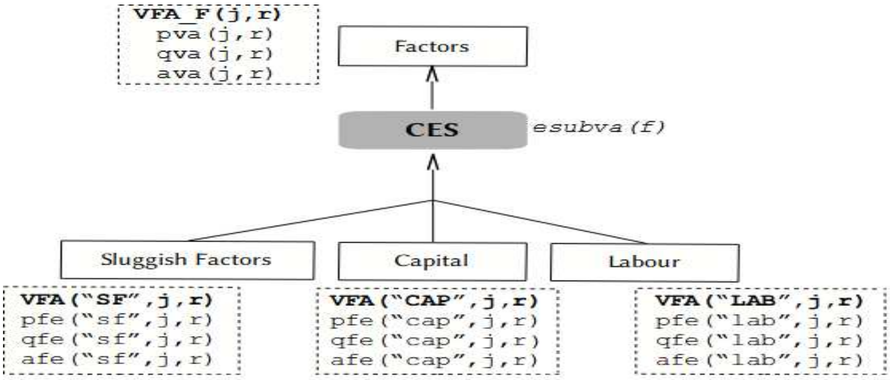


Figure 16 – Value Added Nest

VFA(i,j,r) – producer expenditure on factor *i* by sector *j* in region *r* valued at agent's prices; **VFA_F(j,r)** – producer expenditure on factor *i* by sectorj in region *r* valued at agent's prices summed over factors;
pfe(i,j,r) – firms' price for endowment *i* for use by sector *j* in *r*; **pva(j,r)** – firms' price of value added in industry *j* of region *r*;
qfe(i,j,r) – demand for endowment *i* for use by industry *j* in region *r*; **qva(j,r)** – value added in industry j of region r;
afe(i,j,r) – primary factor *i* augmenting technical change by sector *j* of region *r*; **ava(j,r)** – value added augmenting technical change in sector *j* in region *r* ;
esubva(f) – elasticity of substitution between factors (capital/labor/land), in production of value added in sector *j*.

$\mathtt{PFE}_{\mathtt{i,j,r}}$ is the sector and factor-specific price of endowment $\mathtt{i}$.

$$\mathtt{qfe}_{\mathtt{i,j,r}} = \mathtt{qva}_{\mathtt{j,r}} - \mathtt{afe}_{\mathtt{i,j,r}} - \mathtt{ESUBVA}_{\mathtt{j}}.[\mathtt{pfe}_{\mathtt{i,j,r}} - \mathtt{afe}_{\mathtt{i,j,r}} - \mathtt{pva}_{\mathtt{i,j,r}}] \quad (41)$$

$$\mathtt{PVA}_{\mathtt{j,r}}.\mathtt{QVA}_{\mathtt{j,r}} = \sum_{\mathtt{i}} \mathtt{PFE}_{\mathtt{i,j,r}}.\mathtt{QFE}_{\mathtt{i,j,r}} \quad (42)$$

$$\mathtt{pva}_{\mathtt{j,r}} = \sum_{\mathtt{i}} \mathtt{SVA}_{\mathtt{k,j,r}}.[\mathtt{pfe}_{\mathtt{i,j,r}} - \mathtt{afe}_{\mathtt{k,j,r}}] \quad (42')$$

where $\mathtt{SVA}_{\mathtt{k,j,r}} = \dfrac{\mathtt{VFA}_{\mathtt{k,j,r}}}{\sum_{\mathtt{i}} \mathtt{VFA}_{\mathtt{k,j,r}}}$, $\mathtt{k} \in \mathtt{ENDW\_COMM}$, is the share of $\mathtt{k}$ in total value added in $\mathtt{j}$ in $\mathtt{r}$.

Equation (43) and (44) links the equilibrium market price of endowments, $\mathtt{pmfac}_{\mathtt{i,r}}$ – for mobile endowmnets, and $\mathtt{pmes}_{\mathtt{i,r}}$ – for sluggish endowment, to the producer price, $\mathtt{pfe}_{\mathtt{i,j,r}}$, that includes an endowment and activity-specific tax – the power of the tax is identified with $\mathtt{tf}_{\mathtt{i,j,r}}$.

$$\mathtt{pfe}_{\mathtt{i,j,r}} = \mathtt{pmfac}_{\mathtt{i,r}} + \mathtt{tf}_{\mathtt{i,j,r}}, \qquad \mathtt{i} \in \mathtt{ENDWM\_COM} \quad (43)$$

$$\mathtt{pfe}_{\mathtt{i,j,r}} = \mathtt{pmes}_{\mathtt{i,j,r}} + \mathtt{tf}_{\mathtt{i,j,r}}, \qquad \mathtt{i} \in \mathtt{ENDWS\_COM} \quad (44)$$

Equation (45) represents the equilibrium condition for mobile endowments where $\mathtt{QOFAC}_{\mathtt{i,r}}$ represents the (fixed) aggregate endowment and $\mathtt{QFE}_{\mathtt{i,j,r}}$ is demand for endowment e by activity a.

$$\mathtt{QOFAC}_{\mathtt{i,r}} = \sum_{\mathtt{i}} \mathtt{QFE}_{\mathtt{i,j,r}} \quad (45)$$

$$\mathtt{qofac}_{\mathtt{i,r}} = \sum_{\mathtt{j}} \mathtt{SHREM}_{\mathtt{i,j,r}}.\mathtt{qfe}_{\mathtt{i,j,r}} \quad (61')$$

$$\mathtt{psfac}_{\mathtt{i,r}} = \mathtt{pmfac}_{\mathtt{i,r}} \quad (46)$$

where $\texttt{SHREM}_{\texttt{i,j,r}} = \frac{\texttt{VFM}_{\texttt{i,j,r}}}{\sum_{\texttt{i}} \texttt{VOM}_{\texttt{i,r}}}$, $\texttt{i} \in$ ENDWM_COMM, is the share of mobile endowment, i used by sector j at market prices.

3.4.3.1 The labour income and labour market

In Brazilian regions the industry also have to choose the skills combination. Each industry j,choose to minimize labour cost:

$$\sum_{\texttt{s}} [\texttt{pfe\_lab}_{\texttt{j,bra,s}}.\texttt{qfe\_lab}_{\texttt{j,bra,s}}]$$

such that

$$\texttt{qfe\_lab}_{\texttt{j,bra,s}} = \texttt{CES[all,s,SKL: qfe\_lab}_{\texttt{j,bra,s}}]$$

The DAYANE model does not explicitly consider a labour supply theory. However, the model considers it not acceptable that skilled workers are easily replaced by low-skilled workers. In other words, we assume that workers of different skill levels are imperfect substitutes for each other. This assumption matches with Andrade and Menezes-Filho (2005) and Freire (2017).

The wage is composed of wage rates, $\texttt{plab}_{\texttt{j,bra,s}}$, in relation to the composite price of labour, $\texttt{pavelab}_{\texttt{j ,bra}}$. Changes in the relative prices of different types of skill induce substitution in favour of relatively cheaper ones. The capacity, or velocity, of substitution between different skill levels is determined by the elasticity $\texttt{ESKL}_{\texttt{j,s}}$.

An alternative interpretation of the elasticity of substitution between different qualifications is how many less qualified workers are needed to replace the more qualified ones. Thus, the lower the $\texttt{ESKL}_{\texttt{j,s}}$ elasticity, the lower the substitutability between more and less-skilled workers. Or, the greater the elasticity $\texttt{ESKL}_{\texttt{j,s}}$, the greater the substitutability between different qualifications. For all regions and sectors, the elasticity of substitution among different skills is 0.5.

Equation (47) determines the employment by industry and skills, in percentage change. The market price to each industry of labour composite is determined by (48). Equation (49) shows the market clearing condition for wages.

$$\begin{aligned}\texttt{qlab\_bra}_{\texttt{j,bra,s}} = {} & \texttt{qfe}_{\texttt{"lab",j,bra}} - \texttt{alab\_bra}_{\texttt{j,bra,s}} \\ & - \texttt{ESKL}_{\texttt{j,s}}.[\texttt{plab}_{\texttt{j,bra,s}} - \texttt{alab\_bra}_{\texttt{j,bra,s}} - \texttt{pavelab}_{\texttt{j,bra}}]\end{aligned} \tag{47}$$

$$\texttt{FLAB\_FS}_{\texttt{j,bra}}.\texttt{pavelab}_{\texttt{j,bra}} = \sum_{\texttt{s}} \texttt{FLAB\_F}_{\texttt{j,r,s}}.[\texttt{plab}_{\texttt{j,bra,s}} - \texttt{alab\_bra}_{\texttt{j,bra,s}}] \tag{48}$$

$$\texttt{plab}_{\texttt{j,bra,s}} = \texttt{plabdem}_{\texttt{bra,s}} \tag{49}$$

where $\texttt{FLAB\_FS}_{\texttt{j,bra}}$ is the total value of labour bill in sector j in region bra summed over family and skill; $\texttt{FLAB\_F}_{\texttt{j,r,s}}$ is the sector j wage bills, by s, skill in Brazilian region r summed over families.

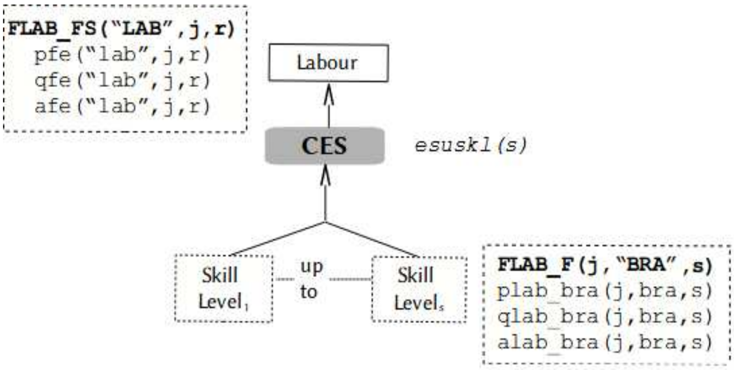


Figure 17 – Labour factor nest
FLAB_F(j,"bra",s) – industry wage bills summed over family *fam* in Brazilian regions *bra*; **FLAB_FS("lab",j,r)** – Total labour bill by industry j in Brazilian region r;
plab_bra(j,bra,s) – market unit wages by industry j and skills s in Brazilian region r; **pfe(i,j,r)** – firms' price for endowment i for use by sector j in r;
qlab_bra(j,bra,s) – employment by industry j and skill s in Brazilian region r; **qfe(i,j,r)** – demand for endowment i for use by industry j in region r;
alab_bra(j,bra,s) – labour-augmenting technical change by sector j and skill s in Brazilian regions; **afe(i,j,r)** – primary factor i augmenting technical change by sector j of region
esuskl(s) – elasticity of substitution between skill types s.

For other regions, $\mathtt{qofac}_{\mathtt{"lab",r}}$ is exogenous, hence fixed. For Brazilian regions, $\mathtt{qofac}_{\mathtt{"lab",r}}$, is the (wage-weighted) add-up of labour over both sectors and skills. To obtain the weighted salary of an individual, we would then multiply the base salary of that position by the number of other workers in the same category earning that amount. Take this figure and divide it by the weighted average salary in that category to obtain the weighted salary. The demand for labour by firms will be higher the lower the wage in each skill level. Thus, by swapping `labslack`[24] for $\mathtt{qofac}_{\mathtt{"lab",r}}$:

$$\sum_{\mathtt{j}} \mathtt{FLAB\_FS}_{\mathtt{j,r}}.[\mathtt{pmfac}_{\mathtt{"lab",r}} + \mathtt{labslack}_{\mathtt{r}}] = \sum_{\mathtt{j}} \mathtt{FLAB\_FS}_{\mathtt{j,r}}.\mathtt{pavelab}_{\mathtt{j,r}} \tag{50}$$

The percentage changes on wage costs (or the producer expenditure in labour), $\mathtt{wfmbra}_{\mathtt{j,r}}$, in each `j` sector, is therefore:

$$\sum_{\mathtt{j}} \mathtt{FLAB\_FS}_{\mathtt{j,r}}\mathtt{wfmbra}_{\mathtt{j,r}} = \sum_{\mathtt{s}} \mathtt{FLAB\_F}_{\mathtt{j,r,s}}.[\mathtt{plab}_{\mathtt{j,r,s}}.\mathtt{qlab\_bra}_{\mathtt{j,r,s}}] \tag{51}$$

The family (`f`) labour income in each region (`bra`) for each skill (`s`), $\mathtt{wlabinc}_{\mathtt{f,bra,s}}$ is determined by equation `(52)`.

$$\mathtt{FLAB\_C}_{\mathtt{f,bra,s}}.\mathtt{wlabinc}_{\mathtt{f,bra,s}} = \sum_{\mathtt{j}} \mathtt{FLAB}_{\mathtt{j,f,bra,s}}.\mathtt{works}_{\mathtt{j,f,bra,s}}.\mathtt{plabf}_{\mathtt{j,f,bra,s}} \tag{52}$$

$$\mathtt{plabf}_{\mathtt{j,f,bra,s}} = \mathtt{plab\_bra}_{\mathtt{j,bra,s}} \tag{53}$$

The family labour income summed over skill and sector, is:

$$\mathtt{FWAGE}_{\mathtt{f,bra}}.\mathtt{wlabinc\_s}_{\mathtt{f,bra}} = \sum_{\mathtt{s}} \mathtt{FLAB\_C}_{\mathtt{f,bra,s}}.\mathtt{wlabinc}_{\mathtt{f,bra,s}} \tag{54}$$

[24] A slack variable to make `qofac` in Brazilian regions endogenous

where:

$$\texttt{FLAB\_C}_{\texttt{f,r,s}} = \sum_{\texttt{c}} \texttt{FLAB}_{\texttt{c,f,r,s}};$$

$$\texttt{FWAGE}_{\texttt{f,r}} = \sum_{\texttt{s}} \texttt{FLAB\_C}_{\texttt{f,r,s}};$$

The change in employment by industry and skill type ($\texttt{works}_{\texttt{j,f,bra,s}}$) follows $\texttt{qlab\_bra}_{\texttt{j,bra,s}}$ variation. However, it is necessary that the add-up over sectors of $\texttt{workrs}_{\texttt{c,f,r,s}}$ to be equal to the exogenous $\texttt{workrs\_c}_{\texttt{f,r,s}}$, hence the slack variable emplslack on equation (55).

$$\texttt{workrs}_{\texttt{j,f,r,s}} = \texttt{qlab\_bra}_{\texttt{j,r,s}} + \texttt{empslack}_{\texttt{f,r,s}} \quad (55)$$

$$\texttt{WORKERS\_C}_{\texttt{f,r,s}}.\texttt{workrs\_c}_{\texttt{f,r,s}} = \sum_{\texttt{j}} \texttt{WORKERS}_{\texttt{j,f,r,s}}.\texttt{workrs}_{\texttt{j,f,r,s}} \quad (56)$$

where $\texttt{WORKERS}_{\texttt{j,f,r,s}}$ is the total employment from families.

It is possible to consider workers' mobility among skills (instead of changes in wages prices). Equation (57) shows the key to change workers (families heads) between different skills.

$$\texttt{WORKERS\_C}_{\texttt{f,r,"s-1"}}.\texttt{workrs\_c}_{\texttt{f,r,"s-1"}} = -\texttt{WORKERS\_C}_{\texttt{f,r,"s"}}.\texttt{workrs\_c}_{\texttt{f,r,"s"}} + \texttt{ffskl}_{\texttt{f,r}} \quad (57)$$

The equation says that, swapping ffskl by workers_c decreases the workers number in, saying, S3 by increasing the number of workers in S5. The families on S3 will now earn higher wages, appropriating the S5 reduction on labour income. The higher the "award" the higher the percentage change in income. But, if the S5 income class receives less than the S3 ones, the impact would be negative. For example, if we simulate an opposite shock, the S5 would earn less than previously.

3.4.3.2 Sluggish endowments nest

For each sluggish endowment, there is an aggregate quantity in fixed supply (total agricultural land, for example). The supply of the aggregate factor to individual activities is less than perfectly elastic, as there is a transformation frontier that moderates the movement of the factor across activities.

Equation (58) determines the supply of the sluggish factor for use in activity j, $\texttt{qoes}_{\texttt{i,j,r}}$. The key transformation elasticity is $\texttt{ETRAE}_{\texttt{j}}$ and $\texttt{pme}_{\texttt{j,i,r}}$ represents the market price of sluggish endowment i used by j in r; equation (59) defines the aggregate price to

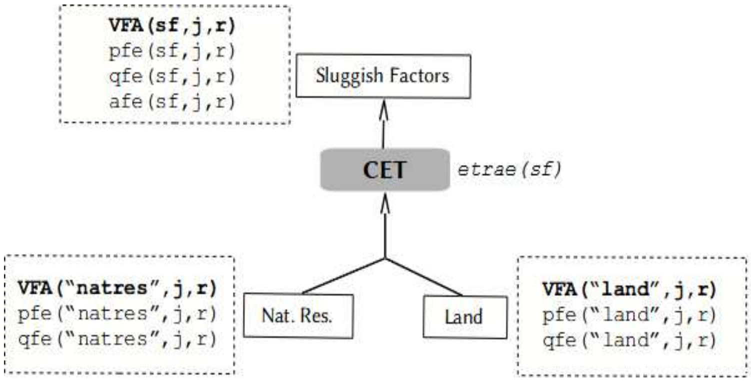


Figure 18 – Sluggish endowments nest

VFA(sf,j,r) – producer expenditure on factor *i* by sector *j* in region *r* valued at agent's prices;
pfe(i,j,r) – firms' price for endowment *i* for use by sector *j* in *r*; **pva(j,r)** – firms' price of value added in industry *j* of region *r*;
qfe(i,j,r) – demand for endowment *i* for use by industry *j* in region *r*;
afe(i,j,r) – primary factor *i* augmenting technical change by sector *j* of region *r*;
etrae(sf) – lasticity of transformation for sluggish primary factor endowment *sf*.

the sluggish factor; equation (60) represents the equilibrium.

$$\mathtt{qoes}_{e,j,r} = \mathtt{qofac}_{e,j,r} - \mathtt{ETRAE}_{j}.[\mathtt{pmes}_{i,j,r} - \mathtt{pmfac}_{i,r}] \tag{58}$$

$$\mathtt{PMFAC}_{i,r}.\mathtt{QOFAC}_{j,r} = \sum_{j} \mathtt{PMES}_{i,j,r}.\mathtt{QOES}_{\ i,j,r} \tag{59}$$

$$\mathtt{pmfac}_{i,r} = \sum_{j} \mathtt{REVSHR}_{i,j,r}.\mathtt{pmes}_{\ i,j,r} \tag{59'}$$

$$\mathtt{qoes}_{i,j,r} = \mathtt{qfe}_{i,j,r} \tag{60}$$

where $\mathtt{REVSHR}_{i,j,r} = \dfrac{\mathtt{VFM}_{i,j,r}}{\sum_j \mathtt{VFM}_{i,j,r}}$, $\mathtt{i} \in \mathtt{ENDWS\_COMM}$, is the Share of endowment e in total endowment revenue/supply.

The land factor is specific to the agricultural sectors (`pdr`, `gro`, `osd`, `c_b`, `oap`, `rmk` and `agr`) and the natural resources factor is specific to the manufacturing sector (`man`). Thus, the transformation elasticity (`ETRAE`) indicates how land use will be distributed, according to the relative price paid in each of the sectors.

3.5 Trade market

3.5.1 Sourcing of imports

At this conjuncture, all agents in the economy have a well-specified commodity-specific demand for domestic and composite imported goods. The sourcing of imports by region of origin is done at the regional level in the destination country.

With a CES preference function for the sourcing of imports, the demand for each good by region of origin is given by equation (61), where $\mathtt{ESUBM}_{i}$ is the substitution elasticity for imports by commodity and the price $\mathtt{pms}_{i,r,s}$ is the domestic price for good `i` supplied from `r` to region `s`. The aggregate import price, $\mathtt{PIM}_{i,s}$ is defined in equation

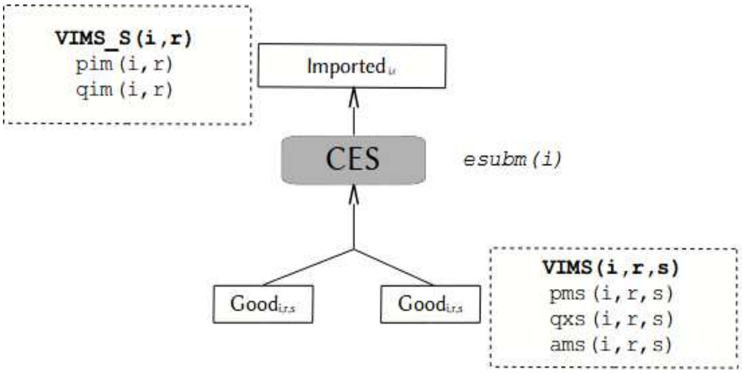


Figure 19 – Imported Nest
VIMS(i,r,s) – imports of commodity i of region r from source region s valued at domestic market prices; **VIMS_S(i,r)** – imports of commodity i of region r summed over source region valued at domestic market prices; **pms(i,r,s)** – domestic price for good i supplied from r to region s; **pim(i,r)** – market price of composite import i in region r;
qxs(i,r,s) – export sales of commodity i from r to region s; **qim(i,r)** – aggregate imports of i in region r, market price weights;
ams(i,r,s) – import of commodity i from region r augmenting technical change in source region s;
esubm(i) – region-generic elasticity of substitution among imports of i in Armington structure.

(62).

$$\mathtt{qxs}_{\mathtt{i,r,s}} = \mathtt{qim}_{\mathtt{i,s}} - \mathtt{ams}_{\mathtt{i,r,s}} - \mathtt{ESUBM}_{\mathtt{i}}\,.\,[\mathtt{pms}_{\mathtt{i,j,r}} - \mathtt{ams}_{\mathtt{i,r,s}} - \mathtt{pim}_{\mathtt{i,s}}] \tag{61}$$

$$\mathtt{PIM}_{\mathtt{i,s}}\,.\,\mathtt{QIM}_{\mathtt{i,s}} = \sum_{\mathtt{r}} \mathtt{PMS}_{\mathtt{i,r,s}}\,.\,\mathtt{QXS}_{\mathtt{i,r,r}} \tag{62}$$

$$\mathtt{pim}_{\mathtt{i,s}} = \sum_{\mathtt{r}} \mathtt{MSHRS}_{\mathtt{i,r,s}}\,.\,[\ \mathtt{pms}_{\mathtt{i,r,s}} - \mathtt{ams}_{\mathtt{i,r,s}}] \tag{62'}$$

where $\mathtt{MSHRS}_{\mathtt{i,r,s}} = \dfrac{\mathtt{VIMS}_{\mathtt{i,r,s}}}{\sum_{\mathtt{r}} \mathtt{VIMS}_{\mathtt{i,r,s}}}$, $\quad \mathtt{r} \in \mathtt{REG}_{\mathtt{dest}}$ is the Share of imports from r in import bill of s at mkt prices

3.5.2 International trade and transport margins

Trade flows from region `r` to region `s` generate demand for trade and transport services. Demand is in fixed proportion to the quantity being delivered, with the possibility of improvements in transport efficiency, captured by the technical coefficient `atmfsd` efficiency of Transportation. Equation (63) describes the demand for trade and transport service `m`, to deliver good `i` from region `r` to region `s`. The global demand for margin service m is the sum of demand across all commodities and across all bilateral trade nodes, as shown in Equation (64).

$$\mathtt{qtmfsd}_{\mathtt{m,i,r,s}} = \mathtt{qxs}_{\mathtt{i,r,s}} - \mathtt{atmfsd}_{\mathtt{m,i,r,s}} \tag{63}$$

$$\mathtt{QTM}_{\mathtt{m}} = \sum_{\mathtt{i}}\sum_{\mathtt{r}}\sum_{\mathtt{s}} \mathtt{QTMFSD}_{\mathtt{m,i,r,s}} \tag{64}$$

$$\mathtt{qtm}_{\mathtt{m}} = \sum_{\mathtt{i}}\sum_{\mathtt{r}}\sum_{\mathtt{s}} \mathtt{VTMUSESHR}_{\mathtt{m,i,r,s}}\,.\,[\mathtt{qtmfsd}_{\mathtt{m,i,r,s}}] \tag{64'}$$

where $\mathtt{VTMUSESHR}_{\mathtt{m,i,r,s}}$ is the share of `i,r,s` usage in global demand for `m`.

The variable qtmfsd computes the bilateral demand for international transportation services. It reflects the fact that the demand for services along any particular route is proportional to the quantity of merchandise shipped, $QXS_{i,r,s}$. The potential for input-augmenting technical change, $atmfsd_{m,i,r,s}$, which is commodity and route-specific.

Thus, in the levels: $ATMFSD_{m,i,r,s} . QTMFSD_{m,i,r,s} = QXS_{i,r,s}$; where QTMFSD is the amount of composite margins services m used along this route. Technological improvements are reflected by atmfsd(i,r,s) > 0, and these reduce the margins of services required for this i,r,s triplet. Tech. Change also dampens the cost of shipping, thereby lowering the CIF price implied by a given FOB value

Given the lack of bilateral supplies of shipping services, each mode of transport, m, is supplied at a uniform price PT_m across the world. This global transport price is a composite based on the price of national margin services exports, as shown in equation (65).

$$PT_m . QT_m = \sum_r PM_{m,r} . QST_{m,r} \tag{65}$$

$$pt_m = \sum_r VTSUPPSHR_{m,r} . [pm_{m,r}] \tag{65'}$$

where $VTSUPPSHR_{m,i,r,s}$ is the share of region r in global supply of margin m.

The variable $pt_{(m}$ generates a price index for transportation services based on zero profits. Sales to international transportation are not subject to export tax (this is why costs are based to the transport sector on market prices of the goods sold to international transportation). It is assumed that the supply shares for margin services are uniform across freight, source of freight, and destination.

To compute the composite FOB-CIF margin, it is necessary to aggregate these modal specific prices overall relevant modes of transport for that particular commodity. Any transport efficiency changes enter into this calculation as well, giving equation (66). There is a 'global' transport sector that purchases the services m from each region. The global purchaser wishes to minimize the cost of purchasing the services across regions, subject to a CES preference function. Optimal demand is given by equation (67), which determines $QST_{m,r}$, the regional supply of trade service m.

$$ptrans_{i,r,s} = \sum_m VTFSD\_MSH_{m,i,r,s} . [pt_m - atmfsd_{m,i,r,s}] \tag{66}$$

$$qst_{m,r} = qtm_m + [pt_m - pm_{m,r}] \tag{67}$$

where $VTFSD\_MSH_{m,i,r,s}$ Share of region r in global supply of margin m.

Variable qst generates the international transport sector's derived demand for regional supplies of transportation services. It reflects a unitary elasticity of substitution between transportation services inputs from different regions.

3.6 Private Expenditure

The domestic market is made up of domestically produced and imported goods, which are, by assumption, a CES-type aggregation. Given the prices of imported and domestic products, the problem for consumers is to acquire a certain quantity of products with the minimum amount of expenditure. The optimal proportion of domestic and imported goods depends on relative prices and on the elasticity of substitution and results from the solution of the problem of minimizing consumption expenditure, restricted to the CES aggregation function.

3.6.1 Government Consumption

Each commodity, indexed by `i` is combined to formulate Government expenditure (`GOVEXP`) in each region `r`. The highest level of the government's technological consumption tree indicates that the government combines the various goods into a Leontief function.($\mathtt{ESUBG_i}$: 0), that is, they are combined in fixed proportions. The second-level technology tree indicates that the government decomposes the domestic and imported goods from individually consumed goods (at the Armington level), at this level `esubd(i)` is the elasticity of substitution of single good composite (domestic and imported).

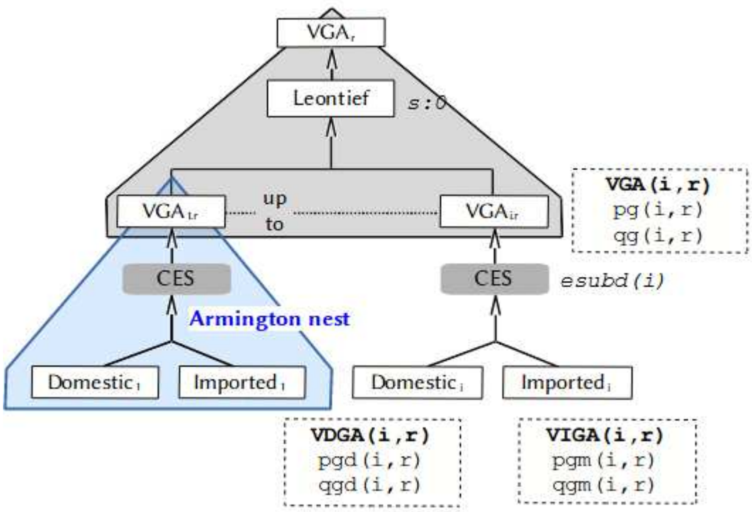


Figure 20 – Government Technological Tree
VDGA(i,r) – government consumption expenditure on domestic good i in region r - valued at agent's prices; **VIGA(i,r)** – government consumption expenditure on imported good i in region r - valued at agent's prices; **VGA(i,r)** – government consumption expenditure on good i in region r valued at agent's prices; **VGA(r)** – government expenditure in region r ;
pgd(i,r) – price of domestic i in government consumption in r; **pgm(i,r)** – price of imports of i in government consumption in region r; **pg(i,r)** – government consumption price for commodity i in region r
qgd(i,r) – government demand for domestic i in region r; **qgm(i,r)** – government demand for imported i in region r; **qg(i,r)** – government demand for commodity i in region r;
esubd(i) – region-generic elasticity of substitution domestic/imported for all agents.

Equation (68) determines composite commodity demand by the government for commodity `i` in region `r`. The government expenditure price index is provided in equation

(69).

$$qgov_r = \sum_i \left[\frac{VGA_{i,r}}{GOVEXP_r}\right].qg_{i,r} \tag{68}$$

$$pgov_r = \sum_i \left[\frac{VGA_{i,r}}{GOVEXP_r}\right].pg_{i,r} \tag{69}$$

Public expenditures on the composite goods are subsequently decomposed into demand for domestic and imported goods using a CES sub-utility preference function. Equations (70), (71) and (72) determine public demand for domestic goods in r ($qgm_{i,r}$), imported goods ($qgd_{i,r}$) and the government price of the composite good ($pg_{i,r}$).

$$qgm_{i,r} = qg_{i,r} - ESUBD_i.[pgm_{i,r} - pg_{i,r}] \tag{70}$$

$$qgd_{i,r} = qg_{i,r} - ESUBD_i.[pgd_{i,r} - pg_{i,r}] \tag{71}$$

$$PG_{i,r}.QG_{i,r} = PGD_{i,r}.QGD_{i,r} + PGM_{i,r}.QGM_{i,r} \tag{72}$$

$$pg_{i,r} = [GMSHR_{i,r}.pgm_{i,r}] + [(1 - GMSHR_{i,r}.pgd_{i,r})] \tag{83'}$$

The government consumption expenditure :

$$ygov_r = pgov_r + qgov_r \tag{73}$$

3.6.2 Private Agent Expenditure

Private consumption, follows the same reasoning of Government, departing from the Armigntion Nest, combining the consumption of domestic and imported goods through a CES function, with elasticity esubd. The upper nest combines the various goods through a CES of unit elasticity (s:1), that is, the quantity consumed varies proportionally to the change in price.

The private consumption price index $ppriv_r$ is just a weighted average of prices of the composite goods:

$$ppriv_r = \sum_i [CONSHR_{i,r}.pp_{i,r}] \tag{74}$$

where $CONSHR_{i,r}$ is the share of household consumption devoted to good i in r.

Private expenditures on the composite goods are subsequently decomposed into demand for domestic and imported commodities using a CES preference function. Equations (75), (76) and (77) determine private demand for domestic($qpd_{i,r}$) and imported goods ($qpm_{i,r}$), and the consumer price of the composite ($pp_{i,r}$).

$$qpm_{i,r} = qp_{i,r} - ESUBD_i.[ppm_{i,r} - pp_{i,r}] \tag{75}$$

$$qpd_{i,r} = qp_{i,r} - ESUBD_i.[ppd_{i,r} - pp_{i,r}] \tag{76}$$

$$PP_{i,r}.QP_{i,r} = PPD_{i,r}.QPD_{i,r} + PPM_{i,r}.QPM_{i,r} \tag{77}$$

$$pp_{i,j,r} = [PMSHR_{i,r}.ppm_{i,r}] + [(1 - PMSHR_{i,r}.ppd_{i,r})] \tag{77'}$$

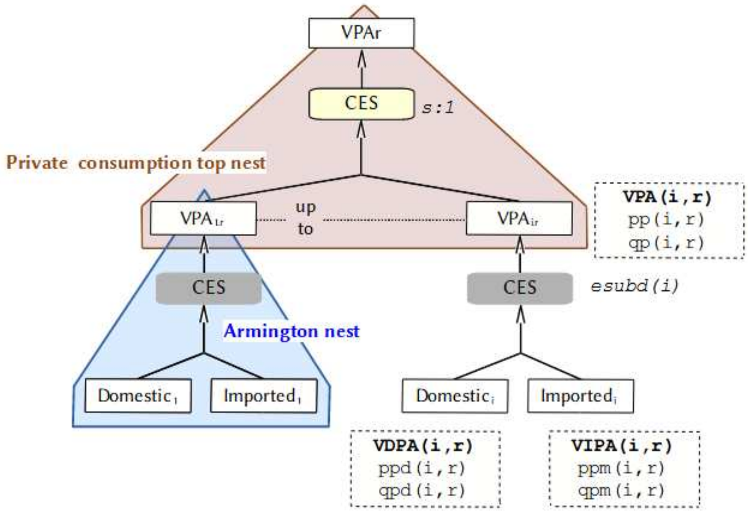


Figure 21 – Private Agent Technological Tree

VDPA(i,r) – private consumption expenditure on domestic good i in region r - valued at agent's prices; **VIPA(i,r)** – private consumption expenditure on imported good i in region r - valued at agent's prices; **VPA(i,r)** – private consumption expenditure on good i in region r valued at agent's prices; **VPA(r)** – private expenditure in region r; **ppd(i,r)** – price of domestic i in private consumption in r; **ppm(i,r)** – price of imports of i in government consumption in region r; **pp(i,r)** – private consumption price for commodity i in region r
qpd(i,r) – private demand for domestic i in region r; **qpm(i,r)** – private demand for imported i in region r; **qp(i,r)** – private demand for commodity i in region r;
esubd(i) – region-generic elasticity of substitution domestic/imported for all agents.

The aggregated private consumption expenditure in region r, is, therefore:

$$\mathtt{yp_r = qp_{i,r} + pp_{i,r}} \tag{78}$$

In the case of families in Brazilian regions, private consumption ($\mathtt{VPA_{i,r}}$) is divided for each income class according to the share of families in the region's total consumption. The strategy to divide consumption is to first read the consumption of each household in the regions from the database ($\mathtt{FVPA_{i,r,f}}$)[25] and add a block of equations that basically has the objective is to link household consumption with private consumption (prices and quantities), considering the share of each household in the total consumption of each region ($\mathtt{FCSHR}$).

$$\mathtt{pfam_{r,f} = \sum_i FCSHR_{i,r,f} \;.\; pp_{i,r}} \tag{79}$$

$$\mathtt{FVPA\_F_{i,r} \;.\; qp_{i,r} = \sum_f FVPA_{i,r,f} \;.\; qfp_{i,r,f}} \tag{80}$$

$$\mathtt{ypf_{r,f} = qfp_{i,r,f} + pp_{r,f}} \tag{81}$$

where $\mathtt{qfp_{i,r,f}}$ is the family $\mathtt{f}$ demand for commodity $\mathtt{i}$ in region $\mathtt{r}$; $\mathtt{pfam_{r,f}}$ is the price index for family expenditure in region $\mathtt{r}$; and, $\mathtt{ypf_{r,f}}$.

[25] $\sum_f \mathtt{FVPA_{i,r,f} = VPA_{i,r}}$

3.6.3 Model's Assumptions

Differently from standard GTAP, DAYANE model does not consider the "Global Bank" approach [26]. The model considers investment volume exogenous, thus fixed. The amount of investments in the database is kept constant after a shock, but their prices are endogenous. Thus, after a shock, the value of investments will change. Total investment equals household savings. The DAYANE adopts Rutherford (2005) assumption, choosing to simplify investment demand assumption, it is kept fixed the international capital flows and the time path of adjustment. We do not model changes in international (interregional) financial capital flows induced by trade policy changes. Rather, the capital market closure we adopt involves fixed net capital inflows and outflows.

We kept the economy in the full-employment[27] condition. Factor markets are competitive, with labour and capital being mobile between sectors but not between regions. The limitation occurs because part of household income also depends on factors. Thus, the model is not prepared to work with multiple households and with capital and labor mobility. The rate of unemployment is, in the long run, determined by mechanisms outside of the model.

Moreover, labour can move between different types of skills. We follow standard GTAP in assuming that employment is determined by demand and that demand reflects industry outputs, technologies, and pre-tax wage rate relative to the costs to industries of using other primary factors. However, we allow a policy shock to generate movements in labor supply between skills. If a policy induces an increase in the wage rate of skilled labor relative to unskilled, then we allow for an increase in skilled labor supply with a corresponding reduction in unskilled supply. As Dixon, Rimmer and Tran (2019), Soliman et al. (2015), we are assuming that wages are free to adjust, in response to a labour supply shock.

The trade sector is modeled as trade in goods that are differentiated by country of origin. Different country varieties are combined through a CES aggregator into a composite good, used as intermediates or for final consumption. In the long run macro-closure, the balance of trade as a proportion to GDP is fixed, because in the long run the rest of the world might be reluctant to fund an increased trade deficit.

The families total expenditure follows increases on total income[28]:

[26] Minor and Walmsley (2013), Horridge (2005) are useful tools in this sense

[27] The unemployment term consists of the fact that all factors available on the model are used, i.e., the model can not predict frictional unemployment, for example

[28] $VFACINC(i,r) * wfacinc(i,r) = sum\{j, COM, VFM(i,j,r) * [pmfac(i,r) + qfe(i,j,r)]\}$

$$\mathtt{VFAMINC}_{f,r}.\mathtt{wfaminc}_{f,r} = \mathtt{VFACTINC}_{f,r}.\mathtt{wfactinc}_{f,} + \sum_{t}\mathtt{TRANSF}_{f,r,t}.\mathtt{wtransf}_{f,r,t} - \mathtt{ITAX}_{f,r}.\mathtt{witax}_{f,r};$$

$$\mathtt{VFACTINC}_{f,r} = \mathtt{FCAP}_{f,r} + \mathtt{FLND}_{f,r} + \mathtt{FWAGE}_{f,r};$$

$$\mathtt{VFACTINC}_{f,r}.\mathtt{wfactinc}_{f,r} = \mathtt{FCAP}_{f,r}.\mathtt{wfamcap}_{f,r} + \mathtt{FLND}_{f,r}.\mathtt{wfamland}_{f,r} + \mathtt{FWAGE}_{f,r}.\mathtt{wlabinc\_s}_{f,r};$$

$$\mathtt{ypf}_{r,f} = \mathtt{wfaminc}_{f,r};$$

The value of factors income is determined by factor prices and quantities. Transfers and direct income tax are, on default mode, endogenous and follow the percentage changes in GDP and in families total income, respectively:

$$\mathtt{VFACTINC}_{i,r}.\mathtt{wfactinc}_{i,r} = \sum_{c}\mathtt{VFM}_{i,c,r}.[\mathtt{pmfac}_{i,r} + \mathtt{qofac}_{i,r}];$$

$$\mathtt{wtransf}_{f,r,t} = \mathtt{ftransf}_{f,r,t} + \mathtt{wgdpbra};$$

$$\mathtt{witax}_{f,r} = \mathtt{wfactinc}_{f,r} + \mathtt{fitax}_{f,r}$$

The variables `ftransf` and `fitax` are shifters that allow us to shock transfers and income tax by making them exogenous, swapping them with previously endogenous `wtransf` and `witax`. If we'd chosen to make transfers and income tax endogenous, the transfers would follow the Brazilian GDP changes, `wgdpbra`, and income tax would follow income gains, `wfactinc`.

The GDP calculated in income side[29] must be the same as expenditure side [30]. Thus, in the DAYANE standard closure, Government spending on commodities has to be residual, as we considered `I` and `BOT` fixed and C following family income in Brazil and the regional income for other regions (as stated above). Adams (2003) argues that the "slack" assumption of Government on GDP simply implies that the deterioration in government budget balances caused by the loss of tariff revenue is not offset by reduced government spending or by increases in other taxes, and many published GTAP applications adopt this assumption.

Although it is reasonable to assume that the Government absorbs all possible distorting effects on the economy (direct and indirect effects), changes in public policies must have a measure of costs. Thus, it is possible to track the Government Accounts, to measure the costs of the new policy. The Government income includes all taxes including the income tax from families, in Brazil). On the other hand, the Government expenses include VGA and transfers to the families in Brazilian regions.

[29] `ENDW + IndTax`
[30] `C + I + G + (X-M)`

It is also important to ensure that Brazilian different governments are not isolated from each other. Therefore, for Brazil, we assume that regional governments receive all commodity taxes, pay for all final demands, get/send transfers to the Federal Government to cover the difference. Federal Government receives all income taxes, pays for transfers to families and Regional Governments. Thus, the equation `qg` forces real government consumption in each Brazilian region to follow the national value. However, `pgov` differs between regions and so does `wgov`.

$$\mathtt{qg}_{i,r} = \mathtt{fqg\_i}_{r} + \mathtt{fqg}_{i,r} + \mathtt{ISBRA}_{r}.\mathtt{govslack}$$

where `ISBRA` is a key for Brazilian regions and `govslack` is a slack variable to align Government spending in Brazil.

3.6.3.1 The applied shocks

I will analyze two standard scenarios. The first one will increase the number of works from Basic Education (S3) to Technical Skill (S5). The second, and not exclusionary from the first, is to increase workers from Incomplete Fundamental (S4) to Technical Skill (S5). It is important to understand that the initials skill levels shocked are the main skill reached by heads of Bolsa Família beneficiaries, representing 56.37% of the total qualification of these families heads. All income families receive transfers from Bolsa Família Program, which is the reason to consider all families, not just poor families here.

By swapping `ffskl` by `workrs_c` it is possible to reduce the workers number in S3/S4 by increasing the number of workers in S5. The shocked variable does not allow shocking only families that receive Bolsa Família Program that is working (on labour market). So, all families will be shocked considering the % of the population that receives the Program from the government in each region uniformly.

There is a substitution between the new labour income and transfers. To calculate the decrease in transfers from government to families, it is possible to write `wtransf` equation as:

$$\mathtt{TRANSF}_{f,r,t}.\mathtt{wtransf}_{f,r,t} = \mathtt{TRANSF}_{f,r,t}.\mathtt{ftransf}_{f,r,t} + \mathtt{TRANSF}_{f,r,t}.\mathtt{wgdpbra};$$

Now each term is (`100 times`) the ordinary change. We want to ensure that:

$$\mathtt{TRANSF}_{f,r,\text{"BolsaFam"}}.\mathtt{ftransf}_{f,r,\text{"BolsaFam"}} = -\ \mathtt{FWAGE}_{f,r}.\mathtt{wlabinc\_s}_{f,r};$$

$$\mathtt{ftransf}_{f,r,\text{"BolsaFam"}} = -\left[\frac{\mathtt{FWAGE}_{f,r}}{\mathtt{TRANSF}_{f,r,\text{"BolsaFam"}}}\right].\mathtt{wlabinc\_s}_{f,r}$$

We can work out the Right Hand Side of equation above and use that to shock $\texttt{ftransf}_{\texttt{f,r,"BolsaFam"}}$ to reduce government transfers via Bolsa Família Program in the same proportion as families wages increase. The shocks can be observed in Appendix F.

There are two assumptions on Government educational expends:

- The first is to simply accept that these expends already exist on base data, and now the families are just absorbing this service;

- The second is to consider that the expends will, in fact, increase the government expenses.

The variable $\texttt{fqg}_{\texttt{i,r}}$ allow us to change government expense on specific sector, for different regions. This shock variable is necessary if we want to simulate increases in specific sectors.

On the database (following PAEG) the 65 sectors on GTAP are aggregated in 19 sectors. The educational sector represents 16.90% of the Brazilian Government's expends on services. The Government spent US$2,379.99 per student in professional courses in 2014 according to INEP/MEC (2021). Thus to calculate the expenses on education in BRA we will run the scenario without shock on `fqg`, find the number of workers moving from different skills, and work out the value of services sectors that this represents.

However, the assumption in this Thesis is: Government already spends on the education sector. Considering that the people are appropriating for this "service". There are two reasons to assume this: expenses on the technical courses are considered on I-O tables (as part of the services sector) and previously approved in terms of the law (approximately R$ 6.8bi yearly) The second assumption is that the policy applied would already increase government expenses on sectors, and mainly in service (education) sector, higher enough to "extra spending".

Disregarding the expenses with family qualification means assuming that the marginal cost (or marginal expense) with each new student being qualified by Pronatec is zero. It is reasonable to believe that in fact, the unit cost for extra students would be lower in t+1 time, considering that all costs already existed previously. More than that, the social return of spending on such a qualification is at least equal to (and probably greater than) the spending, and therefore, it was preferred to ignore such spending.

Income increases would increase the Government's income by increasing income tax revenue. The model assumes that, in Brazil, regional Governments receive all commodity taxes, pay for all final demands, get/send transfers to Federal Government, to cover the difference. Regarding the Federal Government, it gets all income taxes, pays for transfers to families and regional Governments, based on Regional Governments Savings. Investments and capital flows are kept fixed. The representative agent aggregate consumption may change with changes in goods prices, as well as the revenue from taxes is subject to changes in the activity level and consumption. Changes in the real exchange rate must occur to accommodate changes in export and import flows aftershocks.

4 RESULTS AND DISCUSSION

The results and discussion section is divided into two subsections. The first subsection is focused on understanding the model's database and its implications on the results generated by the applied policy. Therefore, it is dedicated to describing the Brazilian family's consumption, income formation, and labour market skill characteristics. The second one will analyze the economic impacts of Bolsa Família beneficiary's skill improvement.

It is expected that changes in the labour market affect all factors price. If the shock aims to increase the number of workers in a specific skill class, it is expected that this skill class wage to fall and lead the labour factor market price to be cheaper related to capital. Another important analysis is the impact on wage costs. The impacts also depend on the elasticity of demand substitution by firms for different types of skills. Such elasticity determines how many firms can choose to reduce the demand for the skill that has become more scarce (low qualification) for the one that has become more abundant (higher qualification).

It is expected that the skill improvement will increase the expenses from industries on labour. This would have two critical effects: impacts on families income, and then the consumption and welfare; impacts on output, leading to impacts on relative prices. Thus, the policy applied will also change intermediate consumption, and international flows besides government and families consumption. The impacts will depend on sector skill level intensity - the more reliant on shocked skill level the higher the impact, and also depends on sector consumption share on total family consumption (in terms of welfare).

The families welfare also depends on transfers and income tax payment changes. We are assuming that increases in wages lead to a decrease in Bolsa Família Transfers and increases in income tax payments. Thus, the earns on labour market must be sufficient to "cover" reduction in transfers and positive variation on income tax. To analyze the success of Bolsa Família beneficiaries' labour improvement, it will be analyzed the policy balance on government accounts (assuming that Government already spends enough on education) besides the impacts on families income and consumption.

Note that the analysis of the results depends on strong assumptions from DAYANE model (as all CGE models). We are considering that the labour qualification policy will affect only employed people – both in formal or informal jobs (the model does not present unemployment). The sectors will absorb the skilled workforce. Also, the values are kept fixed in a specific-moment[31] of the economy. We are also making assumptions for a long-run analysis, considering the macro closure assumption. However, Brazilian training courses for low-skilled people have a duration from two months to one year. Thus, we have

[31] It is common said that input-output matrices and social account matrices are specific-moment photography

to keep in mind that policies adopted here will take effect after one year of qualification, as well as, all change in values is annually interpreted. More than that, the effect of labour qualification would last as many times as workers still employed on the labour market.

Even though the model is useful to analyze Brazilian regional impacts and is very important by considering ten income classes and twelve skill levels for these different regions, the model is not prepared to simulate movement between different income classes or poverty line modeling. Thus, it is not possible to investigate impacts in terms of overcoming the poverty line[32]. Even more, considering that the effects on prices are adjusted to the "new reality". The impacts also depend on the substitution elasticity of demand by firms for different types of skills (ESKL). Such elasticity determines how firms can choose to reduce the demand for the skill that has become more scarce by the one that has become more abundant.

4.1 Brazilian families description

4.1.1 Families consumption

The consumption of aggregated Brazilian families in each aggregated sector can be observed in Figure 22. On the figure is shown the share of each sector on total consumption. The consumption is aggregated in agriculture (pdr, gro, osd, c_b, oap, rmk, and agr), industry (foo, tex, wap, lum, ppp, crp and man), and services (siu, cns, trd, otp, and ser). On Appendix D, it is possible to observe the disaggregated consumption for all families in Brazilian regions.

In general, the less the income class, the higher the consumption in the agriculture and industry sector. On the other hand, the higher the income class, the higher the consumption in service sectors. Families from 1^{st} income class consume 57.27% of total consumption in service sectors, while families from 10^{th} class consume 75.69% a difference of 18.42%. Considering just the sectors included in services aggregation, poor families spend 46.21% on the "other services" sector, while the higher income class spend 66.68%, this sector includes real state, medical care spending, and hospitality services for example.

Regarding the industry aggregate sector, lower-income families spend more on this sector than the richer ones, relative to the total consumption. The Brazilian aggregated first-class consume 35.85% of total consumption, and the wealthier families, 22.08%. If we consider just the industry aggregated sector, families from 1^{Sr} consume 43.59% in manufactures, which includes day-by-day goods, like kitchen stuff and white goods. The proportion of the consumption spent on the manufacturing sector (on aggregated industry sector) does not change significantly between families, the 10^{th} income class consumes 49.29% of total industry consumption in that sector. Also, it is important to consider that poor families consume 29.69% of total industry consumption in foods, and richer, 23.63%.

[32] Hertel et al. (2011) developed the GTAP_POV to evaluate issues related to the poverty line

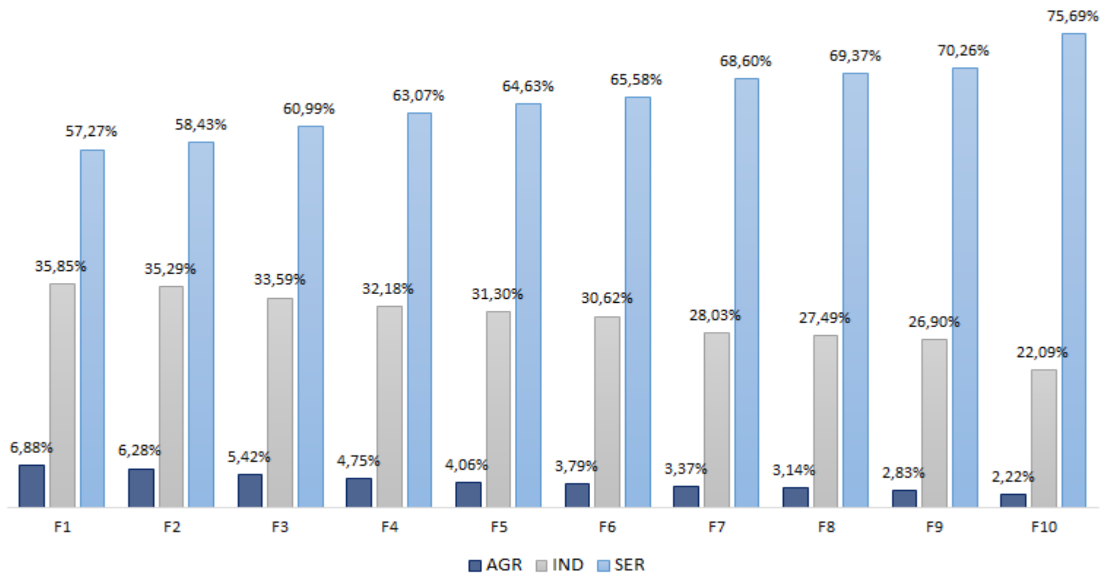


Figure 22 – Brazilian Families Consumption
AGR – agriculture sectors (pdr, gro, osd, c_b, oap, rmk, and agr);
IND – industry sectors (foo, tex, wap, lum, ppp, crp, and man);
SER – service sectors (siu, cns, trd, otp, and ser);
F1 ∼ **F10** – families income classes.

Concerning the agriculture sector, families from the lowest income class consume 6.88% of total consumption. The most part (42.64%) of this consumption is on other agricultural products, like fruits and vegetables; sugar industry (21.14%), and; animal products (19.13%). On the other hand, the last income classes spend just 2.22% of total consumption on the agriculture sector. The wealthier families consume 60.32% of aggregated agriculture sector on other agriculture sectors, 20.40% on animal products, and 5.51% on milk and dairy products.

The consumption of all income classes in Brazilian regions can be observed in Table **??**. It is expected that the consumption pattern (the lower the income, the higher the consumption on the agricultural and industrial sector, and the higher the income class the higher the consumption on services) does not change. What is expected to be different is the amount of total consumption spent on aggregated sectors, and the expenses on sectors individually. Another distinction between regions must be the variation among different classes.

Table 4 – Families Consumption - Brazilian Regions

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
					NORTH					
AGR	3.75%	3.88%	4.11%	3.32%	2.76%	2.96%	2.13%	2.83%	1.90%	1.91%
IND	36.00%	35.95%	38.35%	32.59%	29.46%	31.22%	26.82%	25.23%	22.97%	23.33%
SER	60.25	60.17	57.55	64.09	67.77	65.82	71.06	71.94	75.13	74.76
					NORTHEAST					
AGR	10.04	7.97	7.04	5.91	4.24	4.20	3.24	3.52	3.02	2.29
IND	31.87	27.57	24.84	23.51	20.10	22.31	18.55	19.21	18.47	15.53
SER	58.09	64.47	68.13	70.58	75.66	73.49	78.21	77.27	78.52	82.18
					MIDWEST					
AGR	6.62	5.66	6.63	5.51	5.67	4.51	3.12	2.99	2.64	2.05
IND	24.76	22.44	22.17	21.69	22.39	20.00	13.88	17.78	16.33	13.44
SER	68.62	71.90	71.20	72.79	71.94	75.50	83.00	79.23	81.03	84.52
					SOUTH					
AGR	4.55	6.54	5.07	4.74	4.16	3.45	3.10	2.85	2.96	2.25
IND	28.29	33.03	29.45	27.75	26.92	25.15	25.96	23.57	24.40	19.62
SER	67.17	60.43	65.48	67.51	68.92	71.40	70.93	73.58	72.63	78.13
					SOUTHEAST					
AGR	5.51	5.62	4.74	4.42	3.88	3.77	3.59	3.23	2.86	2.25
IND	46.04	44.45	39.89	38.02	37.99	35.71	32.75	32.54	31.02	25.23
SER	48.45	49.93	55.37	57.56	58.12	60.52	63.66	64.24	66.12	72.52

AGR – agriculture sectors (pdr, gro, osd, c_b, oap, rmk, and agr);
IND – industry sectors (foo, tex, wap, lum, ppp, crp, and man);
SER – service sectors (siu, cns, trd, otp, and ser);
F1 ∼ **F10** – families income classes.

It is possible to observe that poor families consume relatively more in capital-intensive sectors, like agriculture, food, and manufacturing in general. Velludo and Vale (2020) and Vaz and Hoffman (2020) find the same consumption pattern found in the present study. Considering the consumption pattern, it can be said that policies that raise the price of capital-intensive consumer goods would harm the poorest families. On the other hand, the reduction in the price of these goods favours these families relatively. Increased consumption in these sectors raises, on the other hand, the price of the capital factor, which is the main source of income for wealthier families, favouring their income and potentially increasing inequality.

4.2 Families income

Considering the aggregated Brazil, in general, it is observed that labour is the main income source of Brazilian families. The exception is income class ten, which presents capital as the main income source. The higher the income class, the greater the share of capital and tax payments on the income of the families. On the other hand, the lower the income class, the greater the share of social programs (Bolsa Família and Other Programs) on total income.

Table 5 – Families Income Source - Brazil

Class	Lab	Cap	Land	BolsaFam	OthProgm	OthTransf	Retirement	ItaxRef	LessTax
F1	49.53%	22.59%	0.00%	14.85%	0.81%	4.51%	6.71%	0.00%	1.00%
F2	39.12%	20.99%	0.33%	5.56%	4.19%	5.89%	22.63%	0.00%	1.28%
F3	41.18%	21.78%	0.34%	2.17%	2.72%	5.49%	24.80%	0.00%	1.52%
F4	38.11%	24.57%	0.37%	0.86%	1.78%	3.70%	29.18%	0.00%	1.43%
F5	43.06%	26.48%	0.28%	0.45%	1.18%	4.15%	22.68%	0.05%	1.67%
F6	45.39%	29.46%	0.48%	0.30%	0.87%	3.84%	17.75%	0.05%	1.85%
F7	47.21%	30.21%	0.40%	0.17%	0.44%	3.37%	15.98%	0.15%	2.07%
F8	47.54%	31.35%	0.47%	0.10%	0.35%	3.53%	14.31%	0.26%	2.10%
F9	42.56%	37.45%	0.77%	0.04%	0.16%	2.64%	13.76%	0.39%	2.23%
F10	30.63%	55.11%	0.89%	0.01%	0.03%	1.05%	9.23%	0.65%	2.40%

To observe just the relative participation of primary factors (labour, capital, and land) on each income class, it is also possible to isolate just the primary factor income. It is possible to analyze that, first, the role of wages on low-income family's income becomes even more clear, and, secondly, the importance of Government on the total income of the poorest families. The share of each factor on total primary factor on each family can be observed in Figure 23.

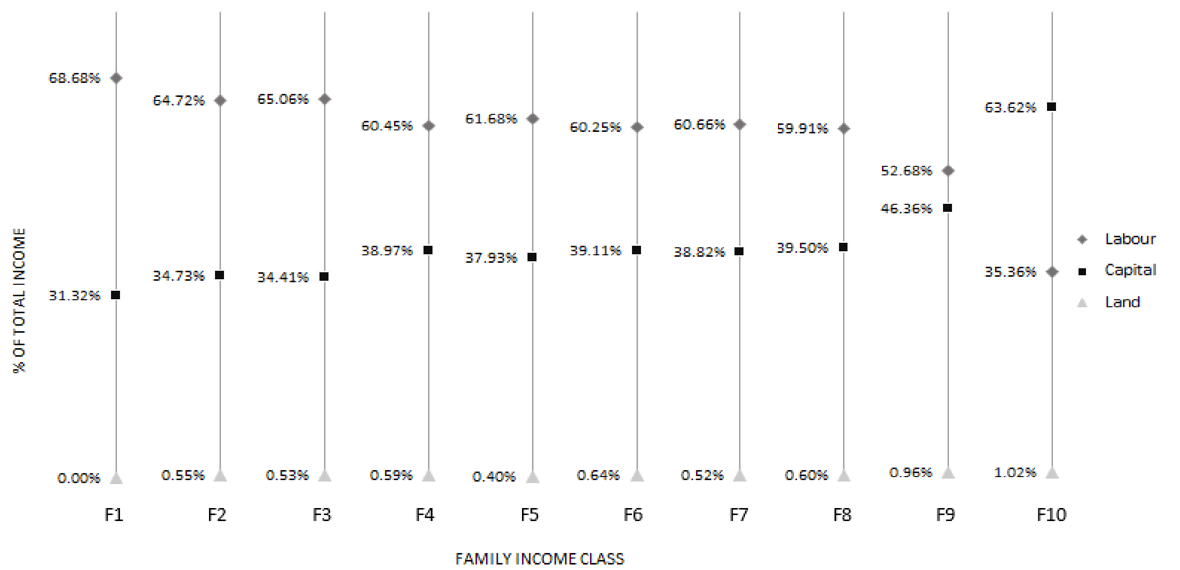


Figure 23 – Families Primary Factors - Brazil

Regardless of the land income, that not represent a large part of families income, it is shown that the share of labour on first-class income increase by 19.15% on total primary factors, while the capital income increase the share by just 8.73%. In other words, without Government transfers, low-income families are heavily dependent on labour income. Continuing on this argumentation, the other incomes (mainly the Government transfers) reduce the labour participation to 49.53%, evidencing the importance of the transfer on families from first income classes.

In contrast, wealthy families, from income class ten, for example, increase the share of capital income by 8.51%, while the share of labour increases by just 4.73%. It is important to observe that, not considering the income from transfers (including the taxes), the shares of capital and labour income do not change considerably for high-income classes. Thus, it is clear that transfers from and to the Government do not generate a great impact on these families.

However, Brazil holds deep social and economic differences among regions, that is, it is significant to consider a disaggregated analysis, Appendix D shows the income source for different regions. Table 6 shows the share of each factor (labour, capital, and land) on total primary factors on each income class in Brazilian regions.

Table 6 – Families Primary Factors - Brazilian regions

	F1	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**
					North					
Lab	63.35%	54.09%	51.55%	34.94%	43.29%	35.80%	41.75%	40.39%	22.98%	22.76%
Cap	36.65%	45.64%	48.16%	64.53%	56.69%	63.55%	57.76%	59.33%	75.68%	76.00%
Land	-	0.27%	0.30%	0.53%	0.02%	0.65%	0.49%	0.28%	1.35%	1.24%
					Northeast					
Lab	61.33%	58.20%	53.88%	50.18%	47.27%	44.34%	49.19%	42.81%	42.17%	31.27%
Cap	38.67%	40.81%	44.72%	48.34%	51.74%	54.18%	49.44%	55.93%	55.67%	67.62%
Land	-	0.99%	1.40%	1.47%	0.99%	1.48%	1.36%	1.25%	2.16%	1.11%
					Midwest					
Lab	76.78%	64.50%	71.56%	67.29%	70.97%	63.46%	57.33%	60.09%	53.89%	32.51%
Cap	23.22%	34.49%	28.37%	32.52%	28.95%	36.06%	42.25%	39.65%	44.52%	66.15%
Land	-	1.01%	0.07%	0.18%	0.08%	0.48%	0.42%	0.26%	1.60%	1.34%
					Southeast					
Lab	80.67%	75.54%	75.16%	70.37%	70.49%	70.33%	68.52%	66.05%	59.32%	37.65%
Cap	19.33%	24.19%	24.80%	29.38%	29.29%	29.23%	31.15%	33.35%	40.01%	61.42%
Land	-	0.27%	0.04%	0.26%	0.22%	0.44%	0.32%	0.60%	0.67%	0.93%
					South					
Lab	61.12%	67.73%	70.97%	66.76%	61.91%	64.37%	58.86%	62.50%	56.63%	35.13%
Cap	38.88%	32.24%	28.67%	32.96%	37.67%	35.41%	40.88%	37.26%	42.92%	63.85%
Land	-	0.03%	0.36%	0.28%	0.42%	0.22%	0.26%	0.24%	0.45%	1.02%

Low-income families (F1) from the Northeast region receive 22.61% of total income from Bolsa Família Progam and 18.15% from other transfers. Families from the North region receive 16.78% of total income from the Bolsa Família Program and 12.25% from other transfers. In the Southeast region, the poorest families income depends on 7.14% from Bolsa Família and 5.84% from other transfers. Midwest and South families receive respectively 4.12% and 1.96% from Bolsa Família Program, 9.47% and 2.44% from other transfers.

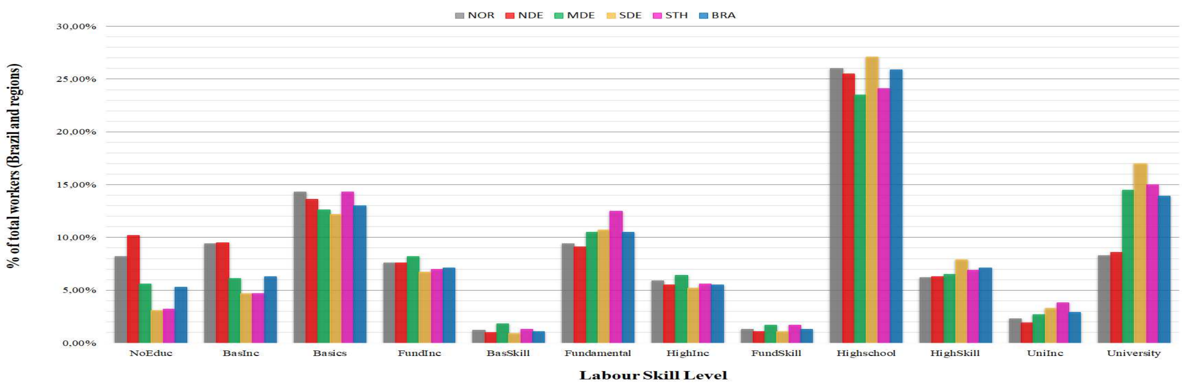
Isolating the primary factor's income, the ratio of labour on total income increases by 25.48% (representing 63.35% of total primary factor income) and capital by 16.06% (38.67% of total primary factor income) on first-income families in Northeast, followed by North regions families, with labour share increase by 19.18% (63.35% of primary factor income), and 11.08% on capital income (36.65% of total primary factors income). The shares in the other regions follow the same pattern, increasing the importance of the wage on poorest families on primary factors income. In the Southeast region, the high impact is due to the populational factor.

In all regions, it is clear that the higher the income class, the lower the significance of Programa Bolsa Família and social programs on total income. Another important fact to observe is that Brazilian families present an important portion of the total income from retirement. Moreover, the higher the income class, the higher the portion of capital on total primary factor income.

The presented data emphasize the importance of labour (wages) for poor families, and the importance of capital (rentals) for richer families. More than that, it is clear that Bolsa Família Program is well focussed on its aim, the poorest families, with greater impact in regions with a higher Gini index. In addition to explaining that, policies aimed at raising labour income and social programs would have more significant impacts on the poorest families.

4.2.1 The labour market

Figure 24 shows the workers labour skill in Brazil and regions.



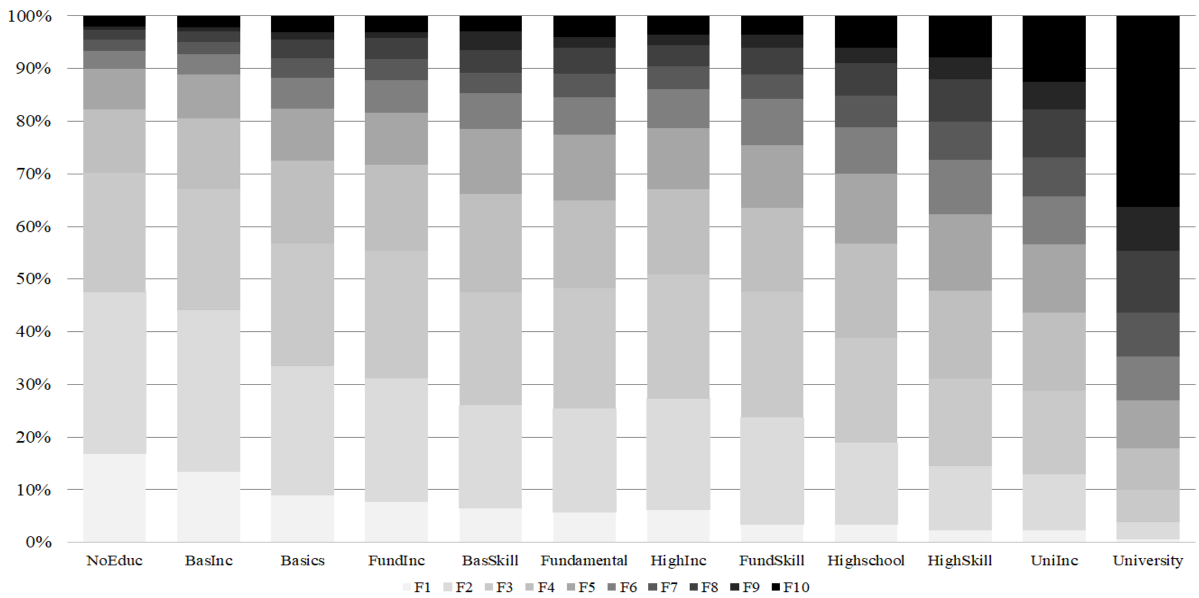
Where: **NoEduc** - No Instruction; **BasInc** - Incomplete Basic; **Basics** - Complete Basics; **FundInc** - Incomplete Fundamental; **BasSkill** - Qualified Basics; **Fundamental** - Complete Fundamental; **FundSkill** - Qualified Fundamental; **Highschool** - Complete High School; **HighSkill** - Qualified High School; **UniInc** - Incomplete University; **University** - Complete University;
NOR - North Region; **NDE** - Northeast Region; **COE** - Midwest Region; **SDE** - Southeast Region; **SUL** - South Region; **BRA** - Brazil

Figure 24 – Workers Skill Level - Regions

In Brazil, 26.43% of total workers, in the labour market, have completed High School. At this skill level, the regions are less unequal - region Midwest has 23.7% of total employers on High School level, South region has 24.9%; Northeast, 25.8%; North, 26.9%; and, Southeast, 27.7%. However, as shown in Figure 24, the educational level for families in Brazilian regions, is, in general, different.

Regions North and Northeast have the high part of workers on No Educated skill level, 8.40%, and 10.6% respectively. In contrast, Midwest, Southeast, and South have less than 6%, 5.8%, 3.2%, and 33%, respectively. The characteristic of the labour market for Incomplete Basic skilled workers is pretty similar: regions with a low Gini index present more unskilled people working. The opposite observed on the upper skill level, the higher the Gini index the most skilled worker. Skill level 5 - Skilled Basic - has 1.05% of total Brazilian workers on the labour market. Comparing the regions, it is clear that educational level is unequal.

In Figure 25 can be observed the skill difference among family classes. The darker the color the higher the income class. For aggregated Brazil, wealthier families have higher skill levels. Nonetheless, poor families completed low-skill levels mainly.



Where: **NoEduc** - No Instruction; **BasInc** - Incomplete Basic; **Basics** - Complete Basics; **FundInc** - Incomplete Fundamental; **BasSkill** - Qualified Basics; **Fundamental** - Complete Fundamental; **FundSkill** - Qualified Fundamental; **Highschool** - Complete High School; **HighSkill** - Qualified High School; **UniInc** - Incomplete University; **University** - Complete University;
F1 to **F10** are family income classes - the darker the color the higher the income class

Figure 25 – Workers Skill Level - Families Classes

Regarding the first income class, 16.12% of the total employed has no education; 44.99% with a maximum of Incomplete Fundamental, and only 20.90% above High School skill level. In the Northeast region, families in this income class have 19.87% of heads in the first level of education. In contrast, in the Southeast region, families in the same income class have just 10.% of total education from S1 (NoEduc)

The second income class has 9.55% of the total workforce on skill level S1 (No Educ); 11.20% on Incomplete Basics skill level; 18.33% on Basics Level, and just 2.64% on University degree. Among regions the qualification of this income class is different: the most educated F2 families are in the Southeast and South region, 3.41% and 3.13%. While in the Northeast region, 13.11% of families in the second income have no education.

From the third income class onwards the high qualified workers increase, but, slowly. Families from low-income classes present the most of workers on low skilled levels. At the extreme, on income class 10, 58% of total workers are on University degree. As expected, families from the 10th income class in the South, Southeast, and Midwest have more the 50% of total workers on the higher skill level. While North and Northeast regions have less than 50%.

Agriculture employs 17% of No Educated workers; 17% of Incomplete Basics; 24% of Basic Skilled; 8% of Incomplete Fundamental; 9% of Fundamental; 11% of High School; and 3.3% of Incomplete University and University skill. Regarding the technical courses, this sector employs 2% of Basic Trained workers(S5). Thus, it is clear that this sector is low-skilled-workers intensive i.e. employs, for the most part, workers in low-graduated-skill.

Regarding the industry, it employs 3% of No Educated workers; 5% of Incomplete Basics; 12% of Basic skill; 7% of Incomplete Fundamental; 11% of Fundamental; 31% of High School; and 14% of Incomplete University and University skill. Regarding the technical courses, this sector employs 1% of total workers of professionalizing course for workers graduated on the Basic level, and 9% of professionalizing course for high school graduated.

Regarding the service sector, it employs 4% of No Educated workers; 5% of Incomplete Basics; 12% of Basic skill; 7% of Incomplete Fundamental; 11% of Fundamental; 28% of High School degree, and; 16% of Incomplete University and University skill. Regarding the technical courses, this sector employs 1% of total workers from a vocational course for workers graduated on the Basic level, and 8% from vocational courses for high school graduates.

4.3 Impacts of skill improvement of Bolsa Família Program beneficiaries

This section will discuss the impacts of the workforce qualification on the Bolsa Família Program beneficiaries. At first, it is analyzed the impacts on factor market values. Both policies applied will increase labour in higher skill level. Thus, due to the low ESUSKL, it is reasonable to expect that the market labour price falls relative to other factors' prices, led by a huge decrease in labour prices of S5. However, it is important to observe that, the negative impact on labour prices related to other factors is led by the shock effect on S5 prices, and does not mean necessarily undesirable impacts on families wages once the analysis of the percentage change on factors must considered their value.

The percentage change in factor income in Brazilian regions can be observed in Table 7.

Table 7 – Impacts of Bolsa Família beneficiaries skill improvement in factor income changes

	BRA	NOR	NDE	MDE	SDE	STH
Basic Educated[1]						
Labour (%Δ)	0.885	0.898	1.047	0.707	0.872	0.897
Capital (%Δ)	0.529	0.962	0.071	0.671	0.551	0.622
Land (%Δ)	0.972	1.100	0.738	0.974	0.767	1.945
NatRes (%Δ)	1.461	2.100	3.453	-0.518	1.502	-0.253
GDP (%Δ)	0.734	0.968	0.567	0.695	0.753	0.754
Incomplete Fundamental[2]						
	BRA	**NOR**	**NDE**	**MDE**	**SDE**	**STH**
Labour (%Δ)	0.521	0.570	0.636	0.399	0.530	0.458
Capital (%Δ)	0.300	0.622	-0.051	0.373	0.332	0.348
Land (%Δ)	0.545	0.559	0.509	0.352	0.380	1.272
NatRes (%Δ)	0.870	1.391	2.350	-0.424	0.869	-0.267
GDP (%Δ)	0.734	0.968	0.567	0.695	0.753	0.754

Where: NOR – North region; NDE – Northeast region; MDE – Midwest region; SDE – Southeast region; STH – South region;
[1] – Improving labour qualification of workers from skill S3 (Complete Basic) to S5 (Qualified Basics) – first shock;
[2] – Improving labour qualification of workers from skill S4 (Incomplete Fundamental) to S5 (Qualified Basics) – second shock;

The movement of workers causes large wage increases for S3 and S4 and very large decreases for S5. On the other hand, the increase in effective skilled labour supply also causes real GDP on income side to rise in aggregated Brazil and all regions. The higher the worker quantity moving among different skills, the higher the impact on labour income concerning other factors. The number of families on Complete Basic educated (S3) skill level is higher than Incomplete Fundamental (S4) one. Thus, on the second shock (moving workers from S4 to S5) the impact on labour income is smaller than the first shock since the amount of effective skilled labour increases less. The changes on factor income is different among regions due to the different skill enhancement in each one.

Regarding the first simulation, the Northeast region increases effective labour by 3.38% and 1.047% on labour income. On the other hand, the Midwest region increases the effective labour by 1.40%, and 0.707% in labour value. In the second scenario, the pattern of the regions is the same. The effective labour increases 2.60% in Northeast, 2.20% on North, 1.43% on Southeast, 0.84% on Midwest and 0.81% on South. The percentage change in families factor income value[33] from factors emphasize that labour value are higher then other factors (see Appendix G) .

It is expected that the movement of workers from S3 (basic educated) and S4 (incomplete fundamental) to S5 (professionalizing course) leads to an increase in wages. The ESKL elasticity is set in a way to leads to large wages differences between low-skilled

[33] `VFACTINC(f,r)*wfactinc(f,r) = FCAP(f,r)*wfamcap(f,r) + FLND(f,r)*wfamland(f,r) + FWAGE(f,r)*wlabinc_s(f,r)`

and high-skilled workers. The higher the salary "gap" between skills the higher the price of labour increase. Table 8 shows the impacts on equilibrium labour prices.

It is important to emphasize that the worker's mobility between the different skills is exogenous (it occurs via shock). In this way, an increase in lower skills wage is an analogy for the transition of workers from these classes to the upper class. Since the model considers full employment, the necessary adjustment is a reduction in the wages of the upper class (this makes a higher salary possible for the lower levels of education. Furthermore, the magnitude of the wage reduction of the upper classes depends on the elasticity of substitution between different skills It is expected, due to the inelasticity of substitution between the different skills in the model, that the impact on the upper-income class (S5) will be significant.

Table 8 – Impacts of Skill improvement in market wage prices

						First Scneario						
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**
NOR	4.68	4.79	27.32	4.65	-84.03	4.39	3.80	4.47	3.39	4.30	4.50	3.78
NDE	5.56	5.10	34.83	5.44	-93.74	5.20	5.27	4.88	4.78	4.78	5.03	4.55
COE	2.32	2.16	12.88	2.15	-45.69	2.12	2.20	2.00	2.01	2.10	2.12	2.02
SDE	3.64	3.38	12.19	3.36	-62.57	3.29	3.25	3.72	3.20	3.12	3.16	3.14
SUL	2.88	3.05	9.83	2.56	-48.24	2.44	2.77	2.60	2.43	2.46	2.57	2.48
						Second Scneario						
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**
NOR	3.03	3.11	2.83	25.74	-64.28	2.82	2.42	2.90	2.13	2.77	2.91	2.4
NDE	3.69	3.35	2.84	34.38	-80.06	3.44	3.48	3.22	3.21	3.21	3.34	3.08
COE	1.38	1.26	1.28	11.94	-33.5	1.23	1.30	1.13	1.18	1.23	1.22	1.19
SDE	2.18	2.02	1.97	10.78	-43.12	1.95	1.92	2.23	1.90	1.84	1.87	1.86
SUL	1.44	1.50	1.29	8.36	-28.47	1.21	1.36	1.28	1.20	1.22	1.25	1.21

Where: NOR – North region; NDE – Northeast region; MDE – Midwest region; SDE – Southeast region; STH – South region;

[1] – Improving labour qualification of workers from skill S3 (Complete Basic) to S5 (Qualified Basics) – first shock;

[2] – Improving labour qualification of workers from skill S4 (Incomplete Fundamental) to S5 (Qualified Basics) – second shock;

It can be observed in Table 8 that the increase in basic educated wage prices due to a decrease in professionalizing training courses are higher than the increase in incomplete fundamental workers wage prices, as expected. The results corroborate with Diaz and Rosas (2016), Psacharopoulos and Patrinos (2018) also showing that families from most impoverished regions present higher impacts. As stated previously, both simulations increase the all effective labour on the economy. Thus, all other skills also present an increase in wage prices, but less than the focussed population (S3 and S4). The impact on sectors output depends on its skill-intensity once factors are inputs for production.

The database indicates that agriculture is a low-skilled-intensive sector, i.e. is most reliant on S3 and S4, that are now receiving higher wages due to the qualification. Thus, there will be a greater increase in expenses in agricultural sectors than manufacturing or services. In a "losers and winner" interpretation it is possible to argue that wage changes tend to be favourable to manufacturing and services at the expense of agriculture.

Thus winning sectors will increase the output, and the loser sectors must decrease it. Appendix G shows the changes in output and international trade. On the other hand, government consumption is service-intensive (which is a labour-intensive sector) and greater enough to change the path, increasing output in that sector. Families would maintain consumption even with an increase in output prices due to the satisfactory impacts on total income.

The wage earned by families in each income class (summed over sectors and skills) can be observed in Table 9.

Table 9 – Impacts on families labour income in Brazilian regions

	First Scenario[1]					*Second Scenario*[2]				
	NOR	**NDE**	**MDE**	**SDE**	**STH**	**NOR**	**NDE**	**MDE**	**SDE**	**STH**
	% ch	**% ch**	**% ch**	**% ch**	**% ch**	**% ch**	**% ch**	**% ch**	**% ch**	**% ch**
	US$bi	**US$bi**	**US$bi**	**US$bi**	**US$bi**	**US$bi**	**US$bi**	**US$bi**	**US$bi**	**US$bi**
F1	2.340	1.500	5.250	0.75	1.860	1.400	1.230	1.880	0.180	0.560
	0.009	0.013	0.008	0.008	0.006	0.005	0.011	0.003	0.002	0.002
F2	0.710	0.570	1.450	0.950	0.960	0.480	0.380	0.930	0.570	0.570
	0.014	0.0250	0.014	0.059	0.014	0.009	0.018	0.009	0.035	0.008
F3	0.840	0.290	1.150	0.500	0.700	0.930	0.260	0.680	0.430	0.390
	0.027	0.020	0.028	0.083	0.028	0.030	0.023	0.016	0.069	0.016
F4	-1.350	-0.510	0.310	0.500	0.380	-0.600	-0.230	0.220	0.230	0.220
	-0.070	-0.340	0.480	6.290	0.390	-0.060	-0.290	0.470	0.250	0.380
F5	1.450	-0.100	0.310	0.220	0.080	1.020	0.340	0.020	0.100	-0.07
	0.052	-0.017	0.013	0.071	0.007	0.036	0.034	0.001	0.033	-0.005
F6	0.420	-0.28	0.570	0.720	0.420	0.360	0.510	-0.480	0.490	0.210
	0.014	-0.031	0.031	0.227	0.046	0.012	0.044	-0.025	0.150	0.023
F7	3.350	0.990	1.040	-0.440	0.250	2.200	0.580	0.540	0.330	0.010
	0.078	0.073	0.043	-0.125	0.025	0.051	0.046	0.022	0.100	0.001
F8	4.200	4.54	0.890	-0.340	1.030	3.130	3.370	0.520	-0.20	1.060
	0.148	0.510	0.063	-0.195	0.208	0.110	0.386	0.037	-0.115	0.215
F9	-2.140	-2.02	2.840	3.230	2.010	-1.640	-2.470	1.060	2.050	0.960
	-0.061	-0.160	0.163	1.259	0.328	-0.047	-0.189	0.061	0.797	0.156
F10	-2.980	0.200	0.970	0.840	1.080	-1.300	-0.500	0.380	0.620	0.480
	-0.391	0.058	0.501	2.600	0.841	-0.171	-0.237	0.188	1.867	0.370

Where: NOR – North region; NDE – Northeast region; MDE – Midwest region; SDE – Southeast region; STH – South region;
[1] – Improving labour qualification of workers from skill S3 (Complete Basic) to S5 (Qualified Basics) – first shock;
[2] – Improving labour qualification of workers from skill S4 (Incomplete Fundamental) to S5 (Qualified Basics) – second shock;
The left column shows families income classes (F1 - F10); Each family has results presented in two rows: the top one is the percentage change on labour income summed over skill and commodities, the bottom one is the change in nominal US$bi

The impacts of labour qualification are positive in almost all families in Brazilian regions even not being uniformly distributed. In all regions, families until Income Class 3 have positive impacts, mainly in the Northeast and North. This is relevant because these families present greater importance of labour on total income formation. So, it will be helpful to guarantee consumption gains (that must be greater than transfers losses). As expected workers moving from skill class S3 will present higher impacts on labour prices. There is not a specific pattern for other income classes.

Families from richer income classes from Professionalized Skill (S5) are employed mainly in manufacturing, industry, and services. Those sectors are the "winners", less dependent on low-skill labour. Considering that these sectors pay less for workers on S3 and S4, compared to S5, there are no gains for workers. Thus, the wealthy families (but not just) will present negative impacts. However, those families total incomes are not mainly labour-dependent, thus, impacts on consumption would not be expressive.

It is important to note that the gains in percentage terms are relative to each income class. Therefore, a smaller percentage variation does not imply smaller gains in nominal prices. It is also important to note that the wage gain described here is summed over sectors and skills. So it is completed understandable for some isolated wages to be higher or lower. Nevertheless, the presented is sufficient to understand the importance of professional qualification for each income class, once the aggregated salary is what will matter for family total income (considering the labour factor).

The impact on families total income still depends on variations in the price of capital and land, and the relative importance of wages in total income formation. Furthermore, for the policies applied, gains on wages will reduce the transfers from Bolsa Família Program as well as increase income taxes. The total income changes in each family income due to improvement in labour skill class can be observed in Table 10.

Table 10 – Impacts of skill improvement combined with Bolsa Família withdraw on families total income

	First Scneario						*Second Scneario*				
	NOR	**NDE**	**MDE**	**SDE**	**STH**		**NOR**	**NDE**	**MDE**	**SDE**	**STH**
F1	1.515	0.865	3.668	0.723	1.349	**F1**	0.421	0.173	0.931	0.121	0.303
F2	0.811	0.556	1.048	0.818	0.832	**F2**	0.346	0.083	0.488	0.318	0.349
F3	0.869	0.432	0.921	0.588	0.699	**F3**	0.530	0.065	0.381	0.266	0.236
F4	0.286	0.145	0.505	0.583	0.549	**F4**	0.188	-0.075	0.185	0.177	0.175
F5	1.123	0.256	0.469	0.433	0.434	**F5**	0.663	0.094	0.093	0.126	0.062
F6	0.790	0.154	0.633	0.693	0.545	**F6**	0.470	-0.168	0.351	0.334	0.202
F7	1.789	0.592	0.853	0.063	0.463	**F7**	1.070	0.198	0.378	0.266	0.123
F8	2.107	1.734	0.772	0.120	0.845	**F8**	1.420	1.112	0.387	-0.009	0.652
F9	0.332	-0.459	1.700	1.867	1.292	**F9**	0.114	-0.821	0.660	1.091	0.578
F10	0.136	0.218	0.766	0.687	0.780	**F10**	0.196	-0.149	0.338	0.402	0.340

Where: NOR – North region; NDE – Northeast region; MDE – Midwest region; SDE – Southeast region; STH – South region;
[1] – Improving labour qualification of workers from skill S3 (Complete Basic) to S5 (Qualified Basics) – first shock;
[2] – Improving labour qualification of workers from skill S4 (Incomplete Fundamental) to S5 (Qualified Basics) – second shock;

It is expected that gains on families total income would be lower than the gains on labour income. This occurs because the families are not receiving transfers from Bolsa

Família anymore besides increases on income tax. The opposite is true, i.e. families that are receiving less income from labour will receive more income from Government. However, the impacts on richer income classes, in response to increasing on Bolsa Família transfers tend to be mild and also depend on other factors income.

Although the losses on transfers balance, the favourable impacts presented in Table 9 should be sustained considering the importance of labour on families total income. Another important highlight is to observe the income-change between labour and Bolsa Família Transfers. The reduction in families Bolsa Família transfer income in response to higher labour income can be observed in Appendix F, on shock design section.

Smaller percentage changes in labour income of the first income classes in almost all regions of the Basil, lead to greater impacts on factor income, in monetary terms. While the percentage variations of the Bolsa Família reduction are high, they result in lower monetary values. Labour has greater relative importance (compared to the factor itself) for the income of the poorest families. This result emphasizes that in fact policies on labour market will be an opportunity for the families to find an "exit door" from Social Programs.

For example, families from 1^{st} income class on North regions increase labour income by 2.34% (US$ 0.009bi) and transfers reductions by 3.60% (US$0.005bi); on Midwest regions the labour increase is 5.30% (US$0.008bi), and in Bolsa Família Program reduction is 24.2% (US$ 0.0101bi); in Southeast the relation is 0.78% (US$ 0.008bi) – labour and 4.04% (US$ 0.109bi); and, in South region is 1.88% (US$ 0.006bi) increase on labour and 24.10% (US$0.0106bi) on transfer reduction. The exeption is Northeast region with increases on labour income by 1.44% (US$0.013bi) and decreasing on Bolsa Família by 13.20% (US$0.073bi).

Even with the reduction in Government transfers to the families, the family's gains on labour market are sufficient to increase total income. Thus, even if the Program withdrawal is not gradual (i.e. a fully-reduction once), since these families are better skilled, would not negatively impact the beneficiary families. This is important to ensure the "income replacement" time. The desirable results on families income will be reflected in consumption, as the model considers the total families expenditures guided by families total income. The impact of skill improvement on total consumption can be observed in Table 11.

Table 11 – Impacts on families welfare in Brazilian regions

	First Scenario[1]					*Second Scenario*[2]				
	NOR	**NDE**	**MDE**	**SDE**	**STH**	**NOR**	**NDE**	**MDE**	**SDE**	**STH**
	% ch US$bi	**% ch US$bi**	**% ch US$bi**	**% ch US$bi**	**% ch US$bi**	**% ch US$bi**	**% ch US$bi**	**% ch US$bi**	**% ch US$bi**	**% ch US$bi**
F1	1.515%	0.865%	3.668%	0.723%	1.349%	0.421%	0.173%	0.931%	0.121%	0.303%
	0.083	0.182	0.191	0.032	0.082	0.023	0.018	0.013	0.009	0.007
F2	0.811%	0.556%	1.048%	0.818%	0.832%	0.346%	0.083%	0.488%	0.318%	0.349%
	0.182	0.344	0.144	0.715	0.183	0.077	0.051	0.067	0.277	0.077
F3	0.869%	0.432%	0.921%	0.588%	0.699%	0.530%	0.065%	0.381%	0.266%	0.236%
	0.191	0.261	0.199	0.903	0.311	0.117	0.039	0.082	0.409	0.105
F4	0.286%	0.145%	0.505%	0.583%	0.549%	0.188%	-0.075%	0.185%	0.177%	0.175%
	0.03	0.04	0.08	0.54	0.17	0.021	-0.022	0.028	0.165	0.053
F5	1.123%	0.256%	0.469%	0.433%	0.434%	0.663%	0.094%	0.093%	0.126%	0.062%
	0.011	0.003	0.005	0.004	0.004	0.048	0.020	0.011	0.108	0.016
F6	0.790%	0.154%	0.633%	0.693%	0.545%	0.470%	-0.168%	0.351%	0.334%	0.202%
	0.082	0.054	0.055	0.373	0.115	0.026	-0.030	0.047	0.298	0.054
F7	1.789%	0.592%	0.853%	0.063%	0.463%	1.070%	0.198%	0.378%	0.266%	0.123%
	0.124	0.065	0.080	0.037	0.106	0.074	0.022	0.035	0.157	0.028
F8	2.107%	1.734%	0.772%	0.120%	0.845%	1.420%	1.112%	0.387%	-0.009%	0.652%
	0.115	0.321	0.136	0.107	0.260	0.078	0.206	0.068	-0.008	0.201
F9	0.332%	-0.459%	1.700%	1.867%	1.292%	0.114%	-0.821%	0.660%	1.091%	0.578%
	0.019	-0.057	0.152	1.563	0.299	0.007	-0.101	0.059	0.913	0.134
F10	0.136%	0.218%	0.766%	0.687%	0.780%	0.196%	-0.149%	0.338%	0.402%	0.340%
	0.026	0.134	0.627	2.838	0.800	0.037	-0.091	0.277	1.660	0.349
Total	0.808%	0.421%	0.825%	0.667%	0.729%	0.457%	0.036%	0.353%	0.343%	0.309%
	0.898	1.281	1.604	7.747	2.418	0.508	0.110	0.687	3.987	1.024

Where: NOR – North region; NDE – Northeast region; MDE – Midwest region; SDE – Southeast region; STH – South region;
[1] – Improving labour qualification of workers from skill S3 (Complete Basic) to S5 (Qualified Basics) – first shock;
[2] – Improving labour qualification of workers from skill S4 (Incomplete Fundamental) to S5 (Qualified Basics) – second shock;
The left column shows families income classes (F1 - F10); Each family has results presented in two rows: the top one is the percentage change on labour income summed over skill and commodities, the bottom one is the change in nominal US$bi

It can be observed that, following the increase in income, families present important results on aggregated consumption as well. The magnitude, however, is low in percentage change terms, reaching a maximum of 3.688% for 1^{st} income class on Northeast. The results for all regions are showing that even with the reduction in total income due to reduction in transfer and increase in direct tax payment. Thus, the impact on consumption on beneficiary's families is favourable. The first scenario results are also greater than the second scenario, due to higher wages between Trained workers and Basic Educated ones.

The aggregated consumption represents the private consumption on Gross Domestic Consumption. Both scenarios increase the aggregated consumption (in GDP) in all regions. Regarding the first scenarios (skill improvement for S3 workers) the impacts are: 0.808% (US$0.898bi) for North; 0,421% (US$1.281bi) for Northeast; 0.825% (US$1.604bi) for Midwest; 0.667% (US$7.747bi) for Southeast; and, 0.729% (US$2.418bi). Regarding the second scenario (skill improvement for S4 workers) the impacts on aggregate private consumption on GDP are: 0.457% (US$0.508bi) for North; 0.036% (US$0.1101bi) for Northeast; 0.353% (US$0.687bi) for Midwest; 0.343% (US$3.987bi) for Southeast; and, 0.309% (US$1.024bi).

After understanding the policy's effects on families, it is important to analyze the effects on Government accounts, presented in Table 12. The public account table is divided into expenses into goods and transfers to the families (Bolsa Família, other social programs, Other Transfers, Public Retirement, and Income Tax Refund) and also the income (indirect tax and income tax) received from families. It is desirable that an increase in government expends (on goods, including services and education) to be covered by gains on income via indirect tax and income tax, besides the relief generated by reduction on Programa Bolsa Família transfers to the families.

It can be observed in Table 12 that, comparing all regions, South Government spends the higher share on goods, US$ 48.74bi (59.81%). The Government from the Northeast region spends US$ 94.242bi (66.19%) of total spending on transfers to families. All governments spend most of the transfers on Public Retirement. Regarding the expenses with Bolsa Família, Northeast (6.40%) and North (4.51%) of total transfers on the Program.

Regarding the spending on education, the Government expends follows the total Brazil pattern. That is, in all regions, the education expenses are 16.90% of the service sector. The percentages are shown below the US$ bi. are the share of education spends on total Government spend on goods. However, the proportion of spending on education on total government consumption on goods changes between the different regions.

Table 12 – Government accounts in Brazilian regions – before shocks

Government Expenses							
	SECTORS	**TRANSFERS**					
Region	Total (%)	Total (%)	PBF (%)	OTHS (%)	OTHT (%)	PBRT (%)	ITAXR (%)
North	16.670 (50.11)	16.600 (49.89)	1.062 (6.40)	0.937 (5.64)	3.086 (18.59)	11.337 (68.30)	0.179 (1.08)
Northeast	48.241 (33.81)	94.424 (66.19)	4.254 (4.51)	4.79 (5.07)	12.129 (12.85)	71.242 (75.45)	2.008 (2.13)
Midwest	29.286 (49.04)	28.177 (50.96)	0.311 (1.10)	0.863 (3.06)	4.446 (15.78)	21.096 (74.87)	1.461 (5.19)
Southeast	171.561 (54.60)	206.324 (45.40)	1.533 (0.74)	3.625 (1.76)	27.298 (13.23)	167.7 (81.28)	6.167 (2.99)
South	48.745 (59.81)	72.547 (40.19)	0.349 (0.48)	0.836 (1.15)	8.102 (11.17)	61.165 (84.31)	2.096 (2.89)

where:
Educ - Government expends on Education; % indicates spends on Government total spend in each region
PBF - Bolsa Família Program; OTHS - Other Social Programs; OTHT - Other Transfers; PBRT - Private Retirement; ITAXR - Income Tax Refund

The government behavior assumption on applied policies is important to understand the impact on its accounts. There is no "extra increase" in consumption, but the government

Government Income					
Region	**North**	**Northeast**	**Midwest**	**Southeast**	**South**
Indirect Tax	27.52	76.12	58.96	370.95	115.03
(%)	(92.24)	(92.24)	(89.33)	(92.53)	(92.35)
Income Tax	2.31	8.39	7.04	29.94	9.53
(%)	(7.76)	(7.76)	(10.67)	(7.47)	(7.65)

where:
Indirect Tax = Government Cons. Tax + Private Cons. Tax + Firms Intermediate Cons. + Firms Primary Factor Usage Tax + Export Tax + Import Tax
Income Tax = Tax on families all income tax

consumption also increases in response to new prices – thus, consumption in educational sectors. On the other hand, ceasing transfers to the families would represent positive impacts on consumption (however, the government consumption is residual on GDP). Moreover, families will pay more tax on consumption and direct taxes to the government due to higher wages received in the labour market.

The public service increases consumption in all regions. In the second scenario, the Government increased consumption of goods by 2.93% in the North region; 2.15% in the Northeast region; 3.14 % in the Midwest region; 2.69% in the Southeast region; and, 2.88% in the South region. The government also increase the collects on indirect taxes by 0.58% in North; 0.53% in Northeast; 0.37% on Midwest; 0.51 % on Southeast; and, 0.39% on South region. Income taxes increase in all regions as well, the exception is Northeast (-0.04%). The transfers to families through Bolsa Família decrease in all regions: -0.073% on North; -0.016% on Northeast; -0.013% on Midwest; -0.005% on Midwest; and, -0.005% on South.

Regarding the first scenario, the Government increased consumption of goods by 2.27% in the North region; 1.66% in the Northeast region; 2.39 % in the Midwest region; 2.15% in the Southeast region; and, 2.29% in the South region. The increase on indirect taxes collection are: 0.94% in North; 0.93% in Northeast; 0.72% on Midwest; 0.86 % on Southeast; and, 0.76% on South region. Income taxes increase in all regions as well. The transfers to families through Bolsa Família decrease in all regions: -0.089% on North; -0.017% on Northeast; -0.028% on Midwest; -0.009% on Midwest; and, -0.010% on South.

The skill enhancement will also increase the regional GDP in both scenarios. However, since the first scenario presents higher income gains, it will present better impacts on GDP. On first simulation, the percentage change on GDP is: 0.95% on North region; 0.50% on Northeast region; 0.72% on Midwest region; 0.75% on Southeast region; and, 0.74% on South region. While the GDP impacts on second scenario are: 0.61% on North region; 0.29% on Northeast region; 0.37% on Midwest region; 0.45% on Southeast; and, 0.39% on South region.

5 FINAL REMARKS

The general objective of this study was to assess the economic impacts of a skill improvement policy via professionalizing courses for Bolsa Família beneficiary families in Brazilian regions. To achieve the objective was applied a general equilibrium model (DAYANE model), which presents several skill levels and families income classes for Brazilian regions. In general, this Thesis showed how the increase in human capital positively impacts society as a whole and the beneficiaries of a cash transfer program, allowing them to exit the program.

Some assumptions must be taken into account to understand (and make reasonable) results. The assumptions are most related to labour market issues. It is considered employed (both in the formal and informal market) heads of families, once the model does not model unemployment. More than that we considered that the skilled worker would not lose the job due to a better qualification and the sector will pay for a higher new wage.

The hypothesis of improvement in Bolsa Família families beneficiaries consumption and income are accepted. Also, the effects tend to be lasting, as the value of labour factor increases in all regions, and it is the main income source for the poorest families. The results suggest that skill improvement increases families income. The impacts are higher in a scenario where the salary "gap" is larger. That is, the workers qualification from lower skill levels have higher wage gains, as expected, and heavily state in literature. However, sectors that are low-skill-intensive (like agriculture) will decrease the output due to an increase in the price of the main productive factor.

There is also clear evidence that skill improvement reduces families dependence on Bolsa Família Program in the long term. More than that, it is clear that the better wages on labour market are enough to ensure the withdrawal of transfers, proportionally to increase on labour income, once even with transfers reduction, the higher wages ensure better economic conditions to the families . Regarding families consumption and welfare, it was observed desirable impacts. Albeit the results in the poorest families could be better since the industries in the sectors that these families consume relatively more are precisely the ones that most reduce their supply.

Future researches would investigate alternatives to alleviate the impacts on industries production. Furthermore, another suggestion relies on upon introduce mechanisms to allow families to move among classes and model poverty line as well, once the model is not prepared to apply such kind of simulation. The model is capable of simulating various social policies, including emergency aid due to COVID-19 in Brazil. However, by assuming that this program is not intended only for beneficiaries of the Bolsa Família Program (the object of research in the thesis), it was decided not to simulate it. Thus, it would be also relevant studies in this sense.

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APPENDIX

APPENDIX A – Bolsa Família Program adjustments and changes

Table A.1 – Adjustments and changes in Bolsa Família Program

Year	Adjustments	Benefit Design
2003	**OCTOBER** Creation of the Bolsa Família Program with two lines of eligibility referred to, but not linked to, the values of 1/4 and 1/2 minimum wage (R$ 200 at the beginning of 2003) of family income per capita, with a basic benefit only for the extremely poor families, and another variable per child from 0 to 15 years old, up to a limit of 3 children	*Extreme Poverty Line:* income up to R$ 50 Basic: R$ 50 Children[1] : R$ 15 to R$ 45 *Poverty Line:* income from R$ 50 to R$ 100 Children: R$ 15 to R$ 45
2006	**APRIL** First readjustment of the value of eligibility lines, without change in benefit	*Extreme Poverty:* income up to R$ 60 Basic: R$ 50 Children: R$ 15 to R$ 45 *Poverty Line:* income from R$ 60 to R$ 120 Children: R$ 15 to R$ 45
2007	**JULY** Benefits are readjusted **DECEMBER** First change in benefit design, with the creation of benefit for up to 2 benefits for 16 and 17 year old	*Extreme Poverty:* income up to R$ 60 Basic:R$ 58 Children: R$ 18 to R$ 54 Youth: R$30 to R$60 *Poverty Line:* income from R$ 60 to R$ 120 Children: R$ 18 to R$ 54 Youth: R$ 30 to R$ 60
2008	**JUNE** Basic benefits are readjusted	*Extreme Poverty:* income up to R$60 Basic: R$62 Children: R$20 to R$60 Youth: R$30 to R$60 *Poverty Line:* income from R$ 60 to R$ 120 Children: R$ 20 to R$ 60 Youth: R$ 30 to R$ 60
2009	**APRIL** The lines are readjusted to R$ 69 and R$ 137 **JULY** The eligibility lines are readjusted again to the values in effect until at least the end of 2012	*Extreme Poverty:* income up to R$ 70 Basic: R$ 68 Children: R$ 22 to R$ 66 Youth: R$ 33 to R$ 66 *Poverty Line:* income from R$70 to R$140 Children: R$22 to R$66 Youth: R$33 to R$66
2011	**MARCH** The benefits are readjusted and the second change in the design of benefits occurs, with the expansion of the limit from 3 to 5 children **JUNE** The second change in the design of variable benefits occurs, with the expansion of the limit from 3 to 5 children	*Extreme Poverty:* income up to R$ 70 Basic: R$ 70 Children: R$ 32 to R$ 160 Youth: R$38 to R$ 76 *Poverty Line:* income from R$ 70 to R$ 140 Children: R$ 32 to R$ 160 Youth: R$ 38 to R$ 76

Table A.1 – Adjustments and changes in Bolsa Família Program (continue...)

Year	Adjustments	Benefit Design
2012	**MAY** The per capita transfer is introduced in the form of the benefit to overcome extreme poverty, for families with at least one child from 0 to 6 years old who, after receiving Bolsa Família, remained extremely poor. **NOVEMBER** The redefinition of the age range of children from 0 to 15 years old is announced for receiving the Benefit for Overcoming Extreme Poverty (BSP)	*With Children from 0 to 15 years* *Extreme Poverty Line:* income up to R$ 70 Basic: R$ 70 Children: R$ 32 to R$ 160 Youth: R$ 38 to R$ 76 BSP: remaining per capita gap *No children from 0 to 15 years* *Extreme Poverty Line:* income up to R$ 70 Basic: R$ 70 Youth: R$ 38 to R$ 76 *With or without children* *Poverty Line:* income from R$ 70 to R$ 140 Children: R$ 32 to R$ 160 Youth: R$ 38 to R$ 76
2013	**MARCH** Extension of the Benefit to Overcome Extreme Poverty for all families who, after receiving the Bolsa Família, remained extremely poor	*Extreme Poverty:* income up to R$ 70 Basic: R$ 70 Children: R$ 32 to R$ 160 Youth: R$ 38 to R$ 76 BSP: remaining per capita gap *Poverty Line:* income from R$ 70 to R$ 140 Children: R$ 32 to R$ 160 Youth: R$ 38 to R$ 76
2014	**JUNE** Readjustment of eligibility lines and of benefit values	*Extreme Poverty:* income up to R$ 77 Basic: R$ 77 Children: R$ 35 to R$ 175 Youth: R$ 42 to R$ 84 BSP: remaining per capita gap *Poverty Line:* income from R$ 77 to R$ 154 Children: R$ 35 to R$ 175 Youth: R$ 42 to R$ 84
2016	**JULY** Readjustment of eligibility lines and of benefit values	*Extreme Poverty:* income up to R$ 85 Basic: R$ 85 Children: R$ 39 to R$ 195 Youth: R$ 46 to R$ 92 BSP: remaining per capita gap *Poverty Line:* income from R$ 85 to R$ 170 Children: R$ 39 to R$ 195 Youth: R$ 46 to R$ 92
2018	**JULY** Readjustment of eligibility lines and of benefit values	*Extreme Poverty:* income up to R$ 89 Basic: R$ 89 Children: R$ 41 to R$ 205 Youth: R$ 48 to R$ 96 BSP: remaining per capita gap *Poverty Line:* income from R$ 89 to R$ 178 Children: R$ 41 to R$ 205 Youth: R$ 48 to R$ 96

Table A.1 – Adjustments and changes in Bolsa Família Program (continue...)

Year	Adjustments	Benefit Design
2019	**APRIL** he Christmas bonus for the Program beneficiaries is approved	*Extreme Poverty:* income up to R$89 Basic: R$89 Children: R$41 to R$205 Youth: R$48 to R$96 BSP: remaining per capita gap *Poverty Line:* income from R$89 to R$178 Children: R$41 to R$205 Youth: R$48 to R$96 `Christmas bonus:` it is the same amount as the instalment received by the family in December (for all beneficiaries)

[1] benefits for pregnant women and nursing mothers are included, categories that, although foreseen since the beginning of Bolsa Família, only began to be paid in 2011
Source: MDS, 2021

During the COVID – 19 pandemic situation, the Brazilian Government has chosen to consider all Family Grants eligible to receive the Emergency Pandemic Aid, since April 2020. It was a benefit granted by the Federal Government for informal workers, individual micro-entrepreneurs, self -employed and unemployed. The benefit was aimed at providing emergency protection in the period of facing the economic crisis. The first action was to transfer R$600.00 in five transfers. Latter, the Government expanded the benefit but reduced the value, for R$300,00 until December.

The Bolsa Família beneficiaries were included in a special way. If the value received from the Program was less than R$ 300,00, the families would receive the Emergency Aid, otherwise (if the value of the Program was more than the Emergency Aid) the family would receive the Bolsa Família transfer. Women heads of families had the right to receive two quotes from the Emergency Aid (tow quotes of R$600.00, a total of R$1200.00). The emergency Aid was renewed for 2021. There are three types of transfer, according to the family size:

- If the family consists of only one person, the benefit is R$ 150.00 per month;
- If the family consists of more than one person, the benefit is R$ 250.00 per month;
- If the family is headed by a woman without a spouse or partner, with at least one person under the age of eighteen, they will receive R$ 375 monthly.

Up to four installments will be made available, as long as the family continues to meet the Aid selection criteria. There are planning to change the present Benefit Design, in 2021.

APPENDIX B – Database treatment

B.1 Matching the databases

At first it is important to consider the characteristics of the insertion in the labor market of the heads of families who receive the Bolsa Família Program. This is important when trying to decide between the types of work considered in the labor market breakdown in the DAYANE model. Figure B.1 shows the participation of heads of households who receive transfers from the Bolsa Família Program.

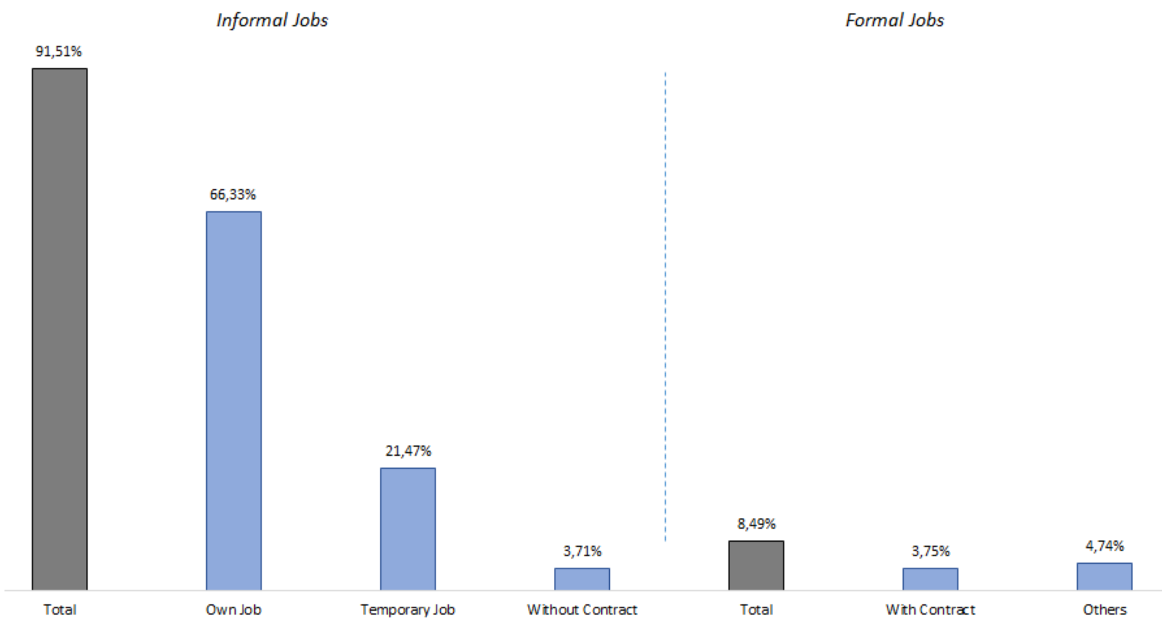

Figure B.1 – Heads of Bolsa Família's families labour market participation
Source: CECAD 2.0 (2021)

It is possible to observe that the largest share of heads of families dependent on the Bolsa Família Program is in the informal labor market, 91.51 with 66.33% being self-employed (and small jobs); 21.47% are temporary workers; 3.71% are workers without a formal employment contract. Only 8.49% of the heads of families who receive transfers from the Bolsa Família Program who are in the labor market is in the formal market, and only 3.75% have a formal employment contract. These data express the importance of considering the two labor markets (formal and informal) in the database of research that aims to analyze families dependent on such a program.

Later, it is necessary to pay attention to the salary range of families. This is an important step, because, as these are low-income families, the lower limit of income classes must match the salary ranges of families that depend on government transfers via Bolsa Família. Figure B.2 shows the salary classification of families receiving the Bolsa Família Program.

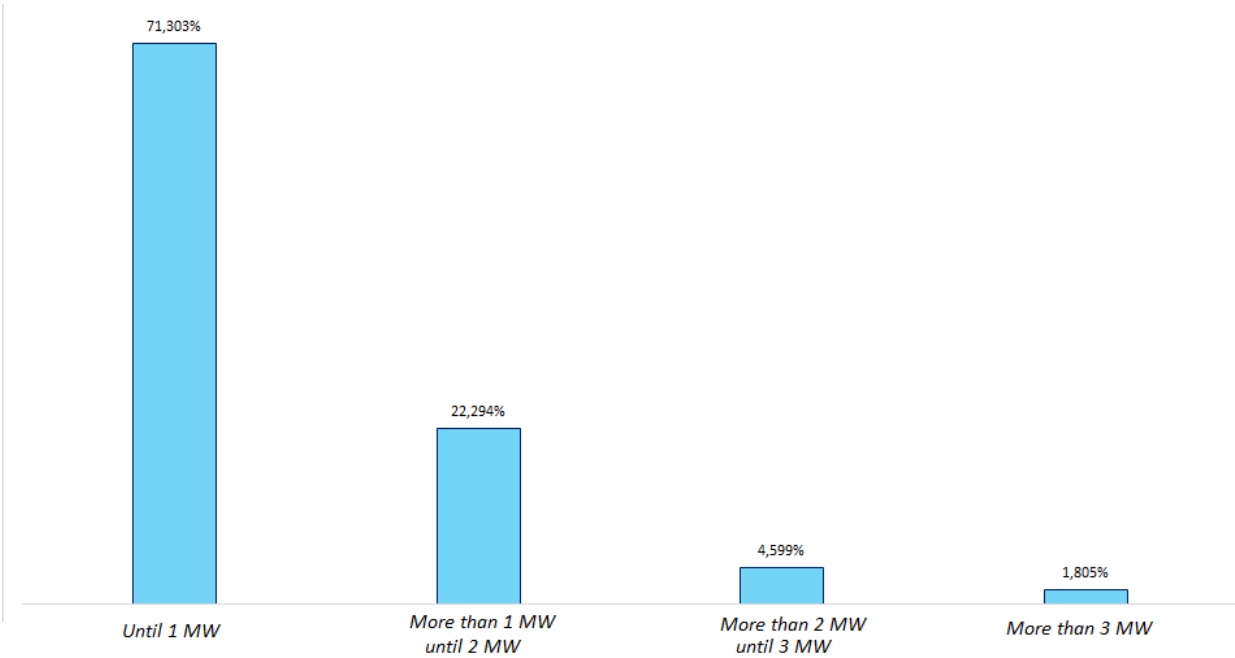

Figure B.2 – Bolsa Família's family heads wage category
Source: CECAD 2.0 (2021)

It is possible to observe that most of the families (93.59%) that depend on the Bolsa Família Program receive up to two minimum wages, and the minority part (6.41%) of the families receive more than two minimum wages . In this way, the lower-income classes of the model must fit with the income levels received by the heads of families, since these families are the most relevant for the analysis proposed in the thesis.

B.2 Making the DAYANE database compatible with PAEG

Once discussed and defined the categories of work and salary to be considered in the research, we can now understand how to make the PAEG base compatible (read in GAMS) with the DAYANE model (read in GEMPACK).

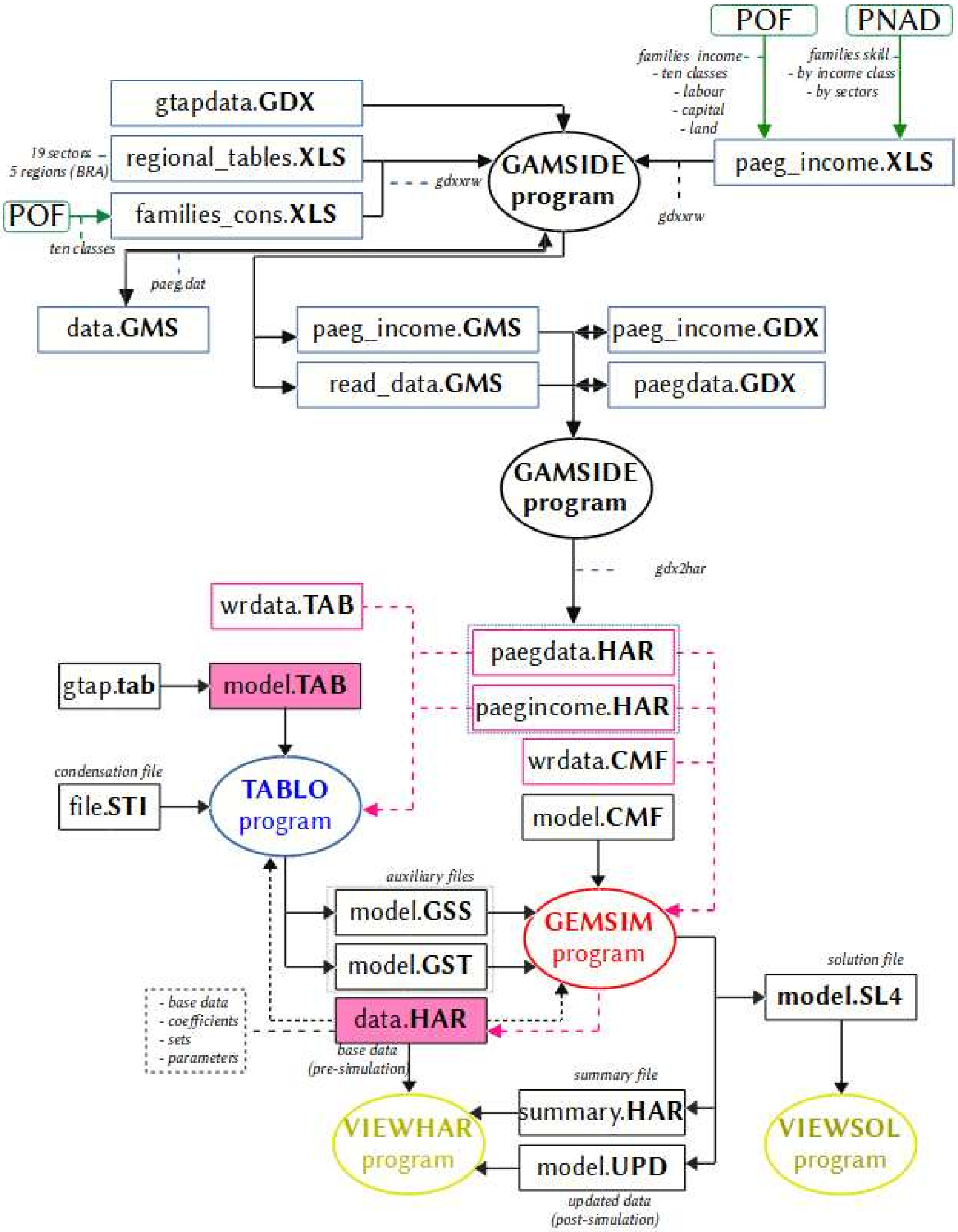

Figure B.3 – Making the DAYANE database compatible with PAEG

Family consumption and income data (income from the factors: capital, land, and work), in both models, come from the Family Budget Survey (IBGE, 2020). The files of different qualifications, in the DAYANE model, come from the National Household Sample Survey IBGE (2014). The basic difference is that the PAEG model considers the standard version of the GTAP model, disaggregating the skilled and unskilled labor factor, while the model exposed here considers 12 different levels of qualification.

Files in .xls format (regional_tables; paeg_income; families_cons) are combined with the GTAP database (gtapdata.gdx) to create the disaggregated database for Brazilian regions, using the paeg.dat, data.gms, read_data.gms, and paeg files _income.gms. At the end of the first round of data adaptation, we will have the base of the standard PAEG model, with the paegdata.gdx files, in addition to paeg_income.gdx, with the disaggregated market data, to be used in the new model database DAYANE.

After obtaining the scaled GTAP data for the Brazilian regions, as is done in the standard form of PAEG, it is necessary to read the files in .HAR format, since the DAYANE model uses GEMPACK. This conversion is done using the program gdx2har[1]. Other details that differ between the two models, such as branded prices, are specified in the wrdata.tab file, using the paegdata.har and paegincome.har files. After reading the .har files, using wrdata.tab and wrdata.cmf, we will have the data.har file, where all the data (database, coefficients, sets, parameters) will supply the DAYANE model, which is written based on the gtap.tap template.

B.3 Agent's Values

```
      !  Reading FLOWS from PAEGDATA !
Coefficient
# Private Households domestic purchases at market prices #;
(all,c,COMM)(all,r,REG) VDPM(c,r);
# Private Households imports at market prices #
(all,c,COMM)(all,r,REG) VIPM(c,r);
# Government domestic purchases at market prices #
(all,c,COMM)(all,r,REG) VDGM(c,r);
# Government imports at market prices #
(all,c,COMM)(all,r,REG) VIGM(c,r);
# Endowment - Firm‘s purchases at mrkt prices #
(all,e,ENDW)(all,c,COMM)(all,r,REG) VFM0(e,c,r);
(all,e,ENDW)(all,c,ACTS)(all,r,REG) VFM1(e,c,r);
# Intermediates - Firm’s domestic purchases at market prices #
(all,c,COMM)(all,a,ACTS)(all,r,REG) VDFM(c,a,r);
# Intermediates - Firm’s imports at market prices #
(all,c,COMM)(all,a,ACTS)(all,r,REG) VIFM(c,a,r);
# Trade - Bilateral exports at market prices #
(all,c,COMM)(all,r,REG)(all,a,REG) VXMD(c,r,a);
# Trade - Exports for international transport #
(all,m,MARG)(all,r,REG) VSTnbr(m,r);
# Trade - Value of Transport Services #
(all,m,MARG)(all,c,COMM)(all,r,REG)(all,a,REG) VTWR(m,c,r,a);
```

[1] see: https://www.copsmodels.com/gp-gams.htm

```
# Trade - Regional supply of inter-regional trnsport srvcs #
(all,m,MARG)(all,i,RBRA) VSTBR(m,i);
# Trade - Exports for international transport #
(all,m,MARG)(all,r,REG) VST(m,r);
Read
VDPM from file INFILE header "VDPM";
VIPM from file INFILE header "VIPM";
VDGM from file INFILE header "VDGM";
VIGM from file INFILE header "VIGM";
VFMO from file INFILE header "VFM";
VDFM from file INFILE header "VDFM";
VIFM from file INFILE header "VIFM";
VXMD from file INFILE header "VXMD";
VSTnbr from file INFILE header "VST";
VTWR from file INFILE header "VTWR";
VSTBR from file INFILE header "VSTB";

Formula
(all,m,MARG)(all,r,REG) VST(m,r) = VSTnbr(m,r);
(all,m,MARG)(all,r,RBRA) VST(m,r) = VSTnbr(m,r) + VSTBR(m,r);

      !  Reading TAXES from PAEGDATA !
Coefficient
# Primary factor tax rates by industry #
(all,e,ENDW)(all,c,COMM)(all,r,REG) RTF(e,c,r);
# Private domestic consumption rates #
(all,c,COMM)(all,r,REG) RTPD(c,r);
# Private imports consumption rates #
(all,c,COMM)(all,r,REG) RTPI(c,r);
# Government domestic rates #
(all,c,COMM)(all,r,REG) RTGD(c,r);
# Government import tax rates #
(all,c,COMM)(all,r,REG) RTGI(c,r);
# Firms domestic rates #
(all,c,COMM)(all,a,ACTS)(all,r,REG) RTFD(c,a,r);
# Firms imports rates #
(all,c,COMM)(all,a,ACTS)(all,r,REG) RTFI(c,a,r);
# Exports subsidy rates #
(all,c,COMM)(all,r,REG)(all,s,REG) RTXS(c,r,s);
# Imports rates #
(all,c,COMM)(all,r,REG)(all,s,REG) RTMS(c,r,s);
Read
```

```
RTF from file INFILE header "RTF";
RTPD from file INFILE header "RTPD";
RTPI from file INFILE header "RTPI";
RTGD from file INFILE header "RTGD";
RTGI from file INFILE header "RTGI";
RTFD from file INFILE header "RTFD";
RTFI from file INFILE header "RTFI";
RTXS from file INFILE header "RTXS";
RTMS from file INFILE header "RTMS";
```

```
    ! Calculating the AGENT PRICES !
Formula
! Firms - Domestic Purchase - AgentPrice !
(all,t,COMM)(all,p,ACTS)(all,r,REG) VDFA(t,p,r) = VDFM(t,p,r)*[1+RTFD(t,p,r)];
! Firms - Imported Purchase - AgentPrice !
(all,t,COMM)(all,p,ACTS)(all,r,REG) VIFA(t,p,r) = VIFM(t,p,r)*[1+RTFI(t,p,r)];
! Government - Domestic Purchase - AgentPrice !
(all,t,COMM)(all,r,REG) VDGA(t,r) = VDGM(t,r)*[1+RTGD(t,r)];
! Government - Imported Purchase - AgentPrice !
(all,t,COMM)(all,r,REG) VIGA(t,r) = VIGM(t,r)*[1+RTGI(t,r)];
! PrivateAgent - Domestic Purchase - AgentPrice !
(all,t,COMM)(all,r,REG) VDPA(t,r) = VDPM(t,r)*[1+RTPD(t,r)];
! PrivateAgent - Imported Purchase - AgentPrice !
(all,t,COMM)(all,r,REG) VIPA(t,r) = VIPM(t,r)*[1+RTPI(t,r)];
! Trade - Bilateral Exports - WORLD price !
(all,t,COMM)(all,r,REG)(all,a,REG) VXWD(t,r,a) = VXMD(t,r,a)*[1-RTXS(t,r,a)];
! Trade - Imports = Exports + Transports - WORLD Price !
(all,t,COMM)(all,r,REG)(all,a,REG) VIWS(t,r,a) = VXWD(t,r,a)
                                               + sum{m,MARG,VTWR(m,t,r,a)};
! Trade - Imports Market Prices !
(all,t,COMM)(all,r,REG)(all,a,REG) VIMS(t,r,a) = VIWS(t,r,a)*[1+RTMS(t,r,a)];

Formula
! Endowment - Firm‘s Purchase - AgentPrice !
(all,e,ENDW)(all,p,COMM)(all,r,REG) VFM1(e,p,r) = 0.0;
(all,e,ENDW)(all,p,ACTS)(all,r,REG) EVFA1(e,p,r) = 0.0;
(all,e,ENDW)(all,p,COMM)(all,r,REG) VFM1(e,p,r) = VFM0(e,p,r);
(all,e,ENDW)(all,p,COMM)(all,r,REG) EVFA1(e,p,r) = VFM0(e,p,r)*[1+RTF(e,p,r)];
Coefficient
(all,e,ENDWX)(all,c,ACTS)(all,r,REG) VFM(e,c,r) # Endowment - Firm‘s purchases at
mrkt prices what households get #;
(all,e,ENDWX)(all,p,ACTS)(all,r,REG) EVFA(e,p,r) # Agents price - What firms pay
#;
(all,e,ENDWX)(all,r,REG) EVOA(e,r) # Endowments - Output at Agents’ Prices #;
Formula
(all,p,ACTS)(all,r,REG) EVFA("lab",p,r) = EVFA1("lab",p,r) + EVFA1("skl",p,r);
(all,p,ACTS)(all,r,REG) EVFA("capital",p,r) = EVFA1("cap",p,r);
(all,p,ACTS)(all,r,REG) EVFA("land",p,r) = EVFA1("lnd",p,r);
(all,p,ACTS)(all,r,REG) EVFA("natres",p,r) = EVFA1("res",p,r);
(all,p,ACTS)(all,r,REG) VFM("lab",p,r) = VFM1("lab",p,r)+VFM1("skl",p,r);
(all,p,ACTS)(all,r,REG) VFM("capital",p,r) = VFM1("cap",p,r);
(all,p,ACTS)(all,r,REG) VFM("land",p,r) = VFM1("lnd",p,r);
```

```
(all,p,ACTS)(all,r,REG) VFM("natres",p,r) = VFM1("res",p,r);
(all,e,ENDWX)(all,r,REG) EVOA(e,r) = sump,ACTS, VFM(e,p,r);
```

APPENDIX C – Structure of economic activity in Brazil

Table C.1 – Structure of economic activity in Brazil

	pdr	gro	osd	c_b	oap	rmk	agr	foo	tex	wap	lum	ppp	crp	man	siu	cns	trd	otp	ser
BRAZIL																			
VA	3.78	5.94	14.87	7.18	18.75	3.82	49.46	178.20	13.35	40.27	14.56	11.04	50.44	238.99	29.91	296.05	152.00	84.29	916.12
VA_%	0.18	0.28	0.70	0.34	0.88	0.18	2.32	8.37	0.63	1.89	0.68	0.52	2.37	11.23	1.41	13.91	7.14	3.96	43.03
X	3.42	5.54	29.33	2.12	15.66	1.50	27.20	95.67	10.80	26.22	10.11	11.75	66.94	203.53	6.65	9.73	35.59	14.88	152.13
X_%	0.47	0.76	4.02	0.29	2.15	0.21	3.73	13.13	1.48	3.60	1.39	1.61	9.19	27.93	0.91	1.34	4.88	2.04	20.87
X_I	0.07	0.11	0.58	0.04	0.31	0.03	0.54	1.90	0.21	0.52	0.20	0.23	1.33	4.03	0.13	0.19	0.71	0.29	3.02
M	3.49	1.65	7.62	2.20	14.82	1.51	22.27	60.99	14.90	26.84	8.24	6.97	102.94	254.29	9.87	9.87	37.90	25.88	181.36
M_%	0.44	0.21	0.96	0.28	1.87	0.19	2.81	7.69	1.88	3.38	1.04	0.88	12.97	32.04	1.24	1.24	4.78	3.26	22.85
M_I	0.17	0.08	0.36	0.10	0.70	0.07	1.06	2.90	0.71	1.28	0.39	0.33	4.90	12.09	0.47	0.47	1.80	1.23	8.62
C	3.20	2.89	2.82	6.07	15.10	2.98	36.30	128.59	16.70	36.70	12.22	10.21	71.57	268.22	36.58	247.74	145.73	88.13	832.55
C_%	0.16	0.15	0.14	0.31	0.77	0.15	1.85	6.55	0.85	1.87	0.62	0.52	3.64	13.65	1.86	12.61	7.42	4.49	42.38
G	0.55	0.48	0.47	1.04	2.59	0.51	6.04	21.34	2.61	5.53	2.08	1.68	10.50	34.92	6.14	42.55	24.63	13.59	137.07
G_%	0.17	0.15	0.15	0.33	0.82	0.16	1.92	6.79	0.83	1.76	0.66	0.54	3.34	11.11	1.95	13.54	7.83	4.32	43.61
NORTH																			
VA	0.04	0.37	0.11	0.07	0.76	0.10	4.05	4.51	1.60	0.39	2.14	1.98	2.51	24.70	2.04	34.41	5.42	1.24	35.82
VA_%	0.03	0.30	0.09	0.06	0.62	0.08	3.31	3.69	1.31	0.32	1.75	1.62	2.05	20.21	1.67	28.14	4.43	1.01	29.30
X	0.04	0.35	0.16	0.06	0.72	0.10	4.28	1.96	0.13	0.08	1.85	1.40	1.51	29.79	0.01	0.02	2.87	0.62	1.12
X_%	0.08	0.75	0.34	0.13	1.54	0.21	9.09	4.16	0.28	0.17	3.94	2.97	3.20	63.30	0.01	0.04	6.09	1.32	2.38
X_I	0.02	0.15	0.07	0.03	0.31	0.04	1.82	0.84	0.06	0.03	0.79	0.60	0.64	12.70	0.00	0.01	1.22	0.27	0.48
M	0.02	0.03	0.04	0.03	0.09	0.02	0.48	3.66	1.05	1.80	0.58	0.62	5.33	21.22	1.82	0.07	0.92	0.78	10.00
M_%	0.04	0.06	0.08	0.07	0.19	0.04	0.99	7.54	2.17	3.71	1.19	1.28	10.97	43.70	3.74	0.14	1.90	1.61	20.60
M_I	0.02	0.03	0.03	0.03	0.08	0.02	0.43	3.29	0.95	1.62	0.52	0.56	4.80	19.10	1.64	0.06	0.83	0.70	9.00
C	0.03	0.12	0.03	0.06	0.45	0.06	2.41	4.89	1.86	1.60	1.43	1.40	3.00	17.89	2.47	26.68	4.00	1.34	35.90
C_%	0.03	0.11	0.02	0.06	0.43	0.06	2.28	4.63	1.76	1.52	1.35	1.33	2.84	16.93	2.34	25.26	3.78	1.27	33.99
G	0.01	0.02	0.00	0.01	0.08	0.01	0.40	0.82	0.29	0.27	0.24	0.23	0.46	2.00	0.42	4.58	0.68	0.20	5.95
G_%	0.03	0.12	0.03	0.06	0.46	0.06	2.38	4.93	1.77	1.60	1.46	1.38	2.73	12.01	2.49	27.50	4.05	1.21	35.69

VA – Value Added net of taxes (US$bi); VA_% – Sectoral Value Added share on total region VA;
X – Exports value net of taxes (US$); X_% – Sectoral export as a percentage on total regional exports; X_I – Export intensity (export as a percentage on total output)
M – Imports value net of taxes (US$); M_% – Sectoral import as a percentage on total regional exports; M_I – Import intensity (export as a percentage on total output)
C – Private consumption net of taxes (US$) ; C_% – Sectoral consumption as a percentage on total private consumption;
G – Government consumption net of taxes (US$) ; G_% – Sectoral consumption as a percentage on total government consumption;

Table C.1 – Structure of economic activity in Brazil (continue...)

	pdr	gro	osd	c_b	oap	rmk	agr	foo	tex	wap	lum	ppp	crp	man	siu	cns	trd	otp	ser
NORTHEAST																			
VA	0.95	1.72	2.56	4.37	3.18	0.29	7.06	21.56	0.86	3.75	0.94	0.20	5.28	7.64	3.51	91.85	23.51	8.62	113.37
VA_%	0.32	0.57	0.85	1.45	1.06	0.10	2.34	7.16	0.29	1.24	0.31	0.07	1.75	2.54	1.16	30.49	7.81	2.86	37.64
X	0.15	0.96	2.87	0.63	1.27	0.06	1.89	5.71	2.58	0.82	0.21	0.12	11.38	7.43	0.01	0.03	16.77	1.57	10.05
X_%	0.23	1.49	4.45	0.98	1.98	0.09	2.93	8.86	4.00	1.27	0.33	0.18	17.63	11.51	0.01	0.05	26.00	2.44	15.58
X_I	0.02	0.15	0.45	0.10	0.20	0.01	0.30	0.89	0.40	0.13	0.03	0.02	1.78	1.16	0.00	0.00	2.63	0.25	1.57
M	0.13	0.13	0.29	0.09	0.61	0.12	1.60	12.00	3.22	4.65	1.28	0.96	23.01	26.43	0.47	0.08	3.28	2.90	10.41
M_%	0.15	0.14	0.32	0.09	0.66	0.13	1.74	13.09	3.52	5.07	1.40	1.05	25.10	28.84	0.51	0.09	3.57	3.16	11.36
M_I	0.04	0.04	0.10	0.03	0.20	0.04	0.52	3.94	1.06	1.53	0.42	0.31	7.56	8.68	0.15	0.03	1.08	0.95	3.42
C	0.71	0.84	0.36	3.64	2.67	0.28	5.95	22.25	2.34	6.17	1.65	0.42	10.22	19.88	4.22	79.83	18.85	9.62	102.64
C_%	0.24	0.29	0.12	1.24	0.91	0.10	2.03	7.60	0.80	2.11	0.57	0.14	3.49	6.80	1.44	27.29	6.44	3.29	35.08
G	0.12	0.14	0.06	0.63	0.46	0.05	0.99	3.72	0.37	0.98	0.28	0.07	1.54	2.81	0.71	13.71	3.18	1.49	16.89
G_%	0.25	0.29	0.12	1.30	0.95	0.10	2.06	7.72	0.76	2.04	0.59	0.15	3.20	5.83	1.47	28.44	6.60	3.10	35.03
MIDWEST																			
VA	0.75	0.11	4.95	0.23	4.10	0.32	2.56	10.91	1.31	1.98	1.67	1.23	5.16	3.71	1.48	51.82	13.31	5.69	94.17
VA_%	0.36	0.06	2.41	0.11	2.00	0.16	1.25	5.31	0.64	0.96	0.81	0.60	2.51	1.80	0.72	25.22	6.48	2.77	45.83
X	1.01	0.16	8.72	0.23	6.13	0.42	3.53	6.91	0.28	0.47	0.52	0.73	2.56	3.72	1.00	1.72	3.12	1.25	15.72
X_%	1.73	0.28	14.97	0.40	10.53	0.72	6.07	11.88	0.48	0.80	0.89	1.25	4.39	6.39	1.73	2.96	5.36	2.15	27.01
X_I	0.23	0.04	2.01	0.05	1.41	0.10	0.82	1.60	0.06	0.11	0.12	0.17	0.59	0.86	0.23	0.40	0.72	0.29	3.63
M	0.22	0.14	0.48	0.17	0.88	0.13	1.78	3.14	1.43	1.33	0.82	1.91	10.55	18.46	0.21	0.09	2.73	1.53	12.27
M_%	0.37	0.24	0.83	0.30	1.52	0.22	3.06	5.38	2.46	2.29	1.40	3.28	18.11	31.68	0.36	0.15	4.68	2.63	21.05
M_I	0.11	0.07	0.25	0.09	0.45	0.06	0.92	1.61	0.74	0.69	0.42	0.98	5.42	9.49	0.11	0.04	1.40	0.79	6.30
C	0.54	0.07	0.46	0.17	2.82	0.23	1.81	6.31	1.60	2.27	1.44	0.99	6.21	11.11	1.70	40.77	11.38	5.54	82.45
C_%	0.30	0.04	0.26	0.09	1.59	0.13	1.02	3.55	0.90	1.28	0.81	0.56	3.49	6.24	0.96	22.92	6.40	3.11	46.36
G	0.09	0.01	0.08	0.03	0.48	0.04	0.30	1.04	0.25	0.35	0.25	0.16	0.93	1.65	0.28	7.00	1.93	0.84	13.54
G_%	0.31	0.04	0.26	0.10	1.65	0.13	1.02	3.55	0.86	1.20	0.84	0.56	3.18	5.63	0.97	23.93	6.58	2.89	46.28

VA – Value Added net of taxes (US$bi); VA_% – Sectoral Value Added share on total region VA;

X – Exports value net of taxes (US$); X_% – Sectoral export as a percentage on total regional exports; X_I – Export intensity (export as a percentage on total output)

M – Imports value net of taxes (US$); M_% – Sectoral import as a percentage on total regional exports; M_I – Import intensity (export as a percentage on total output)

C – Private consumption net of taxes (US$) ; C_% – Sectoral consumption as a percentage on total private consumption;

G – Government consumption net of taxes (US$) ; G_% – Sectoral consumption as a percentage on total government consumption;

Table C.1 – Structure of economic activity in Brazil (continue...)

	pdr	gro	osd	c_b	oap	rmk	agr	foo	tex	wap	lum	ppp	crp	man	siu	cns	trd	otp	ser
SOUTH																			
VA	0.94	0.88	2.46	0.81	2.97	0.42	6.34	37.51	4.50	22.62	4.98	1.46	3.88	21.61	8.27	47.09	24.72	13.53	142.49
VA_%	0.27	0.25	0.71	0.23	0.86	0.12	1.82	10.79	1.30	6.51	1.43	0.42	1.12	6.22	2.38	13.55	7.11	3.89	41.01
X	1.96	1.14	7.20	1.10	5.45	0.48	7.92	36.27	4.23	20.36	5.38	1.31	4.06	15.10	4.49	2.96	7.33	4.89	51.53
X_%	1.07	0.62	3.93	0.60	2.98	0.26	4.33	19.80	2.31	11.11	2.94	0.72	2.22	8.24	2.45	1.62	4.00	2.67	28.13
X_I	0.24	0.14	0.87	0.13	0.66	0.06	0.96	4.37	0.51	2.45	0.65	0.16	0.49	1.82	0.54	0.36	0.88	0.59	6.21
M	0.22	0.34	0.53	0.25	1.71	0.32	4.37	5.86	3.24	3.02	0.52	1.56	19.43	39.51	0.86	6.69	6.45	3.90	70.11
M_%	0.13	0.20	0.32	0.15	1.01	0.19	2.59	3.47	1.92	1.79	0.31	0.93	11.50	23.39	0.51	3.96	3.82	2.31	41.51
M_I	0.07	0.10	0.16	0.08	0.52	0.10	1.32	1.77	0.98	0.91	0.16	0.47	5.86	11.91	0.26	2.02	1.95	1.18	21.14
C	0.75	0.54	0.94	0.59	2.18	0.30	4.73	20.53	3.26	7.97	2.90	1.66	8.10	28.31	9.42	41.79	23.06	13.62	131.23
C_%	0.25	0.18	0.31	0.20	0.72	0.10	1.57	6.80	1.08	2.64	0.96	0.55	2.68	9.38	3.12	13.84	7.64	4.51	43.47
G	0.13	0.09	0.16	0.10	0.37	0.05	0.79	3.36	0.50	0.96	0.49	0.27	1.22	3.87	1.57	7.18	3.90	2.07	21.63
G_%	0.26	0.19	0.32	0.21	0.77	0.11	1.61	6.89	1.03	1.97	1.01	0.56	2.51	7.94	3.23	14.73	8.01	4.24	44.40
SOUTHEAST																			
VA	1.10	2.87	4.79	1.71	7.74	2.70	29.45	103.71	5.08	11.53	4.81	6.17	33.61	181.34	14.61	70.89	85.04	55.22	530.28
VA_%	0.10	0.25	0.42	0.15	0.67	0.23	2.56	9.00	0.44	1.00	0.42	0.54	2.92	15.73	1.27	6.15	7.38	4.79	46.01
X	0.27	2.91	10.38	0.10	2.08	0.45	9.58	44.81	3.58	4.50	2.14	8.19	47.44	147.48	1.14	4.99	5.50	6.53	73.71
X_%	0.07	0.78	2.76	0.03	0.55	0.12	2.55	11.92	0.95	1.20	0.57	2.18	12.62	39.24	0.30	1.33	1.46	1.74	19.61
X_I	0.01	0.10	0.36	0.00	0.07	0.02	0.33	1.54	0.12	0.15	0.07	0.28	1.63	5.07	0.04	0.17	0.19	0.22	2.53
M	2.91	1.01	6.27	1.66	11.53	0.93	14.04	36.34	5.95	16.03	5.04	1.91	44.63	148.66	6.51	2.95	24.52	16.76	78.57
M_%	0.68	0.24	1.47	0.39	2.70	0.22	3.29	8.53	1.40	3.76	1.18	0.45	10.47	34.88	1.53	0.69	5.75	3.93	18.43
M_I	0.25	0.09	0.54	0.14	0.99	0.08	1.21	3.13	0.51	1.38	0.43	0.16	3.84	12.80	0.56	0.25	2.11	1.44	6.77
C	1.17	1.31	1.04	1.60	6.97	2.11	21.40	74.61	7.63	18.69	4.80	5.74	44.04	191.04	18.77	58.67	88.44	58.02	480.32
C_%	0.11	0.12	0.10	0.15	0.64	0.19	1.97	6.87	0.70	1.72	0.44	0.53	4.05	17.58	1.73	5.40	8.14	5.34	44.21
G	0.20	0.22	0.17	0.27	1.19	0.36	3.57	12.40	1.19	2.97	0.82	0.94	6.34	24.59	3.15	10.08	14.94	8.98	79.06
G_%	0.12	0.13	0.10	0.16	0.70	0.21	2.08	7.23	0.69	1.73	0.48	0.55	3.70	14.34	1.84	5.88	8.71	5.24	46.11

VA – Value Added net of taxes (US$bi); VA_% – Sectoral Value Added share on total region VA;

X – Exports value net of taxes (US$); X_% – Sectoral export as a percentage on total regional exports; X_I – Export intensity (export as a percentage on total output)

M – Imports value net of taxes (US$); M_% – Sectoral import as a percentage on total regional exports; M_I – Import intensity (export as a percentage on total output)

C – Private consumption net of taxes (US$) ; C_% – Sectoral consumption as a percentage on total private consumption;

G – Government consumption net of taxes (US$) ; G_% – Sectoral consumption as a percentage on total government consumption;

Table C.1 – Structure of economic activity in Brazil (continue...)

	pdr	gro	osd	c_b	oap	rmk	agr	foo	tex	wap	lum	ppp	crp	man	siu	cns	trd	otp	ser
									BRAZIL										
L_%	14.07	13.50	14.39	12.76	14.12	14.60	13.86	33.86	29.75	49.12	41.08	52.89	22.32	32.88	47.49	14.06	40.23	47.12	62.96
K_%	67.84	68.29	67.59	68.87	67.80	67.42	68.00	66.14	70.25	50.88	58.92	47.11	77.68	56.46	52.51	85.94	59.77	52.88	37.04
LN_%	18.09	18.21	18.02	18.37	18.08	17.98	18.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NR_%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.67	0.00	0.00	0.00	0.00	0.00
									NORTH										
L_%	6.90	6.70	6.71	6.87	6.61	6.61	6.58	36.08	26.04	57.93	58.45	79.35	11.56	15.92	57.88	7.35	47.97	65.90	58.31
K_%	73.50	73.66	73.65	73.52	73.73	73.73	73.75	63.92	73.96	42.07	41.55	20.65	88.44	70.72	42.12	92.65	52.03	34.10	41.69
LN_%	19.60	19.64	19.64	19.61	19.66	19.66	19.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NR_%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.36	0.00	0.00	0.00	0.00	0.00
									NORTHEAST										
L_%	11.39	11.39	11.39	11.39	11.39	11.39	11.39	27.83	26.09	39.75	32.60	33.70	12.00	29.55	44.39	20.40	46.54	51.75	61.30
K_%	69.96	69.96	69.96	69.96	69.96	69.96	69.96	72.17	73.91	60.25	67.40	66.30	88.00	59.25	55.61	79.60	53.46	48.25	38.70
LN_%	18.66	18.66	18.66	18.66	18.66	18.66	18.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NR_%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.19	0.00	0.00	0.00	0.00	0.00
									MIDWEST										
L_%	15.09	15.09	15.09	15.09	15.09	15.09	15.09	35.83	30.58	49.86	38.53	47.39	18.59	33.33	47.07	11.99	38.68	46.27	60.73
K_%	67.04	67.04	67.04	67.04	67.04	67.04	67.04	64.17	69.42	50.14	61.47	52.61	81.41	56.07	52.93	88.01	61.32	53.73	39.27
LN_%	17.88	17.88	17.88	17.88	17.88	17.88	17.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NR_%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.59	0.00	0.00	0.00	0.00	0.00
									SOUTH										
L_%	15.09	15.09	15.09	15.09	15.09	15.09	15.09	36.75	30.58	50.08	38.53	47.39	24.04	35.26	47.07	11.99	38.68	46.27	63.50
K_%	67.04	67.04	67.04	67.04	67.04	67.04	67.04	63.25	69.42	49.92	61.47	52.61	75.96	54.45	52.93	88.01	61.32	53.73	36.50
LN_%	17.88	17.88	17.88	17.88	17.88	17.88	17.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NR_%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.29	0.00	0.00	0.00	0.00	0.00
									SOUTH										
L_%	15.09	15.09	15.09	15.09	15.09	15.09	15.09	33.75	30.58	49.85	38.53	47.39	25.11	35.03	47.07	11.99	38.68	46.27	63.89
K_%	67.04	67.04	67.04	67.04	67.04	67.04	67.04	66.25	69.42	50.15	61.47	52.61	74.89	54.64	52.93	88.01	61.32	53.73	36.11
LN_%	17.88	17.88	17.88	17.88	17.88	17.88	17.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NR_%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.32	0.00	0.00	0.00	0.00	0.00

L_% – Labour share of value added, as percentage form;

K_% – Capital share of value added, as percentage form;

LN_% – Land share of value added, as percentage form;

NR_% – Natural Resource share of value added, as percentage form;

APPENDIX D – Families Characteristics – Brazil and regions

Table D.1 – Families Consumption - Brazil and Regions (%)

BRAZIL										
	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
pdr	0.52	0.40	0.31	0.27	0.24	0.16	0.13	0.11	0.11	0.05
gro	0.23	0.31	0.28	0.23	0.16	0.11	0.12	0.13	0.14	0.08
osd	0.27	0.24	0.21	0.19	0.18	0.15	0.14	0.12	0.12	0.09
c_b	1.45	1.02	0.67	0.51	0.35	0.27	0.21	0.18	0.16	0.08
oap	1.32	1.26	1.15	1.04	0.95	0.92	0.82	0.72	0.61	0.45
rmk	0.16	0.18	0.18	0.18	0.17	0.17	0.16	0.15	0.17	0.12
agr	2.93	2.87	2.62	2.33	2.01	2.00	1.79	1.73	1.54	1.34
foo	10.64	9.99	8.85	8.27	7.92	7.54	6.60	6.26	5.64	4.47
tex	0.92	1.00	0.99	0.95	0.94	0.87	0.82	0.92	0.86	0.72
wap	2.08	2.11	1.96	2.03	2.14	2.09	2.01	1.99	1.90	1.57
lum	1.37	1.14	0.93	0.79	0.77	0.67	0.69	0.55	0.53	0.36
ppp	0.53	0.48	0.49	0.53	0.54	0.48	0.50	0.53	0.57	0.52
crp	4.67	4.06	4.31	3.84	4.09	4.01	3.97	3.49	4.16	3.00
man	15.63	16.51	16.06	15.77	14.90	14.96	13.43	13.76	13.24	11.44
siu	3.15	2.95	2.74	2.49	2.28	2.11	1.94	1.86	1.64	1.11
cns	17.93	14.80	12.90	13.07	13.03	12.02	13.64	12.67	9.61	12.24
trd	5.98	6.69	7.09	7.48	7.35	7.87	7.54	7.82	8.68	7.20
otp	3.74	3.97	4.46	4.31	4.82	4.55	4.38	4.46	4.13	4.66
ser	26.46	30.01	33.80	35.72	37.15	39.02	41.10	42.56	46.20	50.48
BRAZIL - Agg										
AGR	6.88	6.28	5.42	4.75	4.06	3.79	3.37	3.14	2.83	2.22
dom	88.56	86.93	86.08	85.18	85.03	84.36	83.58	84.65	84.13	84.14
imp	11.44	13.07	13.92	14.82	14.97	15.64	16.42	15.35	15.87	15.86
IND	35.85	35.29	33.59	32.18	31.30	30.62	28.03	27.49	26.90	22.09
dom	62.66	64.66	66.32	67.07	67.51	67.77	68.19	67.59	68.29	67.80
imp	37.34	35.34	33.68	32.93	32.49	32.23	31.81	32.41	31.71	32.20
SER	57.27	58.43	60.99	63.07	64.63	65.58	68.60	69.37	70.26	75.69
dom	91.41	90.66	89.48	88.78	88.46	88.01	88.18	87.40	87.38	87.95
imp	8.59	9.34	10.52	11.22	11.55	11.99	11.82	12.60	12.62	12.05

AGR = pdr + gro + osd + c_b + oap + rmk + agr;
IND = foo + tex + wap + lum + ppp + crp + man
SER = man +
%Fam_Totals = Sum{sector%}; % SectorAgg_Totals = dom + imp; %Agg_Totals = AGR% + IND% + SER%

Table D.1 – Families Consumption - Brazil and Regions (%) (continue...)

NORTH										
	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
pdr	0.07	0.06	0.05	0.03	0.03	0.02	0.02	0.02	0.01	0.01
gro	0.09	0.15	0.17	0.22	0.07	0.12	0.06	0.07	0.05	0.06
osd	0.04	0.04	0.04	0.03	0.02	0.02	0.01	0.02	0.01	0.02
c_b	0.12	0.10	0.09	0.06	0.05	0.04	0.03	0.04	0.04	0.02
oap	0.72	0.64	0.62	0.43	0.39	0.41	0.32	0.36	0.28	0.19
rmk	0.06	0.06	0.07	0.06	0.05	0.06	0.05	0.08	0.05	0.05
agr	2.66	2.84	3.08	2.50	2.14	2.29	1.63	2.22	1.45	1.56
foo	7.77	6.43	6.32	4.80	4.63	4.08	2.97	3.67	2.41	2.95
tex	1.37	1.85	2.16	1.89	1.58	1.76	1.73	1.95	1.53	1.53
wap	1.53	1.65	1.74	1.59	1.57	1.65	1.55	1.46	1.45	1.16
lum	1.95	2.00	2.06	1.37	1.23	1.56	1.46	0.90	0.75	0.56
ppp	1.15	1.34	1.60	1.54	1.44	1.08	1.23	1.20	1.17	1.18
crp	2.80	3.05	3.35	2.51	2.38	3.14	2.06	3.56	2.83	2.56
man	19.44	19.63	21.12	18.88	16.64	17.95	15.81	12.50	12.83	13.39
siu	2.66	2.83	2.76	2.46	2.24	2.37	1.95	2.25	1.78	1.86
cns	29.63	25.41	18.09	26.92	29.68	20.92	30.95	29.34	12.83	27.80
trd	3.11	3.80	4.21	3.79	3.35	4.68	3.33	3.58	3.16	3.95
otp	1.01	1.13	1.14	1.01	1.27	1.68	0.89	0.81	1.01	1.94
ser	23.83	26.99	31.34	29.92	31.23	36.18	33.94	35.96	56.35	39.20
NORTH - Agg										
AGR	3.75	3.88	4.11	3.32	2.76	2.96	2.13	2.83	1.90	1.91
dom	87.19	87.47	87.77	87.94	87.97	88.27	88.25	88.24	88.11	88.38
imp	12.81	12.53	12.23	12.06	12.03	11.73	11.75	11.76	11.89	11.62
IND	36.00	35.95	38.35	32.59	29.46	31.22	26.82	25.23	22.97	23.33
dom	54.90	55.23	55.40	54.77	54.71	54.81	54.75	56.05	54.97	54.95
imp	45.10	44.77	44.60	45.23	45.29	45.19	45.25	43.95	45.03	45.05
SER	60.25	60.17	57.55	64.09	67.77	65.82	71.06	71.94	75.13	74.76
dom	91.57	90.49	88.76	90.45	90.55	88.62	90.62	90.23	86.10	89.28
imp	8.43	9.51	11.24	9.55	9.45	11.38	9.38	9.77	13.90	10.72

AGR = pdr + gro + osd + c_b + oap + rmk + agr;
IND = foo + tex + wap + lum + ppp + crp + man
SER = siu + cns + trd + otp + ser
%Fam_Totals = Sum{sector%}; % SectorAgg_Totals = dom + imp; %Agg_Totals = AGR% + IND% + SER%

Table D.1 – Families Consumption - Brazil and Regions (%) (continue...)

NORTHEAST										
	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
pdr	0.77	0.51	0.38	0.30	0.19	0.16	0.10	0.10	0.08	0.05
gro	0.36	0.49	0.49	0.35	0.22	0.19	0.20	0.25	0.15	0.12
osd	0.34	0.21	0.17	0.13	0.09	0.08	0.07	0.09	0.06	0.06
c_b	3.22	2.34	1.82	1.60	1.01	0.97	0.72	0.71	0.59	0.35
oap	1.76	1.46	1.35	1.09	0.85	0.84	0.61	0.65	0.55	0.37
rmk	0.12	0.11	0.11	0.10	0.09	0.10	0.08	0.10	0.09	0.08
agr	3.47	2.84	2.72	2.34	1.80	1.86	1.46	1.63	1.51	1.27
foo	12.53	10.97	9.82	8.70	7.31	7.75	5.98	6.07	5.38	4.25
tex	0.87	0.79	0.83	0.90	0.78	0.74	0.72	0.75	0.83	0.78
wap	2.23	2.14	2.19	2.34	2.13	2.50	2.06	2.17	1.95	1.79
lum	1.41	0.95	0.75	0.59	0.44	0.43	0.37	0.44	0.36	0.30
ppp	0.16	0.13	0.14	0.13	0.13	0.18	0.14	0.15	0.14	0.15
crp	5.81	4.39	3.71	3.50	3.16	4.03	3.26	3.39	3.15	2.61
man	8.86	8.20	7.39	7.34	6.15	6.69	6.03	6.25	6.67	5.66
siu	2.43	2.00	1.79	1.58	1.28	1.42	1.16	1.22	1.22	0.93
cns	22.14	24.45	26.58	26.09	32.51	23.12	32.97	26.63	22.67	29.63
trd	6.51	6.14	6.27	6.15	5.54	7.29	5.70	6.54	7.86	6.88
otp	3.17	3.57	3.50	3.76	3.12	3.57	3.05	3.16	3.10	2.88
ser	23.85	28.31	29.99	33.00	33.21	38.09	35.34	39.72	43.67	41.87
NORTHEAST - Agg										
AGR	10.04	7.97	7.04	5.91	4.24	4.20	3.24	3.52	3.02	2.29
dom	92.26	92.13	91.79	91.86	91.51	91.37	91.17	90.95	90.81	90.14
imp	7.74	7.87	8.21	8.14	8.49	8.63	8.83	9.05	9.19	9.86
IND	31.87	27.57	24.84	23.51	20.10	22.31	18.55	19.21	18.47	15.53
dom	57.69	57.13	56.80	56.11	56.17	56.38	55.58	55.45	54.62	54.13
imp	42.31	42.87	43.20	43.89	43.83	43.62	44.42	44.55	45.38	45.87
SER	58.09	64.47	68.13	70.58	75.66	73.49	78.21	77.27	78.52	82.18
dom	95.86	95.75	95.84	95.65	96.10	95.37	96.07	95.59	95.29	95.74
imp	4.14	4.25	4.16	4.35	3.90	4.63	3.93	4.41	4.71	4.26

AGR = pdr + gro + osd + c_b + oap + rmk + agr;
IND = foo + tex + wap + lum + ppp + crp + man
SER = siu + cns + trd + otp + ser
%Fam_Totals = Sum{sector%}; % SectorAgg_Totals = dom + imp; %Agg_Totals = AGR% + IND% + SER%

Table D.1 – Families Consumption - Brazil and Regions (%) (continue...)

MIDWEST										
	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
pdr	1.13	0.75	0.83	0.66	0.56	0.37	0.25	0.22	0.24	0.09
gro	0.04	0.04	0.04	0.03	0.08	0.03	0.03	0.06	0.03	0.03
osd	0.56	0.53	0.60	0.43	0.46	0.30	0.22	0.18	0.19	0.14
c_b	0.28	0.24	0.25	0.16	0.13	0.12	0.07	0.08	0.09	0.04
oap	2.60	2.60	2.89	2.47	2.67	2.30	1.51	1.38	1.19	0.95
rmk	0.17	0.15	0.18	0.20	0.20	0.14	0.11	0.12	0.12	0.10
agr	1.84	1.34	1.84	1.56	1.56	1.25	0.93	0.94	0.78	0.69
foo	5.99	5.08	5.35	4.80	5.12	4.49	2.65	3.59	3.07	2.67
tex	1.19	1.08	1.16	1.10	1.16	1.00	0.76	1.05	0.83	0.75
wap	1.81	1.36	1.63	1.59	1.71	1.58	1.12	1.11	1.39	1.08
lum	2.18	1.55	1.25	1.16	1.45	1.05	0.77	0.65	0.77	0.49
ppp	0.52	0.79	0.66	0.60	0.79	0.42	0.38	0.53	0.52	0.53
crp	3.15	3.88	3.46	4.76	4.15	4.63	2.80	4.44	3.10	2.94
man	9.92	8.71	8.66	7.69	8.01	6.84	5.40	6.42	6.65	4.98
siu	2.21	2.00	1.82	1.50	1.33	1.17	0.91	0.86	0.85	0.57
cns	20.52	18.22	14.33	16.72	12.19	12.64	38.55	26.66	19.83	26.31
trd	6.10	6.16	6.99	7.20	6.79	6.89	5.51	6.29	7.78	6.01
otp	4.59	3.66	3.88	3.42	3.68	3.46	2.69	3.19	3.41	2.73
ser	35.19	41.86	44.18	43.96	47.95	51.35	35.34	42.23	49.16	48.90
MIDWEST - Agg										
AGR	6.62	5.66	6.63	5.51	5.67	4.51	3.12	2.99	2.64	2.05
dom	93.59	93.98	93.62	93.72	93.67	93.85	93.58	93.15	93.37	92.94
imp	6.41	6.02	6.39	6.28	6.33	6.15	6.42	6.85	6.63	7.06
IND	24.76	22.44	22.17	21.69	22.39	20.00	13.88	17.78	16.33	13.44
dom	92.99	92.64	92.11	92.39	91.79	91.79	94.64	93.39	92.50	93.19
imp	7.01	7.36	7.89	7.61	8.21	8.21	5.36	6.61	7.50	6.81
SER	68.62	71.90	71.20	72.79	71.94	75.50	83.00	79.23	81.03	84.52
dom	92.99	92.64	92.11	92.39	91.79	91.79	94.64	93.39	92.50	93.19
imp	7.01	7.36	7.89	7.61	8.21	8.21	5.36	6.61	7.50	6.81

AGR = pdr + gro + osd + c_b + oap + rmk + agr;
IND = foo + tex + wap + lum + ppp + crp + man
SER = siu + cns + trd + otp + ser
%Fam_Totals = Sum{sector%}; % SectorAgg_Totals = dom + imp; %Agg_Totals = AGR% + IND% + SER%

Table D.1 – Families Consumption - Brazil and Regions (%) (continue...)

SOUTH										
	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
pdr	0.54	0.63	0.57	0.42	0.40	0.25	0.24	0.16	0.18	0.09
gro	0.36	0.34	0.25	0.28	0.25	0.18	0.15	0.12	0.29	0.10
osd	0.53	0.63	0.54	0.43	0.37	0.31	0.31	0.26	0.28	0.20
c_b	0.45	0.54	0.34	0.32	0.31	0.21	0.19	0.14	0.12	0.10
oap	0.92	1.23	1.03	1.05	0.89	0.74	0.73	0.72	0.66	0.48
rmk	0.09	0.16	0.14	0.12	0.12	0.11	0.09	0.09	0.11	0.07
agr	1.65	3.01	2.19	2.12	1.83	1.65	1.40	1.36	1.33	1.20
foo	11.55	10.89	9.12	8.47	8.57	7.34	7.19	6.37	6.33	4.89
tex	0.63	0.96	1.29	1.22	1.15	1.23	1.22	1.05	1.25	0.91
wap	2.96	2.79	2.74	2.85	2.74	2.67	2.65	2.95	3.10	2.30
lum	1.06	1.56	1.36	1.52	1.18	0.93	1.10	0.88	1.09	0.58
ppp	0.46	0.45	0.58	0.53	0.56	0.51	0.56	0.56	0.52	0.57
crp	3.35	3.67	2.95	2.74	2.87	2.85	3.21	2.71	2.28	2.36
man	8.29	12.71	11.41	10.41	9.84	9.62	10.03	9.04	9.85	8.01
siu	6.04	6.01	5.01	4.26	3.82	3.34	3.35	2.91	2.72	1.91
cns	16.17	9.98	12.17	14.63	13.41	16.60	12.00	14.89	9.35	14.88
trd	7.83	7.35	7.45	7.05	7.58	7.86	8.20	7.35	8.88	7.53
otp	5.14	4.02	4.02	3.67	4.88	4.28	4.66	4.48	4.82	4.74
ser	31.99	33.07	36.83	37.90	39.22	39.33	42.72	43.94	46.87	49.07
SOUTH - Agg										
AGR	4.55	6.54	5.07	4.74	4.16	3.45	3.10	2.85	2.96	2.25
dom	92.76	92.25	92.55	92.37	92.40	92.19	92.38	92.25	92.32	91.89
imp	7.24	7.75	7.45	7.63	7.60	7.81	7.62	7.75	7.68	8.11
IND	28.29	33.03	29.45	27.75	26.92	25.15	25.96	23.57	24.40	19.62
dom	71.24	68.41	68.51	68.89	68.91	67.89	67.44	67.42	67.46	66.36
imp	28.76	31.59	31.49	31.11	31.09	32.11	32.56	32.58	32.54	33.64
SER	67.17	60.43	65.48	67.51	68.92	71.40	70.93	73.58	72.63	78.13
dom	78.18	76.78	76.27	76.21	75.94	76.26	75.16	75.24	74.15	74.47
imp	21.82	23.22	23.73	23.79	24.06	23.74	24.84	24.76	25.85	25.54

AGR = pdr + gro + osd + c_b + oap + rmk + agr;
IND = foo + tex + wap + lum + ppp + crp + man
SER = siu + cns + trd + otp + ser
%Fam_Totals = Sum{sector%}; % SectorAgg_Totals = dom + imp; %Agg_Totals = AGR% + IND% + SER%

Table D.1 – Families Consumption - Brazil and Regions (%) (continue...)

SOUTHEAST										
	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
pdr	0.40	0.30	0.19	0.19	0.17	0.13	0.10	0.08	0.08	0.04
gro	0.15	0.24	0.22	0.20	0.13	0.08	0.11	0.12	0.11	0.08
osd	0.19	0.18	0.13	0.14	0.13	0.11	0.11	0.08	0.08	0.06
c_b	0.47	0.42	0.32	0.27	0.23	0.16	0.14	0.12	0.11	0.05
oap	1.00	1.07	0.93	0.91	0.80	0.85	0.82	0.65	0.55	0.38
rmk	0.31	0.28	0.23	0.24	0.23	0.22	0.21	0.19	0.21	0.15
agr	2.99	3.12	2.71	2.47	2.19	2.22	2.11	1.98	1.72	1.49
foo	10.73	10.82	9.20	9.01	8.76	8.25	7.36	6.95	6.13	4.81
tex	0.69	0.93	0.77	0.73	0.81	0.70	0.68	0.79	0.71	0.62
wap	2.07	2.18	1.74	1.81	2.10	1.93	1.97	1.80	1.66	1.47
lum	0.83	0.86	0.67	0.52	0.59	0.53	0.58	0.41	0.35	0.28
ppp	0.62	0.47	0.42	0.53	0.51	0.51	0.53	0.54	0.63	0.54
crp	5.18	4.22	5.24	4.34	4.99	4.35	4.63	3.62	5.14	3.25
man	25.93	24.98	21.85	21.08	20.25	19.45	17.00	18.43	16.40	14.26
siu	3.85	3.18	2.79	2.46	2.27	2.02	1.83	1.74	1.51	1.01
cns	2.85	3.89	4.88	5.44	4.61	7.04	5.37	4.98	5.54	5.62
trd	6.84	7.99	7.95	8.64	8.45	8.43	8.29	8.92	9.32	7.55
otp	6.05	5.23	5.73	5.27	5.98	5.27	5.05	5.28	4.47	5.40
ser	28.86	29.65	34.03	35.74	36.81	37.76	43.12	43.32	45.27	52.94
SOUTHEAST - Agg										
AGR	5.51	5.62	4.74	4.42	3.88	3.77	3.59	3.23	2.86	2.25
dom	77.25	77.70	78.25	77.95	77.96	78.49	78.48	79.10	78.97	79.67
imp	22.75	22.30	21.75	22.05	22.04	21.51	21.52	20.90	21.03	20.33
IND	46.04	44.45	39.89	38.02	37.99	35.71	32.75	32.54	31.02	25.23
dom	71.44	71.07	71.68	71.44	71.37	71.30	71.37	71.04	71.84	71.11
imp	28.56	28.93	28.32	28.56	28.63	28.70	28.63	28.96	28.16	28.89
SER	48.45	49.93	55.37	57.56	58.12	60.52	63.66	64.24	66.12	72.52
dom	88.91	88.96	89.04	89.05	88.93	89.21	89.00	88.92	88.96	88.99
imp	11.09	11.04	10.96	10.95	11.07	10.79	11.00	11.08	11.04	11.01

AGR = pdr + gro + osd + c_b + oap + rmk + agr;
IND = foo + tex + wap + lum + ppp + crp + man
SER = siu + cns + trd + otp + ser
%Fam_Totals = Sum{sector%}; % SectorAgg_Totals = dom + imp; %Agg_Totals = AGR% + IND% + SER%

Table D.2 – Families Income - Brazilian Regions (%)

	F1	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**
					% OF REGIONAL SAMPLE					
North	10.10	32.94	23.74	9.49	5.93	3.44	3.74	3.38	2.06	5.18
Northeast	9.07	34.83	25.30	8.44	5.88	3.80	2.36	3.02	1.91	5.39
Midwest	2.06	16.80	22.09	13.11	8.27	6.42	4.45	7.00	4.10	15.71
South	1.92	14.25	21.21	12.28	8.91	8.50	6.32	8.20	5.35	13.05
Southeast	1.94	16.63	22.79	11.39	9.28	8.12	4.93	6.82	4.67	13.43
					% OF LABOUR ON FAMILY TOTAL INCOME					
North	44.17	35.94	36.39	28.27	35.93	30.73	34.73	34.87	20.34	21.09
Northeast	35.85	29.01	30.74	31.40	30.69	31.83	35.91	33.29	32.55	26.08
Midwest	64.09	45.65	47.08	46.13	52.88	50.29	45.87	49.65	46.76	28.66
South	56.58	56.17	44.77	43.87	41.08	49.38	47.53	50.50	46.28	29.42
Southeast	69.50	49.89	50.09	47.16	49.85	51.98	53.24	51.71	46.98	32.91
					% OF CAPITAL ON FAMILY TOTAL INCOME					
North	25.57	30.33	34.00	52.21	47.06	54.55	48.04	51.21	66.99	70.43
Northeast	22.61	20.35	25.51	30.25	33.59	38.89	36.09	43.49	42.98	56.39
Midwest	19.39	24.41	18.67	22.29	21.57	28.58	33.81	32.75	38.63	58.31
South	36.01	26.74	18.09	21.66	24.99	27.16	33.02	30.10	35.07	53.47
Southeast	16.65	15.97	16.53	19.69	20.71	21.61	24.20	26.11	31.68	53.69
					% OF LAND ON FAMILY TOTAL INCOME					
North	0.00	0.18	0.21	0.43	0.02	0.56	0.40	0.24	1.19	1.15
Northeast	0.00	0.49	0.80	0.92	0.64	1.07	1.00	0.97	1.67	0.92
Midwest	0.00	0.71	0.04	0.13	0.06	0.38	0.34	0.21	1.38	1.18
South	0.00	0.03	0.23	0.18	0.28	0.17	0.21	0.19	0.37	0.86
Southeast	0.00	0.18	0.02	0.17	0.16	0.33	0.25	0.47	0.53	0.82
					% OF BOLSA FAMÍLIA PROGRAM ON FAMILY TOTAL INCOME					
North	16.78	5.20	2.84	1.31	0.77	0.59	0.44	0.31	0.08	0.02
Northeast	22.93	8.38	3.59	1.71	0.85	0.62	0.37	0.26	0.10	0.02
Midwest	4.23	2.23	1.33	0.82	0.43	0.34	0.20	0.16	0.04	0.01
South	1.97	3.10	0.95	0.40	0.25	0.10	0.07	0.03	0.01	0.00
Southeast	7.14	2.88	1.16	0.52	0.26	0.17	0.08	0.05	0.03	0.00
					% OF OTHER SOCIAL PROGRAMS ON FAMILY TOTAL INCOME					
North	0.39	3.06	2.40	1.56	1.62	0.51	0.48	0.46	0.11	0.09
Northeast	1.59	5.52	3.54	3.27	1.99	1.68	0.94	0.65	0.42	0.04
Midwest	0.70	4.01	2.65	2.02	1.63	1.16	0.78	0.57	0.11	0.04
South	0.00	3.39	1.91	1.18	0.66	0.33	0.23	0.11	0.06	0.03
Southeast	0.11	3.06	2.31	1.34	0.80	0.71	0.26	0.30	0.14	0.03

Table D.2 – Families Income - Brazilian Regions (%) (continue...)

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
% OF OTHER TRANSFERS ON FAMILY TOTAL INCOME										
North	3.38	9.77	9.94	3.11	2.08	2.82	3.15	3.02	0.64	0.25
Northeast	6.16	5.45	6.06	5.33	3.80	4.86	4.47	3.50	4.01	1.01
Midwest	7.34	4.88	4.35	4.51	5.12	5.02	5.48	3.06	2.02	0.97
South	2.45	8.51	3.77	3.35	4.66	2.76	2.33	3.36	1.82	1.14
Southeast	2.80	4.40	4.40	3.40	4.39	3.75	3.01	3.70	3.02	1.10
% OF PUBLIC RETIREMENT ON FAMILY TOTAL INCOME										
North	8.48	14.46	12.93	11.93	11.05	9.01	11.01	7.39	9.49	4.80
Northeast	10.40	29.83	28.51	25.79	27.02	19.36	19.32	15.55	15.40	11.95
Midwest	2.13	16.48	23.81	22.16	15.80	11.97	11.09	10.58	7.62	6.93
South	0.00	0.00	28.23	27.67	26.09	18.19	14.43	13.42	13.84	12.04
Southeast	2.93	22.04	23.88	26.09	22.10	19.39	16.57	15.33	14.90	8.61
% OF INCOME TAX REFUND ON FAMILY TOTAL INCOME										
North	0.00	0.00	0.00	0.00	0.00	0.02	0.05	0.37	0.08	0.20
Northeast	0.00	0.00	0.00	0.00	0.01	0.10	0.24	0.26	0.59	0.93
Midwest	0.00	0.00	0.00	0.00	0.04	0.12	0.19	0.37	0.56	0.76
South	0.00	0.00	0.00	0.00	0.12	0.01	0.09	0.14	0.37	0.71
Southeast	0.00	0.00	0.00	0.00	0.06	0.04	0.15	0.28	0.37	0.59
% OF TAX PAYMENT ON FAMILY TOTAL INCOME										
North	1.23	1.07	1.31	1.16	1.46	1.22	1.69	2.13	1.08	1.98
Northeast	0.46	0.97	1.24	1.34	1.40	1.59	1.67	2.04	2.28	2.67
Midwest	2.12	1.64	2.06	1.94	2.47	2.14	2.24	2.65	2.88	3.14
South	2.99	2.07	2.05	1.69	1.87	1.91	2.09	2.13	2.17	2.34
Southeast	0.86	1.58	1.61	1.62	1.68	2.02	2.23	2.04	2.34	2.25

APPENDIX E – Model Documentation

E.1 The General Equilibrium Modelling Package - GEMPACK

GEMPACK[1] (General Equilibrium Modeling Package) is a package of programs for economic modeling. It is especially suitable for Computable General Equilibrium (CGE) models, but can handle a wide range of economic behaviour. Basically, the following programs are part of the GEMPACK suite: TABMATE, GEMSIM, VIEWSOL, and VIEWHAR. How the programs work together can be seen in Figure E.1.

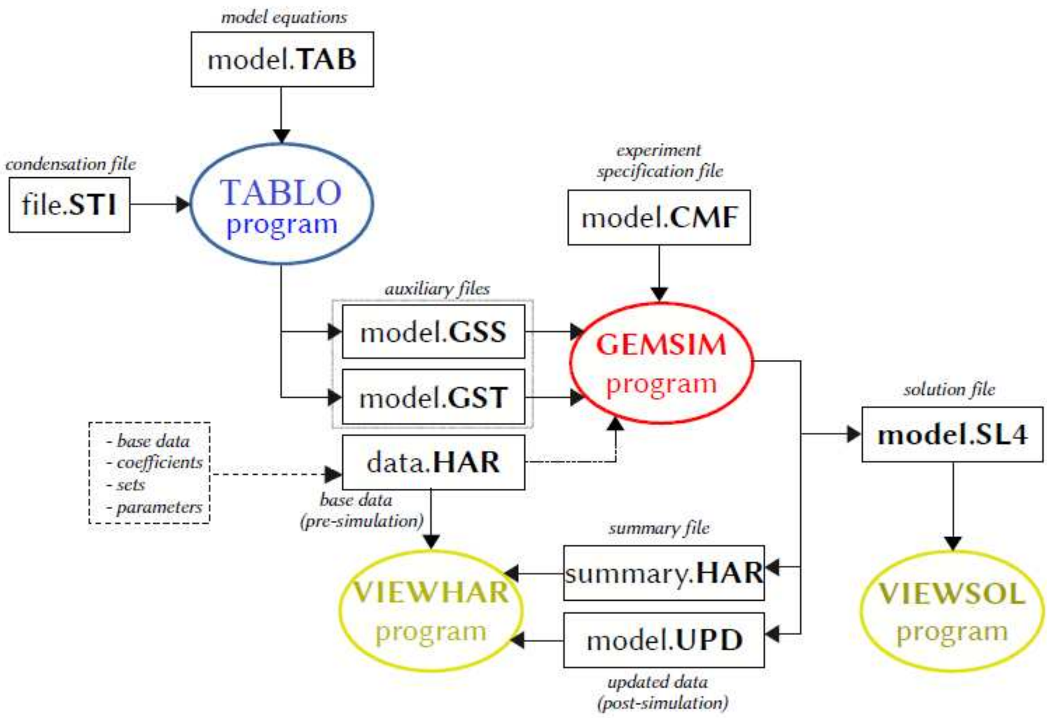

Figure E.1 – The functioning of GEMPACK

The circular boxes represent each program in the GEMPACK package; rectangular boxes represent files generated/used by programs. Files in `.TAB` and `.STI` format are text files, which describe the model's coefficients, variables, equations, and specifications (such as omissions, substitutions, and back solves).

From the text files used as input, *TABLO* generates auxiliary files (`.GSS` and `.GST`) which contain binary files, in computational language, representing the model. *GEMSIM* compiles the `.GSS` and `.GST` files to solve the model described in *model.TAB* and *file.STI*. In addition to the binary files, *GEMSIM* requires a file in `.HAR` format (Header ARray file) that contains the model database (flows, sets, coefficients and parameters), that is, all the information on the behavior of the agents and the initial balance of the model.

GEMSIM also needs a text file in `.CMF` (CoMmand File) format that contains guidelines for: exogenous and endogenous variables; the shocks applied to the model; solution method;

[1] This section is based on Dixon et al. (1982), Harrison et al. (2014), Horridge (2003)

output and input filenames. The files generated at the end of the simulation can be in the following formats: .HAR and .UPD, read by the *VIEWHAR* program; .SL4, read by the *VIEWSOL* program.

.SL4 files are solution files that show percentage changes in variables from the initial equilibrium. The *summary.HAR* files are check files for the initial model data, which do not need the .CMF file to be generated. The files *model.UPD* contain the post-simulation values of the values presented in *data.HAR*.

E.2 The Percentage-Change Approach to Model Solution

The model used in this Thesis,as all models using GEMPACK, is solved by represent it as a series of linear equations relating percentage changes in model variables, following Johansen (1960). A Computable General Equilibrium model can be represented in level by:

$$F(Y,X) = 0 \tag{E.1}$$

where Y is the vector of endogenous variables; X is a vector of exogenous variables; and, F is a system of non-linear equations. The problem is, therefore, to describe Y, given X. Normally, you cannot explicitly write Y. The linearisation approach assumes that there is already a solution for the system, $\{Y^0,X^0\}$:

$$F(Y^0,X^0) = 0 \tag{E.2}$$

The initial solution $\{Y^0,X^0\}$ is the initial balance found from a database (assumed that the system of equations "was true at some point in the past"). Small changes dY and dX are expressed by:

$$F_Y(Y,X)dY + F_X(Y,X)dX = 0 \tag{E.3}$$

where F_Y and F_X are matrices of the derivatives of F with respect to Y and X, evaluated at Y^0,X^0. Lets accept that it is more convenient to express dY and dX as small percentage changes y and x. Thus, some typical elements of y and x, are given by:

$$y = 100\frac{dY}{Y} \text{ and } x = 100\frac{dX}{X}$$

Thus, it is defined:

$$G_Y(Y,X) = F_Y(Y,X)\widehat{Y} \text{ and } G_X(Y,X) = F_X(Y,X)\widehat{X}$$

being $\widehat{Y}$ e $\widehat{X}$ diagonal arrays. Therefore, the linear system can be described as:

$$G_Y(Y,X)y + G_X(Y,X)x = 0 \tag{E.4}$$

These systems can be solve by computers using standard linear algebra techniques. But they are only accurate for small changes in Y and X. Otherwise, linearisation error may occur. The error is illustrated by Figure E.2, showing some endogenous Y variables change as an exogenous

X variable moves from X^0 to X^F. The true non-linear relationship between X and Y is shown as a curve. The linear (first-order) approximation:

$$y = - \quad G_Y(Y,X)^{-1}G_X(Y,X)x \qquad \text{(E.5)}$$

let Y^J to Johansen's estimate, and an approximation of the true answer, Y^{exact}:

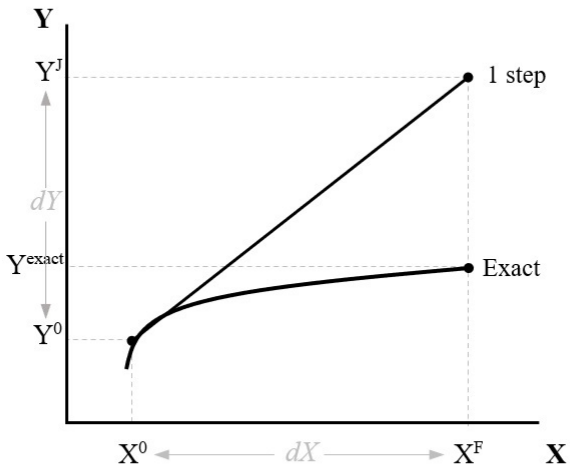

Figure E.2 – Linearisation error – 1 step

The figure shows that, the larger is x, the greater is the proportional error in y. This observation leads to the idea of breaking large changes in X into a number of steps, as shown in Figure E.3. For each sub-change in X, it is used the linear approximation to derive the consequent sub-change in Y. Then, using the new values of X and Y, recomputing the coefficient matrices G_Y and G_X.

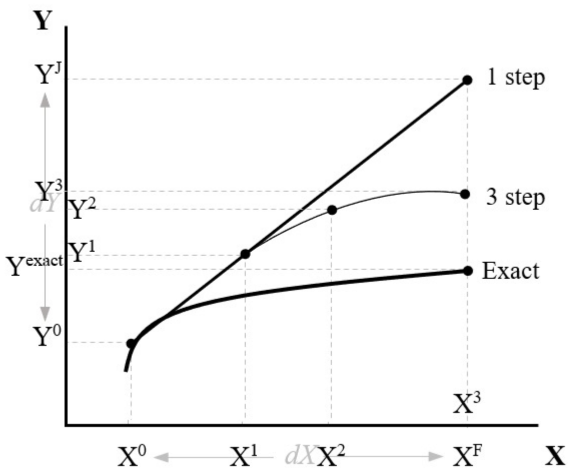

Figure E.3 – Linearisation error – many steps

The process is repeated for each step. Then, using the new values of X and Y, we recalculate the coefficient matrices G_Y and G_X. The process is repeated for each step. If 3 steps is used, the final value Y^3 is closer to Y^{exact} than Johansen's estimate of Y^J. It is possible to show that, given the derivative-sensitive constraints of $F(Y,X)$, to get as precise a solution as liked by dividing the process into several steps.

In practice, it is not necessary, during a multi step calculation, to record values for each element in X and Y. Instead, it is possible to define a set of data coefficients V, which are functions of X and Y, i.e. V = H(X,Y). Most elements of V are simple costs or expense streams, as they appear in the input and output tables. G_Y and G_X are functions of V; often identical to the elements of V.

After each small change, V is updated using the formula v = HY(X,Y)y + HX(X,Y)x. The advantages of storing V instead of X and Y are:

- The expressions for G_Y and G_X in terms of V tend to be simple, often much simpler than the original F functions, and;
- There are fewer elements in V than in X and Y (for example, instead of storing prices and quantities separately, it is stored only their products, commodity values, or factor flows).

E.2.1 The linearised system

Considering a system of equations representing a demand with Constant Substitution Elasticity (CES) for a producer that produces an output Z from N inputs X_k= 1,N, with prices p_k. There is, in a percentage change approach:

$$x_k = z - \sigma(p_k - p_{ave}), \qquad k = 1,N \tag{E.6}$$

$$p_{ave} = \sum_{i=1}^{N} S_i p_i \tag{E.7}$$

where S_i are the costs shares, $S_i = \frac{V_i}{\sum_{k=1}^{N} V_K}$.

The flows data, after a change, is updated as follows: $V_{k,new} = V_{k,old} + \frac{V_{k,old}(x_k + p_k)}{100}$.

GEMPACK is designed to make the linear solution process as easy as possible. The user specifies the linear equations and the update formulae in the TABLO language (resembles algebraic notation), and the software repeatedly:

- evaluates G_Y and G_X at given values of V;
- solves the linear system to find y, taking advantage of the sparsity of G_Y and G_X; and
- updates the data coefficients V.

The linearised approach has three further advantages:

1. It allows free choice of which variables are to be exogenous or endogenous;
2. In GEMPACK, the model can be specified in terms of its original behavioural equations, rather than in a reduced form, reducing the potential for error and making equations easier to check.
3. The linearised equations help to understand simulation results. It is possible to see the contribution of (the change in) each *Right Hand Side* variable to the textitLeft Hand Side of each equation. For example, in the price index equation:

$$p_{ave} = \sum_{i=1}^{N} S_i p_i$$

it is possible to identify the contribution of each individual price p_i to the index p_{ave}.

E.2.1.1 Derivating the Constant Elasticity Substitution demand equation system

Considering a Constant Elasticity Substitution (CES)[2] Production Function where each user combines imported and domestically-produced commodity to produce a “composite”. Let X_d and X_m be the quantities of domestic and imported, and X is the output of composite. A_d, A_m and α are parameters, $\alpha<1$. Different isoquants correspond to different values of X. Each of the isoquants in Figure E.4 shows the different combinations of domestic and imported input which would yield the same amount of composite. The lower curve shows all the import-domestic combinations which produce 10 units of composite. Similarly the upper curve shows combinations yielding 15 units. These curves may be represented by the CES equation:

$$X^{\alpha} = \left[\frac{X_d}{A_d}\right]^{\alpha} + \left[\frac{X_m}{A_m}\right]^{\alpha} \tag{E.8}$$

The Constant Elasticity Substitution function has the constant-returns-to-scale property: if double both inputs, the output, X, will also be doubled. This means that, on Figure E.4, the $X=15$ isoquant has just the same shape as the $X=10$ isoquant (being simply 50% larger and 50% further from the origin). Therefore, if a ray R is drawn from the origin it will cut each isoquant at the same angle.

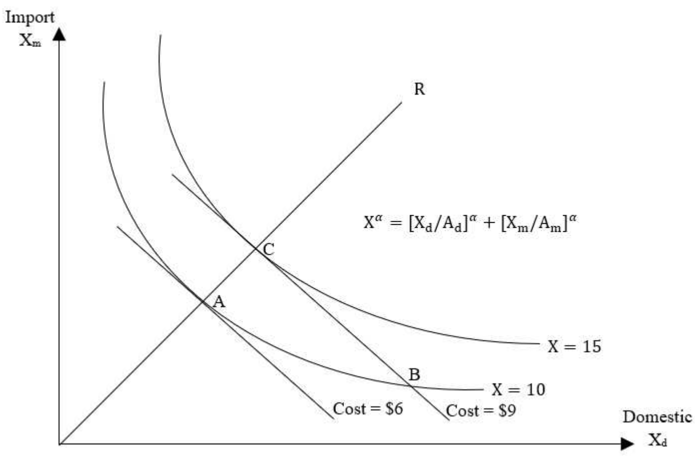

Figure E.4 – Isoquants of CES production function

The downward-sloping straight lines in Figure E.4 are isocost lines, showing the different combinations of domestic and imported input which would add up to the same cost - this is the cost restriction as well. For example, the lower line shows all the import-domestic combinations which in total cost \$6. On the other hand, the upper line shows combinations costing \$9. The equations of the isocost lines are:

$$C = X_d P_d + X_m P_m \tag{E.9}$$

where C is total cost; P_d and P_m are the domestic and imported prices. The user treats these prices as given (price-taker assumption), and can not affect input prices.

[2] This subsection is based on Horridge (2001)

Each price ratio, $\frac{P_d}{P_m}$, gives rise to a unique set of parallel isocost lines. If both prices doubled, the cost associated with each line would double, but the slope $\left(= -\frac{P_d}{P_m}\right)$ would not change. The lower isoquant in Figure E.4 shows that not all ways to produce 10 units of composite are equally cost-effective. For example, at point B we get 10 units of outputs at a cost of \$9 (unit cost 90 cents). At point A the same output costs only \$6 (unit cost 60 cents). Indeed, with the isocost lines shown,A, where the price line is tangent to the isoquant X=10, is the minimum cost combination. Each user always will choose the minimum cost combination corresponding to its X.

At given prices, all these combinations will lie along the ray R. It is deduced that:

a. demand for each input is proportional to the composite quantity X;

b. demand for each input is a function of the price ratio $\left[\frac{P_m}{P_d}\right]$;

c. the minimum unit cost depends on P_m and P_d but not on X;

d. if P_m and P_d double, so will the minimum unit cost of X.

It is also possible to observe that moving a little way from A along the isoquant will not increase the unit cost much. This is illustrated in Figure E.5, which shows unit cost (given the input prices) as a function of the ratio of inputs. At the minimum cost combination, small changes in inputs will not affect the unit cost of output.

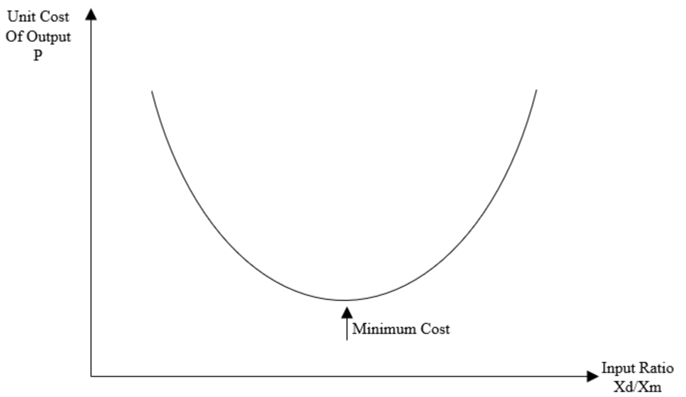

Figure E.5 – Unit cost as function of input ratio

Figure E.6 shows the effect of a change in prices. The line PR1 corresponds to the minimum cost of 10 units of output at the initial price ratio; PR2 corresponds to the minimum cost of a new price ratio (increase on P_d in this example). The change in the ratio of input prices causes the cost-minimizing combination to move from A to B. The size of the change depends on the curvature of the isoquant: if it were flatter (α nearer to 1) the change would be greater.

It is possible to show how input proportions depend on input prices for the CES "agregator". Assuming that each user has chosen a cost-minimizing combination, and defining a unit cost of output, P, such that:

$$XP = X_d P_d + X_m P_m \text{ or } P = \frac{[X_d P_d + X_m P_m]}{X} \tag{E.10}$$

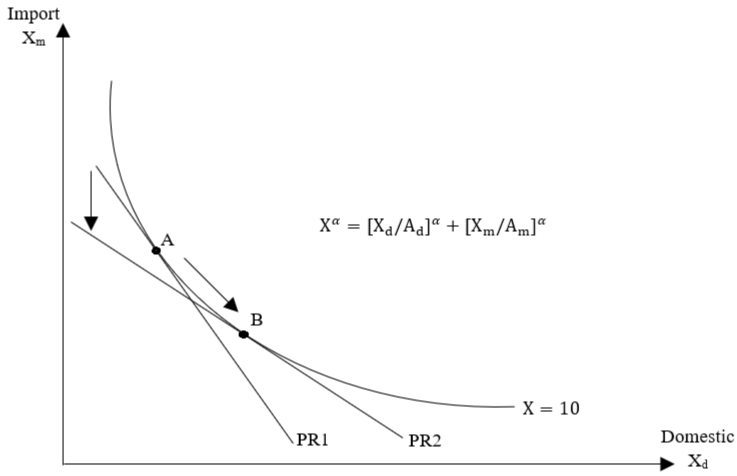

Figure E.6 – Effect of a price change

Remembering that near the cost-minimizing optimum, small changes in input quantities do not affect P: at the optimum P is a function only of input prices P_d and P_m. This means that increasing X_d by \$1 worth will increase the value of output by \$1.In other words, a small increase in X_d, dX_d, will give rise to a small increase in output, dX, such that:

$$PdX = P_d dX_d \tag{E.11}$$

Another way to calculate dX is to totally differentiate the CES production function presented on (17):

$$X^{\alpha} = \left[\frac{X_d}{A_d}\right]^{\alpha} + \left[\frac{X_m}{A_m}\right]^{\alpha}$$

Assuming that X_m does not change:

$$X^{\alpha}\frac{dX}{X} = [X_d/A_d]^{\alpha}\frac{dX_d}{X_d} \tag{E.12}$$

so adding 1\$ worth of X_d ($dX_{d=1}/P_d$) adds 1\$ to minimum cost ($dX=1/P$):

$$X^{\alpha}\frac{1}{XP} = [X_d/A_d]^{\alpha}\frac{1}{X_d P_d} \tag{E.13}$$

$$\frac{X_d P_d}{XP} = \frac{[X_d/A_d]^{\alpha}}{X^{\alpha}} = S_d \tag{22'}$$

where S_d is the share of X_d in total cost.

Em percentage-change form:

$$x_d + p_d - (x + p) = \alpha(x_d - x)$$

so $p_d - p = (\alpha - 1)(x_d - x)$, thus:

$$x_d = x - \sigma(p_d - p)$$

where $\sigma = \dfrac{1}{(1 - \alpha)}$.

To x_m:

$$x_m = x - \sigma(p_m - p)$$

CGE models use CES for more than 1 inputs, thus:

$$x_i = x - \sigma(pi - p) \quad i = 1,..,N$$

$$p = \sum_{i=1}^{n} S_i p_i$$

Two special cases arise: if $\sigma = 0$, then demand for each input simply follows output: the Leontief demand structure (or input are combined in fixed proportion). If $\sigma = 1$, then expenditure on each input follows total cost (take into account each input cost):

$$x_i + p_i = x + p \qquad i = 1..N,$$

is the Cobb-Douglas demand structure, where cost shares do not change.

E.2.1.2 An example between consumption of imported and domestic goods

Considering a linear model, with a percentage change approach; each industry and each final demand substitutes between imported and domestically-produced versions of each commodity. For each good and agent, the ratio of imported and domestic purchases is a function only of the relative prices of goods from the two sources. The same functional form applies in all cases: derived from the Constant-Elasticity-of-Substitution (CES) production function.

For a particular good and user—for example, household use of services, the following percent change equations determine the import/domestic ratio (lowercase indicate percentage change):

$$p_{ave} = S_d p_d + S_m p_m \tag{E.14}$$

$$x_d = x - \sigma(p_d - p_{ave}) \tag{E.15}$$

$$x_m = x - \sigma(p_m - p_{ave}) \tag{E.16}$$

where x_d and x_m are the demands for domestic and imported Services, with p_d and p_m the corresponding prices; x is the overall demand for Services, and p_{ave} is an average of domestic and imported prices (also called the demand and price for the composite); S_d and S_m are the shares for each source of total spending (by this specific user) on Services; and, σ is the elasticity of substitution between sources (the Armington elasticity).

The equations (23), (24) and (25) determine the variables p_{ave}, x_d, x_m; the remaining variables x, p_d, p_m are determined elsewhere in the model (in other words, they are exogenous, and can be shocked). The effect of the 3 equations is that:

- if the ratio of domestic and imported prices do not change, x_d and x_m will both follow the total demand for the composite, x;
- if the import price, p_m, rises relative to the domestic price, p_d, the ratio of imported to domestic input will fall (the opposite is true).

As an example, suppose that the imported price p_m falls by 10% with x and p_d unchanged ($x = p_d = 0$). Let $S_m = 0.3$ and $\sigma = 2$. This gives:

$$p_{ave} = 0.3(-10) = -3$$

$$x_d = -2(3) = -6$$

$$x_m = -2(-10+3) = 14$$

Thus, cheaper imports increase in 14% import volumes and fall in domestic demand in 6% . The effect on domestic sales is proportional to both S_m and σ. Furthermore, the approach considers a two-stage decision system. First, the agent decides how much to consume of a given commodity, then, depending on the price of the relatives (between domestic and imported), the quantity of each source.

Table E.3 – Examples of Percentage-Change Forms

Original (Nível)	Intermediate Form	Percentage-Change
$Y = 4$	$Yy = 4^*0$	$y = 0$
$Y = X$	$Yy = Xx$	$x = y$
$Y = 3X$	$Yy = 3Xx$	$x = y$
$Y = ZX$	$Yy = ZzXx$	$x = z + y$ or $y = x + 100(\frac{X}{Y})\Delta Z$
$Y = X/Z$	$Yy = (X/Z)x - (X/Z)z$	$y = x - z$ or $100(Z)\Delta Y = Xx - Xz$ or $100\Delta Y = Y(x - z)$
$X_1 = M/4P_1$	$X_1x_1 = (M/4P_1)m - (M/4P_1)p_1$	$x_1 = m - p_1$
$Y = X^a$	$Yy = X^a ax$	$y = ax$ (a constant)
$Y = X + Z$	$Yy = Xx + Zz$	$y = S_x x + S_z z$ where $S_x = X/Y$
$Y = X - Z$	$Yy = Xx - Zz$	$y = S_x x - S_z z$ or where $100(\Delta Y) = Xx - Zz$
$PY = PX + PZ$	$PY(y + p) = PX(x + p) + PZ(p + z)$ or $PYy = PXx + PZz$	$y = S_x x - S_z z$ or where $100(\Delta Y) = Xx - Zz$
$Z = \sum X_i$	$Zz = \sum X_i x_i$ or $0 = \sum X_i(x_i - z)$	$z = \sum S_i x_i$ where $S_i = X_i/Z$
$XP = \sum X_i P_i$ (adding up values)	$XP(x + p) = \sum X_i P_i(x_i + p_i)$ or $V(x + p) = \sum V_i(x_i + p_i)$ where $V_i = P_i X_i$ and $V = \sum V_i$	$x + p = \sum S_i(x_i + p_i)$ where $S_i = V_i/V$
$X = \sum X_i$ where all X_i have price P	$Xx = \sum X_i x_i$ or $PX_x = \sum PX_i x_i$ or $V_x = \sum V_i x_i$ where $V_i = PX_i$ and $V = \sum V_i$	$x = \sum S_i x_i$ where $S_i = V_i/V$
$PX = \sum X_i P_i$ (price and quantity indices)	$V(x + p) = \sum V_i(x_i + p_i)$ where $V_i = P_i X_i$ and $V = \sum V_i$	$V_x = \sum V_i x_i$ or $0 = \sum V_i(x - x_i)$ $V_p = \sum V_i p_i$ or $0 = \sum V_i(p - p_i)$

It is assumed that:
a vector of quantities X_i, total X;
a vector of prices P_i, average P;
a vector of values V_i, total V, such that $V_i = P_i X_i$, (thus $v_i = p_i + x_i$);
that $V = PX$, (thus $v = p + x$).

E.4 Change Equations of a CES Nest

E.4.1 How to derive percent-change equations

Starting from a level equation:

$$Y = X^2 + Z$$

taking the total differences:

$$dY = 2XdX + dZ$$

percent-change x, y and z are defined as: $y = 100\frac{dY}{Y}$, or $dY = \frac{Yy}{100}$ and similarly for $dX = \frac{Xx}{100}$ and $dZ = \frac{Zz}{100}$.
Therefore, the equation can be written as:

$$\frac{Yy}{100} = 2X\frac{Xx}{100} + \frac{Zz}{100}$$
$$Yy = 2X^2x + Zz$$

E.4.2 Percentage-Change Equations of a CES Nest

Starting from the problem of choosing inputs $X_i > 0$ ($i = 1$ *to* N), aiming to minimize the production costs of the output $Z : \sum_i P_iX_i$, subject to the production function:

$$Z = \left(\sum_i \delta_i X_i^{-\rho}\right)^{-(1/\rho)} \qquad -1 > \rho > \infty$$

The first order conditions are:

$$P_k = \lambda\frac{\partial Z}{\partial X_k} = \lambda\delta_k X_k^{(1-\rho)}\left(\sum_i \delta_i X_i^{-rho}\right)^{-(1-\rho)/\rho}$$

So $\frac{P_k}{P_i} = \frac{\delta_k}{\delta_i}\left(\frac{X_i}{X_k}\right)^{1+\rho}$, or $X_i^{-\rho} = \left(\frac{\delta_i P_k}{\delta_k P_i}\right)^{-\rho/(\rho+1)} X_k^{-\rho}$. Substituting into the production function, we have:

$$Z = X_k\left(\sum_i \delta_i \left[\frac{\delta_k P_i}{\delta_i P_k}\right]^{\rho/(\rho+1)}\right)^{-1/rho}$$

Which gives us the demand for inputs: $X_k = Z\delta_k^{1/(\rho+1)}\left[\frac{P_k}{P_{ave}}\right]^{-1/(\rho+1)}$, where
$P_{ave} = \left(\sum_i \delta_i^{1/(\rho+1)} p_i^{\rho/\rho+1}\right)^{(\rho+1)/\rho}$.

In percentage change, we have:

$$x_k = z - \sigma(p_k - p_{bird}),$$
$$p_{bird} = \sum_i S_i p_i,$$

where $\sigma = \frac{1}{1+\sigma}$, i.e. $\sigma = \frac{1-\sigma}{\sigma}$ so $0 > \sigma >$ and $S_i = \frac{\delta_i^{1/(\rho+1)} p_i^{\rho/(\rho+1)}}{\sum_k \delta_k^{1/(\rho+1)} p_k^{\rho/(\rho+1)}}$.

Multiplying both sides of the input demand equation by P_k, we get:

$$P_k X_k = Z\delta_k^{1/(\rho+1)} p_k^{\rho/(\rho+1)} p_{bird}^{1/(\rho+1)}$$

.

Therefore, $\dfrac{P_k X_k}{\sum_i P_i X_i} = \dfrac{\delta_k^{1/(\rho+1)} P_k^{\rho/(p+1)}}{\sum_i \delta_i^{1/(\rho+1)} p_i^{\rho/(\rho+1)}} = S_k$, thus, S_i are the cost shares.

E.4.3 Technical change terms

Adding technological changes, you should choose the X_i inputs to minimize $\sum_i P_i X_i$, subject to:

$$Z = \left(\sum_i \delta_i \left[\frac{X_i}{A_i} \right]^{-\rho} \right)^{-1/\rho)}$$

.

Assuming $\tilde{X}_i = \dfrac{X_i}{A_i}$ and $\tilde{P} = P_i A_i$, we have:

Minimize $\sum_i \tilde{P}_i \tilde{X}_i$ subject to $Z = \left(\sum_i \delta_i \tilde{X}_i^{-\rho} \right)^{-1/\rho}$.

In percentage-change form, one can write:

$$\tilde{x}_k = z - \sigma(\tilde{p} - \tilde{p}_{bird}),$$

$$\tilde{p}_{bird} = \sum_i S_i \tilde{p}_i$$

.

If $\tilde{x}_i = x_i - a_i$, and $\tilde{p}_i = p_i - a_i$, we have:

$$x_k - a_k = z - \sigma(p_k + a_k - \tilde{p}_{ave}),$$

$$\tilde{p}_{bird} = \sum_i S_i(p_i + a_i).$$

When technical change terms are included, we call $\tilde{x}_k$, $\tilde{p}_k$ and $\tilde{p}_{ave}$ effective indices of input quantities and prices. One can write the above equation, to aggregate a_k, as:

$$x_k = z - \sigma(p_k - \sum_i S_i p_i) + a_k - \sigma(a_k - \sum_i S_i a_i)$$

E.4.4 Adding Taxes on CES

First, it is necessary to differentiate approaches to rates of change in prices. In GEMPACK it is about changes in the power of the tariff instead of changes in the tariff, because the code is essentially written in *log differentials*. Considering the equation relating prices is rate *ad valorem*, in level:

$$P_a = P * (1 + T)$$

where T is the change in the rate *ad valorem* and (1+T) is the power of the tariff. Considering the differential log, we have:

$$d\ln(P_a) = d\ln(P) + d\ln(1 + T)$$

$$p_a = p + t$$

where t is the change in the power of the tariff.

So

$$t = \frac{1+T}{100}$$

Starting from a Function with Constant Substitution Elasticity - let's say that expresses the consumption of imported and domestic manufactures by households, in terms of percentage changes:

$$p_{ave} = S_d p_d + S_m p_m$$
$$x_d = x - \sigma(p_d - p_{ave})$$
$$x_m = x - \sigma(p_m - p_{ave})$$

You can add the power of the tariff on imported and domestic goods, considering:

$$p_d = 1 + tg_d$$
$$p_m = 1 + tg_m$$

Now, we must assume p_d and p_m as endogenous (assuming that the number of endogenous variables is equal to the number of equations), and the rates as exogenous, which can suffer shocks. Assuming $S_m = 0.3$; $S_d = 0.7$; $\sigma = 2$. Choosing to raise the tax on imported products by 10%, we have:

$$p_d = 1 + 0.10$$
$$p_m = 1 + 0$$

Então:

$$p_{ave} = 0.7(1) + 0.3(1.10) = 1.03$$
$$x_d = -2(1 - 1.03) = 0.06$$
$$x_m = -2(1.10 - 1.03) = 0.14$$

Thus, a 10% increase in taxes on imported goods would raise the relative price of imports against domestic goods by (1.03 - 1) = 3%, the quantity imported is reduced by 6% and the quantity consumed domestically rises by 14%.

E.4.5 Model Information

Table E.4 – Model's Information

Parameter	Dimension	Desciption
COM	19	Tradded commodities
IND	19	Industries
MARG	1	Margin commodities (otp) - subset of COM
NMRG	18	Non-marging commodities (COM - MARG)
CGDS	1	Capital good commodities
ENDW	4	Endowment commodities (ENDWS + ENDWM)
BRA	5	Brazilian regions - subset of REG
NONBRA	16	REG - BRA
FAM	10	Families classes in BRA
SKLL	12	Families skill levels in BRA
TRNSF	5	Tranfers from GOVT to FAM in BRA
PROD	20	Produced commodities (COM + CGDS)
DEMD	25	Demanded commodities (ENDW + COM)
NSAV	26	Non-saving commodities (DEMD + CGDS)

Model's Size

Number of Coefficients	193	
Number of Variables	Un-condensed	Condensed
	229	203
	(250,546 Components)	*(83,518 Components)*
Number of Equations Blocks	Un-condensed	Condensed
	214	196
	(182,254 Components)	*(41,581 Components)*
	Closure Requirement	41937 exog.

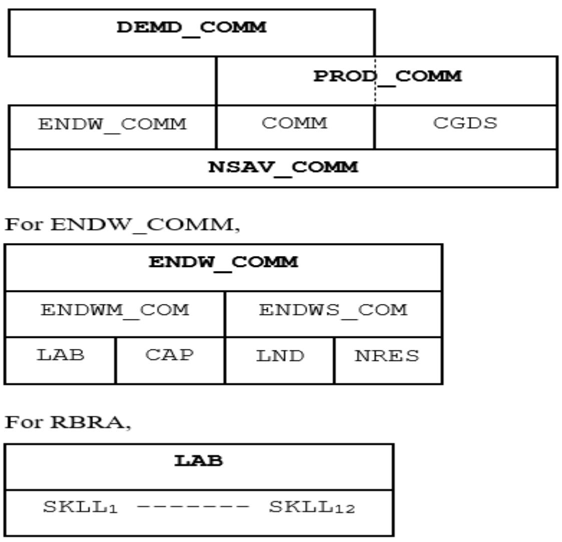

Figure E.7 – Aide-Memoire for Sets

Table E.5 – Model's List of Coefficient

Header	Size	Description
BRABAL		ratio BOT/GDP
CHKMKCLIMP(c,r)	c_ϵCOM r_ϵREG	Checking the accounting on imports supply and demand
CONSHR(i,r)	i_ϵCOM r_ϵREG	Share of private hhld consumption devoted to good i in r
COSTSUM(a,r,c)	a_ϵCOM r_ϵREGPLUS c_ϵCOSTS	Industry cost summary
COSTSUMBRA(a,c)	a_ϵCOM c_ϵCOSTS	Brazil industry cost summary
delGVACC(i,r)	i_ϵITEMS r_ϵBRA	Change Government accounts
DFTAX(i,j,r)	i_ϵCOM j_ϵPROD_COMM r_ϵREG	Tax on use of domestic intermediate good i by j in r
DGTAX(i,r)	i_ϵCOM r_ϵREG	Tax on government consumption of domestic good i in region r
DPTAX(i,r)	i_ϵCOM r_ϵREG	Tax on private consumption of domestic good i in region r
ESUBD(i)	i_ϵCOM	Region-generic el. of sub. domestic/imported for all agents
ESUBM(i)	i_ϵCOM	Region-generic el. of sub. among imports of i in Armington structure
ESUBT(j)	j_ϵPROD_COMM	Elst. of sub. among composite intermediate inputs in production
ESUBVA(j)	j_ϵPROD_COMM	Elst. of sub. capital/labour/land, in production of value added in j
ESUSKL(c,s)	c_ϵCOM s_ϵSKLL	CES substitution between skill types
ETAX(i,j,r)	i_ϵENDW j_ϵPROD_COMM r_ϵREG	Tax on use of endowment good i by industry j in region r
ETRAE(i)	i_ϵENDW	Elst. of transformation for sluggish primary factor endowments
EVFA(i,j,r)	i_ϵENDW j_ϵPROD_COMM r_ϵREG	Producer expenditure on i by j in r at agent's prices
EVOA(i,r)	i_ϵENDW r_ϵREG	Value of commodity i output in region r
FAMINCSUM(f,r,b)	f_ϵFAM r_ϵBRA b_ϵFAMINCBITS	Family income summary
FCAP(f,r)	f_ϵFAM r_ϵBRA	Families Capital Income
FCHECK(i,r)	i_ϵCOM r_ϵBRA	VPA(i,r)-sum{f,FAM,FPA(i,r,f)
FCSHR(i,r,f)	i_ϵCOM r_ϵBRA f_ϵFAM	Share of families consumption devoted to good i in r
FLAB(c,f,r,s)	c_ϵCOM f_ϵFAM r_ϵBRA s_ϵSKLL	Industry wage bills by family
FLAB_C(f,r,s)	f_ϵFAM r_ϵBRA s_ϵSKLL	Wage bills subtotal
FLAB_CF(r,s)	r_ϵBRA s_ϵSKLL	Total wage bill by skill
FLAB_F(c,r,s)	c_ϵCOM r_ϵBRA s_ϵSKLL	Industry wage bills
FLAB_FS(c,r)	c_ϵCOM r_ϵBRA	Total labour bill in industry i in region r
FLAB_CF(r,s)	r_ϵBRA s_ϵSKLL	Total wage bill by skill
FLAB_F(c,r,s)	c_ϵCOM r_ϵBRA s_ϵSKLL	Industry wage bills

Table E.5 – Model's List of Coefficient (continued...)

Header	Size	Description
FLAB_FS(c,r)	c$_\epsilon$COM r$_\epsilon$BRA	Total labour bill in industry i in region r
FLND(f,r)	f$_\epsilon$FAM r$_\epsilon$BRA	Families Capital Income
FMSHR(i,j,s)	i$_\epsilon$COM j$_\epsilon$PROD_COMM s$_\epsilon$REG	Share of firms' imports in dom. composite, agent's prices
FOBSHR(i,r,s)	i$_\epsilon$COM r$_\epsilon$REG s$_\epsilon$REG	FOB share in VIW
FPA(i,r,f)	i$_\epsilon$COM r$_\epsilon$BRA f$_\epsilon$FAM	Families expenditure on i in r valued at agent's prices
FPA_C(r,f)	r$_\epsilon$BRA f$_\epsilon$FAM	Total families consumption
FPA_F(i,r)	i$_\epsilon$COM r$_\epsilon$BRA	All-Families expenditure on i in r valued at agent's prices
FWAGE(f,r)	f$_\epsilon$FAM r$_\epsilon$BRA	Family labour income
FY(r)	r$_\epsilon$REG	Primary factor income in r
GOVEXP(r)	r$_\epsilon$REG	Government expenditure in region r
GVACC(i,r)	i$_\epsilon$ITEMS r$_\epsilon$BRA	Government accounts
GVACC0(i,r)	i$_\epsilon$ITEMS r$_\epsilon$BRA	Government accounts
GVEXP(g,r)	g$_\epsilon$GEXP r$_\epsilon$BRA	Government spending
GVEXPTOT(r)	r$_\epsilon$BRA	Government expenditure
GVINC(g,r)	g$_\epsilon$GINC r$_\epsilon$BRA	Government income
GVINCTOT(r)	r$_\epsilon$BRA	Government income
GVSAV(r)	r$_\epsilon$BRA	Government income - expenditure
IFTAX(i,j,r)	i$_\epsilon$COM j$_\epsilon$PROD_COMM r$_\epsilon$REG	Tax on use of imported intermediate good i by j in r
IGTAX(i,r)	i$_\epsilon$COM r$_\epsilon$REG	Tax on government consumption of imported good i in region r
INCOME(r)	r$_\epsilon$REG	Level of expenditure, which equals NET income in region r
INDTAX(r)	r$_\epsilon$REG	Indirect tax receipts in r
INDTAX2(r)	r$_\epsilon$REG	INDTAX + TINC
INITGDP(r)	r$_\epsilon$REG	Initial real GDP at current prices
INITGDP_B		Initial real GDP at current prices - BRA
IPTAX(i,r)	i$_\epsilon$COM r$_\epsilon$REG	Tax on private consumption of imported good i in region r
ISBRA(r)	r$_\epsilon$REG	Dummy, 1 for BRA
ISPBF(t)	t$_\epsilon$TRNSF	Dummy, 1 for PBF
ITAX(f,r)	f$_\epsilon$FAM r$_\epsilon$BRA	Income Tax from Families to Govt (POF)
LABCHECK(c,r)	c$_\epsilon$COM r$_\epsilon$BRA	Labour check % err
LBAL(i,r)	i$_\epsilon$COM r$_\epsilon$REG	VXW(i,r) - VIW(i,r)
LEVTPD(i,r)	i$_\epsilon$COM r$_\epsilon$REG	Levels TPD
MSHRS(i,r,s)	i$_\epsilon$COM r$_\epsilon$REG s$_\epsilon$REG	Share of imports from r in import bill of s at mkt prices

Table E.5 – Model's List of Coefficient (continued...)

Header	Size	Description
MTAX(i,r,s)	i_ϵCOM r_ϵREG s_ϵREG	Tax on imports of good i from source r in destination s
NREG		
PMSHR(i,s)	i_ϵCOM s_ϵREG	Share of imports for priv hhld at agent's prices
PTAX(i,r)	i_ϵNSAV_COMM r_ϵREG	Output tax on good i in region r
PW_PM(i,r)	i_ϵCOM r_ϵREG	Ratio of world to domestic prices
RECIPNREG		
REGINV(r)	r_ϵREG	Regional GROSS investment in r (value of "cgds" output)
REVSHR(i,j,r)	i_ϵENDW j_ϵPROD_COMM r_ϵREG	
SALESUM(c,r,s)	c_ϵCOM r_ϵREGPLUS s_ϵSALES	Commodity sales summary
SALESUMBRA(c,s)	c_ϵCOM s_ϵSALES	Brazil commodity sales summary
SAM(r,e,i)	r_ϵREG e_ϵEXP i_ϵRES	Aggregate SAM
SAMCHECK(r,s)	r_ϵREG s_ϵSAMC	
SAMCOLTOT(r,i)	r_ϵREG i_ϵRES	
SAMROWTOT(r,e)	r_ϵREG e_ϵEXP	
SHRDFM(i,j,r)	i_ϵCOM j_ϵPROD_COMM r_ϵREG	Share of dom. prod. i used by sector j in r at mkt prices
SHRDGM(i,r)	i_ϵCOM r_ϵREG	Share of imports of i used by gov't hhlds in r
SHRDM(i,r)	i_ϵCOM r_ϵREG	Share of domestic sales of i in r
SHRDPM(i,r)	i_ϵCOM r_ϵREG	Share of domestic prod. of i used by private hhlds in r
SHREM(i,j,r)	i_ϵENDWM_COMM j_ϵPROD_COMM r_ϵREG	Share of mobile endowment i used by sector j at mkt prices
SHRIFM(i,j,r)	i_ϵCOM j_ϵPROD_COMM r_ϵREG	Share of import i used by sector j in r
SHRIGM(i,r)	i_ϵCOM r_ϵREG	The share of import i used by gov't hhlds in r
SHRIPM(i,r)	i_ϵCOM r_ϵREG	Share of import i used by private hhlds in r
SHRST(m,r)	m_ϵMARG r_ϵREG	Share of sales of m to global transport services in r
SHRXMD(i,r,s)	i_ϵCOM r_ϵREG s_ϵREG	Share of export sales of i to s in r
SIZE_CGDS		Size of CGDS_COMM set
SIZE_DEMD		Size of DEMD set
SIZE_ENDW		Size of ENDW set
SIZE_PROD		Size of PROD_COMM set
SIZE_TRAD		Size of COM set
SLUG(i)	i_ϵENDW	Sluggish primary factor endowments
SM_IR(i,r)	i_ϵCOM r_ϵREG	Share of good i in total imports into r
SM_IRS(i,r,s)	i_ϵCOM r_ϵREG s_ϵREG	Share of imports of good i into s from r at FOB prices

Table E.5 – Model's List of Coefficient (continued...)

Header	**Size**	**Description**
SMT_IR(m,r)	m_{ϵ}MARG r_{ϵ}REG	Share of transport cost in imports of margin commodity
STC(i,j,r)	i_{ϵ}DEMD j_{ϵ}PROD_COMM r_{ϵ}REG	Share of i in total costs of j in r
SVA(i,j,r)	i_{ϵ}ENDW j_{ϵ}PROD_COMM r_{ϵ}REG	Share of i in total value added in j in r
SVADEFAULT(i)	i_{ϵ}ENDW	Zerodivide default for SVA
SW_I(i)	i_{ϵ}COM	Share of exports of i in world total
SW_IR(i,r)	i_{ϵ}COM r_{ϵ}REG	Share of region r exports in world total for good i
SX_IR(i,r)	i_{ϵ}COM r_{ϵ}REG	Share of good i in total exports from r
SX_IRS(i,r,s)	i_{ϵ}COM r_{ϵ}REG s_{ϵ}REG	Share of exports of good i from region r to s
SXT_IR(m,r)	m_{ϵ}MARG r_{ϵ}REG	Share of margins in exports of good i from region r
TBAL(r)	r_{ϵ}REG	Trade balance for region r
TEX(r)	r_{ϵ}REG	Export tax payments in r
TFU(r)	r_{ϵ}REG	Firms' tax payments on primary factor usage in r
TGC(r)	r_{ϵ}REG	Government consumption tax payments in r
TIM(r)	r_{ϵ}REG	Import tax payments in r
TINC(r)	r_{ϵ}REG	Income tax payments in r
TINY		Small number to prevent zerodivides or singular matrix
TIU(r)	r_{ϵ}REG	Firms' tax payments on intermediate goods usage in r
TOUT(r)	r_{ϵ}REG	Production tax payments in r
TPC(r)	r_{ϵ}REG	Private consumption tax payments in r
TRANSF(f,r,t)	f_{ϵ}FAM r_{ϵ}BRA t_{ϵ}TRNSF	Transfers from govt to fam
TRDCHK(c,s,d)	c_{ϵ}COM s_{ϵ}REG d_{ϵ}REG	VIWS (c,s,d) - [VXWD(c,s,d) + VTFSD(c,s,d)] should be tiny
TRNSHR(i,r,s)	i_{ϵ}COM r_{ϵ}REG s_{ϵ}REG	Transport share in VIW
UNITWAGE(c,f,r,s)	c_{ϵ}COM f_{ϵ}FAM r_{ϵ}BRA s_{ϵ}SKLL	Million*wagebill/numbers workers employed
UNITWAGE_C(f,r,s)	f_{ϵ}FAM r_{ϵ}BRA s_{ϵ}SKLL	Million*wagebill/numbers workers employed
UNITWAGE_F(c,r,s)	c_{ϵ}COM r_{ϵ}BRA s_{ϵ}SKLL	Million*wagebill/numbers workers employed
VCIF(c,s,d)	c_{ϵ}COM s_{ϵ}REG d_{ϵ}REG	Imported Value at World Price (c.i.f)
VDFA(i,j,r)	i_{ϵ}COM j_{ϵ}PROD_COMM r_{ϵ}REG	Purchases of domestic i for use by j in region r
VDFM(i,j,r)	i_{ϵ}COM j_{ϵ}PROD_COMM r_{ϵ}REG	Purchases of domestic i for use by j in region r
VDGA(i,r)	i_{ϵ}COM r_{ϵ}REG	Govt consumption expenditure on domestic i in r - agent price
VDGM(i,r)	i_{ϵ}COM r_{ϵ}REG	Govt consumption expenditure on domestic i in r - market price
VDM(i,r)	i_{ϵ}COM r_{ϵ}REG	Domestic sales of i in r at mkt prices (tradeables only)
VDPA(i,r)	i_{ϵ}COM r_{ϵ}REG	Private consumption expenditure on domestic i in r

Table E.5 - Model's List of Coefficient (continued...)

Header	**Size**	**Description**
VDPM(i,r)	i_{ϵ}COM r_{ϵ}REG	Private consumption expenditure on domestic i in r
VENDWREG(r)	r_{ϵ}REG	Value of primary factors, at mkt prices, by region
VENDWWLD		Value of primary factors, at mkt prices, worldwide
VFA(i,j,r)	i_{ϵ}DEMD j_{ϵ}PROD_COMM r_{ϵ}REG	Producer expenditure on i by j in r valued at agent's prices
VFAC(i,r)	i_{ϵ}ENDW r_{ϵ}NONBRA	Factor income
VFACINC(i,r)	i_{ϵ}ENDW r_{ϵ}BRA	Factor income
VFACTINC(f,r)	f_{ϵ}FAM r_{ϵ}BRA	Family Factor Income
VFAMCAP(r)	r_{ϵ}BRA	All-Family capital income
VFAMINC(f,r)	f_{ϵ}FAM r_{ϵ}BRA	Family Income
VFM(i,j,r)	i_{ϵ}ENDW j_{ϵ}PROD_COMM r_{ϵ}REG	Producer expenditure on i by j in r valued at mkt prices
VGA(i,r)	i_{ϵ}COM r_{ϵ}REG	Government consn expenditure on i in r at agent's prices
VGNE(r)	r_{ϵ}REG	GNE values
VGNEB		Brazil GNE
VIFA(i,j,r)	i_{ϵ}COM j_{ϵ}PROD_COMM r_{ϵ}REG	Purchases of imported i for use by j in region r
VIFM(i,j,r)	i_{ϵ}COM j_{ϵ}PROD_COMM r_{ϵ}REG	Purchases of imports i for use by j in region r
VIGA(i,r)	i_{ϵ}COM r_{ϵ}REG	Government consumption expenditure on imported i - agent price
VIGM(i,r)	i_{ϵ}COM r_{ϵ}REG	Gov't consumption expenditure on i in r - market price
VIM(i,r)	i_{ϵ}COM r_{ϵ}REG	Value of imports of commodity i in r at domestic market prices
VIMCHK(i,s)	i_{ϵ}COM s_{ϵ}REG	Imports of i to s valued at domestic mkt prices
VIMS(i,r,s)	i_{ϵ}COM r_{ϵ}REG s_{ϵ}REG	Imports of i from r to s valued at domestic mkt prices
VIPA(i,r)	i_{ϵ}COM r_{ϵ}REG	Private consumption expenditure on imported i in r
VIPM(i,r)	i_{ϵ}COM r_{ϵ}REG	Private consumption expenditure on i in r
VIW(i,s)	i_{ϵ}COM s_{ϵ}REG	Value of commodity imports i into s at CIF prices
VIWCOMMOD(i)	i_{ϵ}COM	Global value of commodity imports, CIF, by commodity
VIWDATOT(s)	s_{ϵ}REG	Total imports into s, calculated on direct allocation basis
VIWDIRALL(i,s)	i_{ϵ}COM s_{ϵ}REG	Imports of i into s, with direct allocation of margins
VIWREGION(r)	r_{ϵ}REG	Value of commodity imports by region r at CIF prices
VIWS(i,r,s)	i_{ϵ}COM r_{ϵ}REG s_{ϵ}REG	Imports of i from r to s valued CIF (tradeables only)
VIWSCOST(i,r,s)	i_{ϵ}COM r_{ϵ}REG s_{ϵ}REG	Value of imports calculated as total cost of imports
VOA(i,r)	i_{ϵ}NSAV_COMM r_{ϵ}REG	Value of commodity i output in region r at agent's prices
VOM(i,r)	i_{ϵ}NSAV_COMM r_{ϵ}REG	Value of commodity i output in region r at market prices
VOW(i,r)	i_{ϵ}COM r_{ϵ}REG	Value of output in r at FOB including transportation services
VPA(i,r)	i_{ϵ}COM r_{ϵ}REG	Private hhld expenditure on i in r valued at agent's prices

Table E.5 – Model's List of Coefficient (continued...)

Header	Size	Description
VST(m,r)	m_ϵMARG r_ϵREG	Exprts of m from r for int'l trnsport valued at mkt p (tradeables only)
VT		International margin supply
VTFSD(i,r,s)	i_ϵCOM r_ϵREG s_ϵREG	Aggregate value of svces in the shipment of i from r to s
VTFSD_MSH(m,i,r,s)	m_ϵMARG i_ϵCOM r_ϵREG s_ϵREG	Share of margin m in cost of getting i from r to s
VTICOMM(m,s)	m_ϵMARG s_ϵREG	Margin usage of m in getting imports to region s
VTMCHK(m)	m_ϵMARG	VTMUSE(m) - VTMPROV(m) should be tiny
VTMFSD(m,i,r,s)	m_ϵMARG i_ϵCOM r_ϵREG s_ϵREG	Int'l margin usage, by margin, freight, source, and destination
VTMPROV(m)	m_ϵMARG	International margin services provision
VTMUSE(m)	m_ϵMARG	International margin services usage, by type
VTMUSESHR(m,i,r,s)	m_ϵMARG i_ϵCOM r_ϵREG s_ϵREG	Share of i,r,s usage in global demand for m
VTRPROV(r)	r_ϵREG	International margin supply, by region
VTSUPPSHR(m,r)	m_ϵMARG r_ϵREG	Share of region r in global supply of margin m
VTUSE		International margin services usage
VVA(j,r)	j_ϵPROD_COMM r_ϵREG	Value added in activity j in region r
VWOU(i)	i_ϵCOM	Value of world output of i at user prices
VWOW(i)	i_ϵCOM	Value of world supply at world prices for i
VXDM(c,r)	c_ϵCOM r_ϵREG	Basic value of com. c exports to all dest. (tradeables only)
VXMD(i,r,s)	i_ϵCOM r_ϵREG s_ϵREG	Exports of i from r to s valued at mkt prices (tradeables only)
VXW(i,r)	i_ϵCOM r_ϵREG	Value of exports by comm. i and region r at FOB prices
VXWCOMMOD(i)	i_ϵCOM	Value of world exports by commodity i at FOB prices
VXWD(i,r,s)	i_ϵCOM r_ϵREG s_ϵREG	Exports of i from r to s valued FOB (tradeables only)
VXWLD		Value of commodity exports, FOB, globally
VXWREGION(r)	r_ϵREG	Value of exports by region r at FOB prices
WORKERS(c,f,r,s)	c_ϵCOM f_ϵFAM r_ϵBRA s_ϵSKLL	Numbers of workers employed
WORKERS_C(f,r,s)	f_ϵFAM r_ϵBRA s_ϵSKLL	Numbers of workers employed
WORKERS_CF(r,s)	r_ϵBRA s_ϵSKLL	Numbers of workers employed
WORKERS_F(c,r,s)	c_ϵCOM r_ϵBRA s_ϵSKLL	Numbers of workers employed
WORKERS_FS(c,r)	c_ϵCOM r_ϵBRA	Numbers of workers employed
XTAXD(i,r,s)	i_ϵCOM r_ϵREG s_ϵREG	Tax on exports of good i from source r to destination s
ZPP(c,r)	c_ϵCOM r_ϵREG	Costs - sales

Table E.6 – Model's List of Variable

Variable	Dimension	Description
af(i,j,r)	i_ϵCOM j_ϵPROD r_ϵREG	Composite intermed. input i augmenting tech change by j of r
afall(i,j,r)	i_ϵCOM j_ϵPROD r_ϵREG	Intermediate input i augmenting tech change by j in r
afcom(i)	i_ϵCOM	Intermediate tech change of input i, worldwide
afe(i,j,r)	i_ϵENDW j_ϵPROD r_ϵREG	Primary factor i augmenting tech change by j of r
afeall(i,j,r)	i_ϵENDW j_ϵPROD r_ϵREG	Primary factor i augmenting tech change sector j in r
afecom(i)	i_ϵENDW	Factor input tech change of input i, worldwide
afereg(r)	r_ϵREG	Factor input tech change in region r
afesec(j)	j_ϵPROD	Factor input tech change of sector j, worldwide
afreg(r)	r_ϵREG	Intermediate tech change in region r
afsec(j)	j_ϵPROD	Intermediate tech change of sector j, worldwide
ams(i,r,s)	i_ϵCOM r_ϵREG s_ϵREG	Import i from region r augmenting tech change in region s
ao(j,r)	j_ϵPROD r_ϵREG	Output augmenting technical change in sector j of r
aoall(j,r)	j_ϵPROD r_ϵREG	Output augmenting technical change in sector j of r
aoreg(r)	r_ϵREG	Output tech change in region r
aosec(j)	j_ϵPROD	Output tech change of sector j, worldwide
atall(m,i,r,s)	m_ϵMARG i_ϵCOM r_ϵREG s_ϵREG	Tech change in m's shipping of i from region r to s
atd(s)	s_ϵREG	Tech change shipping to s
atf(i)	i_ϵCOM	Tech change shipping of i, worldwide
atm(m)	m_ϵCOM	Tech change in mode m, worldwide
atmfsd(m,i,r,s)	m_ϵMARG i_ϵCOM r_ϵREG s_ϵREG	Tech change in m's shipping of i from region r to s
atpd(i,r)	i_ϵCOM r_ϵREG	Power of tax on domestic i purchased by private hhld in r
atpm(i,r)	i_ϵCOM r_ϵREG	Power of tax on imported i purchased by private hhld in r
ats(r)	r_ϵREG	Tech change shipping from region r
ava(i,r)	i_ϵPROD r_ϵREG	Value added augmenting tech change in sector i of r
avaall(j,r)	j_ϵPROD r_ϵREG	Value added augmenting technical change in sector j of r
avareg(r)	r_ϵREG	Value added tech change in region r
avasec(j)	j_ϵPROD	Value added tech change of sector j, worldwide
avelabprice(c,r)	c_ϵPROD r_ϵBRA	Average labour price
aVFM_lab(c,r,s)	c_ϵCOM r_ϵBRA s_ϵSKLL	labour-augmenting tech change
btf(i,j,r)	i_ϵENDW j_ϵPROD r_ϵREG	Driver for Tax on primary factor i used by j in region r
btfbra		Brazil Driver for Tax on primary factor i used by j in region r

Table E.6 – Model's List of Variable (continued...)

Variable	Dimension	Description
c1_ir(i,r)	i_ϵCOM r_ϵREG	Contribution of world price, px_i, to ToT
c1_r(r)	r_ϵREG	Contribution of world prices for all goods to ToT
c2_ir(i,r)	i_ϵCOM r_ϵREG	Contribution of regional export price, px_ir, to ToT
c2_r(r)	r_ϵREG	Contribution of regional export prices to ToT
c3_ir(i,r)	i_ϵCOM r_ϵREG	Contribution of regional import price, pm_ir, to ToT
c3_r(r)	r_ϵREG	Contribution of regional import prices to ToT
compvalad(i,r)	i_ϵPROD r_ϵREG	Composition of value added for good i and region r
contBOT(r)	r_ϵREG	Contribution of BOT to real expenditure-side GDP
contBOT_BRA		Contribution of BOT to real expenditure-side GDP - BRA
contGDPe(r,g)	r_ϵREG g_ϵGDPEX	Contributions to % change in real expenditure-side GDP
contGDPeBRA(g)	g_ϵGDPEX	Contributions to % change in real expenditure-side GDP - BRA
del_indtaxr(r)	r_ϵREG	Change in indirect tax revenue
del_taxrexp(r)	r_ϵREG	Change in export tax revenue
del_taxrfu(r)	r_ϵREG	Change in tax revenue on primary factor usage
del_taxrgc(r)	r_ϵREG	Change in government consumption tax revenue
del_taxrimp(r)	r_ϵREG	Change in import tax revenue
del_taxrinc(r)	r_ϵREG	Change in income tax revenue
del_taxriu(r)	r_ϵREG	Change in tax revenue on intermediate usage
del_taxrout(r)	r_ϵREG	Change in output tax revenue
del_taxrpc(r)	r_ϵREG	Change in private consumption tax revenue
del_ttaxr(r)	r_ϵREG	Change in revenue of all taxes
delgvsav(r)	r_ϵBRAPLUS	Government saving
delLabInc(c,f,r,s)	c_ϵCOM f_ϵFAM r_ϵBRA s_ϵSKLL	change in Wages by fam., industry and skills
delworkrs_c(f,r,s)	f_ϵFAM r_ϵBRA s_ϵSKLL	Change in worker numbers
dtbal(r)	r_ϵREG	Change in trade balance X - M, $ US million
dtbal_i(i,r)	i_ϵCOM r_ϵREG	Change in trade balance by i and by r, $ US million
dtbal_r(r)	r_ϵREGPLUS	Change in ratio of trade balance to regional income
empslack(f,r,s)	f_ϵFAM r_ϵBRA s_ϵSKLL	Employment slack
endwslack(i,r)	i_ϵENDW r_ϵREG	Slack variable in endowment market clearing condition
ffskl(f,r)	f_ϵFAM r_ϵBRA	Driver slack
fincome(r)	r_ϵREG	Factor income at market prices
fitax(f,r)	f_ϵFAM r_ϵBRA	Shifter: Income Tax from Families to Govt (POF)
fqg(i,r)	i_ϵCOM r_ϵREG	Government demand shift
fqg_i(r)	r_ϵREG	Overall Government demand shift

Table E.6 – Model's List of Variable (continued...)

Variable	Dimension	Description
ftransf(f,r,t)	f_{ϵ}FAM r_{ϵ}BRA t_{ϵ}TRNSF	Shift variable, Transfers from govt to fam
govbal		Change in ratio of Brazil gov surplus to Brazil income
govslack		Slack to align gov spending in Brazil
govslack2		
labslack2(r)	r_{ϵ}BRA	
lambda		
pcgds(r)	r_{ϵ}REG	Price of investment goods = ps("cgds",r)
pcif(i,r,s)	i_{ϵ}COM r_{ϵ}REG s_{ϵ}REG	CIF world price of commodity i supplied from r to s
pdw(r)	r_{ϵ}REG	Index of prices paid for tradeables used in region r
pf(i,j,r)	i_{ϵ}COM j_{ϵ}PROD r_{ϵ}REG	Firms' price for commodity i for use by j in r
pfactor(r)	r_{ϵ}REG	Market price index of primary factors, by region
pfactreal(i,r)	i_{ϵ}ENDW r_{ϵ}REG	Ratio of return to primary factor i to CPI in r
pfactwld		World price index of primary factors
pfam(r,f)	r_{ϵ}BRA f_{ϵ}FAM	Price index for Fam expenditure in region r
pfd(i,j,s)	i_{ϵ}COM j_{ϵ}PROD s_{ϵ}REG	Price index for domestic purchases of i by j in region s
pfe(i,j,r)	i_{ϵ}ENDW j_{ϵ}PROD r_{ϵ}REG	Firms' price for endowment commodity i in ind. j, region r
pfm(i,j,s)	i_{ϵ}COM j_{ϵ}PROD s_{ϵ}REG	Price index for imports of i by j in region s
pfob(i,r,s)	i_{ϵ}COM r_{ϵ}REG s_{ϵ}REG	FOB world price of commodity i supplied from r to s
pg(i,r)	i_{ϵ}COM r_{ϵ}REG	Government consumption price for commodity i in region r
pgd(i,s)	i_{ϵ}COM s_{ϵ}REG	Price of domestic i in government consumption in s
pgdp(r)	r_{ϵ}REG	GDP price index
pgdpexp(r,g)	r_{ϵ}REG g_{ϵ}GDPEXPLUS	GDP expenditure side price indices
pgdpexpb(g)	g_{ϵ}GDPEXPLUS	Brazil GDP expenditure side price indices
pgdpfac(r)	r_{ϵ}REG	Primary factor price index GDP
pgdpinc(r,g)	r_{ϵ}REG g_{ϵ}ENDW	GDP income side price indices
pgm(i,s)	i_{ϵ}COM s_{ϵ}REG	Price of imports of i in government consumption in s
pgne(r)	r_{ϵ}REG	GNE price index
pgneB		Brazil GNE price index
pgov(r)	r_{ϵ}REG	Price index for gov't hhld expenditure in region r
pim(i,r)	i_{ϵ}COM r_{ϵ}REG	Market price of composite import i in region r
piw(i,r)	i_{ϵ}COM r_{ϵ}REG	World price of composite import i in region r
piwcom(i)	i_{ϵ}COM	Price index of global merchandise imports by commodity
piwreg(r)	r_{ϵ}REG	Price index of merchandise imports, by region
plabdem(r,s)	r_{ϵ}BRA s_{ϵ}SKLL	Market clearing wage

Table E.6 – Model's List of Variable (continued...)

Variable	Dimension	Description
pm(i,r)	i_ϵPROD r_ϵREG	Market price of commodity i in region r
pm_ir(i,r)	i_ϵCOM r_ϵREG	Imports price index for good i and region r
pmes(i,j,r)	i_ϵENDWS_COMM j_ϵPROD r_ϵREG	Market price of sluggish endowment i used by j in r
pmfac(i,r)	i_ϵENDW r_ϵREG	Market price of factor i in region r
pms(i,r,s)	i_ϵCOM r_ϵREG s_ϵREG	Domestic price for good i supplied from r to region s
pp(i,r)	i_ϵCOM r_ϵREG	Private consumption price for commodity i in region r
ppd(i,s)	i_ϵCOM s_ϵREG	Price of domestic i to private households in s
ppm(i,s)	i_ϵCOM s_ϵREG	Price of imports of i by private households in s
ppriv(r)	r_ϵREG	Price index for private consumption expenditure in region r
pr(i,r)	i_ϵCOM r_ϵREG	Ratio of domestic to imported prices in r
profitslack(j,r)	j_ϵPROD r_ϵREG	Slack variable in the zero profit equation
ps(i,r)	i_ϵPROD r_ϵREG	Supply price of commodity i in region r
psfac(i,r)	i_ϵENDW r_ϵREG	Supply price factor i in region r
psw(r)	r_ϵREG	Index of prices received for tradeables produced in r
pt(m)	m_ϵMARG	Price of composite margins services, type
ptrans(i,r,s)	i_ϵCOM r_ϵREG s_ϵREG	Cost index for international transport of i from r to s
pva(j,r)	j_ϵPROD r_ϵREG	Firms' price of value added in industry j of region r
pVFM_lab(c,r,s)	c_ϵCOM r_ϵBRA s_ϵSKLL	Market unit Wages (from families) by industry and skills
pVFM_labf(c,f,r,s)	c_ϵCOM f_ϵFAM r_ϵBRA s_ϵSKLL	Wages by fam., industry and skills
pw(i)	i_ϵCOM	World price index for total good i supplies
pwu(i)	i_ϵCOM	World price index for total good i supplies at user prices
px_		World export price index for all commodities
px_i(i)	i_ϵCOM	World export price index for commodity i
px_ir(i,r)	i_ϵCOM r_ϵREG	Export price index for good i and region r
pxw(i,r)	i_ϵCOM r_ϵREG	Aggregate exports price index of i from region r
pxwcom(i)	i_ϵCOM	Price index of global merchandise exports by commodity
pxwreg(r)	r_ϵREG	Price index of merchandise exports, by region
pxwwld		Price index of world trade
qcgds(r)	r_ϵREG	Output of capital goods sector = qo("cgds",r)
qds(i,r)	i_ϵCOM r_ϵREG	Domestic sales of commodity i in r
qf(i,j,r)	i_ϵCOM j_ϵPROD r_ϵREG	Demand for commodity i for use by j in region r
qfd(i,j,s)	i_ϵCOM j_ϵPROD s_ϵREG	Domestic good i demanded by industry j in region s
qfe(i,j,r)	i_ϵENDW j_ϵPROD r_ϵREG	Demand for endowment i for use in ind. j in region r

Table E.6 – Model's List of Variable (continued...)

Variable	Dimension	Description
qfm(i,j,s)	i$_\epsilon$COM j$_\epsilon$PROD s$_\epsilon$REG	Demand for i by industry j in region s
qfp(i,r,f)	i$_\epsilon$COM r$_\epsilon$BRA f$_\epsilon$FAM	Fam hhld demand for commodity i in region r
qg(i,r)	i$_\epsilon$COM r$_\epsilon$REG	Government demand for commodity i in region r
qgd(i,s)	i$_\epsilon$COM s$_\epsilon$REG	Government hhld demand for domestic i in region s
qgdp(r)	r$_\epsilon$REG	GDP quantity index
qgdpexp(r,g)	r$_\epsilon$REG g$_\epsilon$GDPEXPLUS	GDP real expenditure side aggregates
qgdpexpb(g)	g$_\epsilon$GDPEXPLUS	Brazil GDP expenditure side real aggregates
qgdpfac(r)	r$_\epsilon$REG	Primary factor real GDP
qgdpinc(r,g)	r$_\epsilon$REG g$_\epsilon$ENDW	GDP real income side aggregates
qgm(i,s)	i$_\epsilon$COM s$_\epsilon$REG	Government hhld demand for imports of i in region s
qgne(r)	r$_\epsilon$REG	Real GNE
qgneB		Brazil Real GNE
qim(i,s)	i$_\epsilon$COM s$_\epsilon$REG	Aggregate imports of i in region s, market price weights
qiw(i,s)	i$_\epsilon$COM s$_\epsilon$REG	Aggregate imports of i into region s, CIF weights
qiwcom(i)	i$_\epsilon$COM	Volume of global merchandise imports by commodity
qiwreg(r)	r$_\epsilon$REG	Volume of merchandise imports, by region
qo(i,r)	i$_\epsilon$PROD r$_\epsilon$REG	Industry output of commodity i in region r
qoes(i,j,r)	i$_\epsilon$ENDWS_COMM j$_\epsilon$PROD r$_\epsilon$REG	Supply of sluggish endowment i used by j in r
qofac(i,r)	i$_\epsilon$ENDW r$_\epsilon$REG	Use factor i in region r
qow(i)	i$_\epsilon$COM	Quantity index for world supply of good i
qowu(i)	i$_\epsilon$COM	Quantity index for world supply of good i at user prices
qp(i,r)	i$_\epsilon$COM r$_\epsilon$REG	Private hhld demand for commodity i in region r
qpd(i,s)	i$_\epsilon$COM s$_\epsilon$REG	Private hhld demand for domestic i in region s
qpm(i,s)	i$_\epsilon$COM s$_\epsilon$REG	Private hhld demand for imports of i in region s
qst(m,r)	m$_\epsilon$MARG r$_\epsilon$REG	Sales of m from r to international transport
qtm(m)	m$_\epsilon$MARG	Global margin usage
qtmfsd(m,i,r,s)	m$_\epsilon$MARG i$_\epsilon$COM r$_\epsilon$REG s$_\epsilon$REG	International usage margin m on i from r to s
qva(j,r)	j$_\epsilon$PROD r$_\epsilon$REG	Value added in industry j of region r
qVFM_lab(c,r,s)	c$_\epsilon$COM r$_\epsilon$BRA s$_\epsilon$SKLL	Employment (from families) by industry and skills
qxs(i,r,s)	i$_\epsilon$COM r$_\epsilon$REG s$_\epsilon$REG	Export sales of commodity i from r to region s
qxw(i,r)	i$_\epsilon$COM r$_\epsilon$REG	Aggregate exports of i from region r, FOB weights
qxwcom(i)	i$_\epsilon$COM	Volume of global merchandise exports by commodity
qxwreg(r)	r$_\epsilon$REG	Volume of merchandise exports, by region

Table E.6 – Model's List of Variable (continued...)

Variable	Dimension	Description
qxwwld		Volume of world trade
realgov(r)	r_ϵREG	Real gov spending
tf(i,j,r)	i_ϵENDW j_ϵPROD r_ϵREG	Tax on primary factor i used by j in region r
tfd(i,j,r)	i_ϵCOM j_ϵPROD r_ϵREG	Tax on domestic i purchased by j in r
tfm(i,j,r)	i_ϵCOM j_ϵPROD r_ϵREG	Tax on imported i purchased by j in r
tgd(i,r)	i_ϵCOM r_ϵREG	Tax on domestic i purchased by government hhld in r
tgm(i,r)	i_ϵCOM r_ϵREG	Tax on imported i purchased by gov't hhld in r
tm(i,s)	i_ϵCOM s_ϵREG	Source-gen. change in tax on imports of i into s
tms(i,r,s)	i_ϵCOM r_ϵREG s_ϵREG	Source-spec. change in tax on imports of i from r into s
to(i,r)	i_ϵNSAV_COMM r_ϵREG	Output (or income) tax in region r
tot(r)	r_ϵREG	Terms of trade for region r: tot(r) = psw(r) - pdw(r)
tot2(r)	r_ϵREG	Trade terms for region r, computed from components
tpdall(i,r)	i_ϵCOM r_ϵREG	Comm.-, source-spec. shift in tax on private cons. of dom.
tpmall(i,r)	i_ϵCOM r_ϵREG	Comm.-, source-spec. shift in tax on private cons. of imp.
tpreg(r)	r_ϵREG	Comm.-, source-gen. shift in tax on private cons.
tradslack(i,r)	i_ϵCOM r_ϵREG	Slack variable in tradeables market clearing condition
tx(i,r)	i_ϵCOM r_ϵREG	Dest.-gen. change in subsidy on exports of i from r
txs(i,r,s)	i_ϵCOM r_ϵREG s_ϵREG	Dest.-spec. change in subsidy on exports of i from r to s
valuew(i)	i_ϵCOM	Value of world supply of good i
valuewu(i)	i_ϵCOM	Value of world supply of good i at user prices
vgdp(r)	r_ϵREG	Change in value of GDP
viwcif(i,s)	i_ϵCOM s_ϵREG	Value of merchandise regional imports, by commodity, CIF
viwcom(i)	i_ϵCOM	Value of global merchandise imports i, at world prices
viwreg(r)	r_ϵREG	Value of merchandise imports, by region, at world prices
vxwcom(i)	i_ϵCOM	Value of global merchandise exports by commodity
vxwfob(i,s)	i_ϵCOM s_ϵREG	Value of merchandise regional exports, by commodity, FOB
vxwreg(r)	r_ϵREG	Value of merchandise exports, by region
vxwwld		Value of world trade
wfac(i,r)	i_ϵENDW r_ϵNONBRA	% Change Factor income
wfacinc(i,r)	i_ϵENDW r_ϵBRAPLUS	% Change Factor income
wfacincBRA(i)	i_ϵENDW	% Change Factor income Brazil
wfactinc(f,r)	f_ϵFAM r_ϵBRA	Family Income
wfamcap(f,r)	f_ϵFAM r_ϵBRA	Family capital income
wfamcap_f(r)	r_ϵBRA	All-Family capital income
wfaminc(f,r)	f_ϵFAM r_ϵBRA	Family Income

Table E.6 – Model's List of Variable (continued...)

Variable	Dimension	Description
wfamland(f,r)	f_ϵFAM r_ϵBRA	Family land income
wfmbra(c,r)	c_ϵCOM r_ϵBRA	Wage costs
wgdpbra		Change in value of Brazil GDP
wgdpdiff(r)	r_ϵREG	Diff GDP expenditure - income
wgdpexp(r,g)	r_ϵREG g_ϵGDPEXPLUS	GDP expenditure side values
wgdpexpb(g)	g_ϵGDPEXPLUS	Brazil GDP expenditure side values
wgdpfac(r)	r_ϵREG	Primary factor nominal GDP
wgdpinc(r,g)	r_ϵREG g_ϵGDPIPLUS	GDP values income side
wgne(r)	r_ϵREG	GNE values
wgneB		Brazil GNE values
wgov(r)	r_ϵREG	Nominal gov spending
wgvexp(r)	r_ϵBRA	Government expenditure
wgvexpBRA		Brazil government expenditure
wgvinc(r)	r_ϵBRA	Government income
wgvincBRA		Brazil government income
windtax(r)	r_ϵREG	Aggregate revenue from all indirect taxes
witax(f,r)	f_ϵFAM r_ϵBRA	Income Tax from Families to Govt (POF)
wlabinc(f,r,s)	f_ϵFAM r_ϵBRA s_ϵSKLL	Family labour income, summed over sec
wlabinc_s(f,r)	f_ϵFAM r_ϵBRA	Family labour income, summed over skill and sec
workrs(c,f,r,s)	c_ϵCOM f_ϵFAM r_ϵBRA s_ϵSKLL	Employment by fam., industry and skills
workrs_c(f,r,s)	f_ϵFAM r_ϵBRA s_ϵSKLL	Numbers of workers
workrs_cf(r,s)	r_ϵBRA s_ϵSKLL	Numbers of workers
workrs_f(c,r,s)	c_ϵCOM r_ϵBRA s_ϵSKLL	Numbers of workers
workrs_fs(c,r)	c_ϵCOM r_ϵBRA	Numbers of workers
wtransf(f,r,t)	f_ϵFAM r_ϵBRA t_ϵTRNSF	Transfers from govt to fam
y(r)	r_ϵREG	Regional household income in region r
ybra		Brazil income
yp(r)	r_ϵREG	Regional private consumption expenditure in region r
ypf(r,f)	r_ϵBRA f_ϵFAM	Regional family private consumption expenditure

E.5 Formal Checks on Model Validity

According to Horridge, a number of tests should be performed each time a model's equations or data are changed. We set out here the proper procedure to follow.

E.5.1 Check initial and updated data

Both, initial and updated data-base must be balanced.

E.5.1.1 *Families Consumption Check*

One of the most important contributions of PAEG and DAYANE models is to have 10 families income classes in Brazilian regions. Considering that, it is important to check (and ensure) that the families consumption match the Value of Private consumption at the Agent's price (VPA) for each commodity in each region on base data and after any change - on updated file:

```
Coefficient
(all,i,COM)(all,r,BRA) FCHECK(i,r) # VPA(i,r) - sum{f,FAM,FPA(i,r,f)} #;
Read
FPA from file BASEDATA header "FVPA";
Update
(all,i,COM)(all,r,BRA)(all,f,FAM) FPA(i,r,f) = pp(i,r)*qfp(i,r,f);
Formula
(all,i,COMM)(all,r,BRA) FPA_F(i,r) = sum{f,FAM,FPA(i,r,f)};
(all,i,COMM)(all,r,BRA) FCHECK(i,r)= VPA(i,r) - FPA_F(i,r);
(all,r,BRA)(all,f,FAM) FPA_C(r,f) = sumc,COMM, FPA(c,r,f);
Write
FCHECK to file SUMMARY header "FCHK";
Assertion
(always) # FCHECK should be tiny # (all,i,COMM)(all,r,BRA) ABS[FCHECK(i,r)] < 0.1;
```

E.5.1.2 *Families Labour Income Check*

Another important check to run is the families labour income. The assumption is that the labour factor's usage (capital and land as well) by industries is paid to the families. Thus, the split of the skills must match with the Value of Factors at Market prices for labour - VFM("lab',c,r),for all sectors in Brazilian regions:

```
 Coefficient
(all,c,COMM)(all,f,FAM)(all,r,BRA)(all,s,SKLL) FLAB(c,f,r,s) # Ind.  wage bills by fam.#;
(all,c,COMM)(all,r,BRA)(all,s,SKLL) FLAB_F(c,r,s) # Ind.  wage bills #;
(all,c,COMM)(all,r,BRA) FLAB_FS(c,r) # Total labour bill in ind.  c in region r #;
(all,r,BRA)(all,s,SKLL) FLAB_CF(r,s) # Total wage bill by skill #;
```

```
(all,c,COMM)(all,r,BRA) LABCHECK(c,r) # labour check % error #;
Read
FLAB from file BASEDATA header "FLAB" ;
Formula
(all,c,COMM)(all,r,BRA)(all,s,SKLL) FLAB_F(c,r,s)= sum{f,FAM, FLAB(c,f,r,s)};
(all,c,COMM)(all,r,BRA) FLAB_FS(c,r) = sum{s,SKLL, FLAB_F(c,r,s)};
(all,r,BRA)(all,s,SKLL) FLAB_CF(r,s) = sum{c,COMM,FLAB_F(c,r,s)};
(all,c,COMM)(all,r,BRA) LABCHECK(c,r) = 100*[FLAB_FS(c,r) - VFM("lab",c,r)]/[FLAB_FS(c,r) + VFM("lab",c,r)];
Write
LABCHECK to file SUMMARY header "LCHK";
Assertion
(always) (all,c,COMM)(all,r,BRA) ABS[LABCHECK(c,r)] < 1 # Labour update check within 1% # ;
```

E.5.1.3 *Trade Check*

In a balanced data Value of Imports at World's price must be the same as the Value of Exports at World's price plus Transportation Costs; imports supply and demand must equals zero; and, the margin summary must guarantee that the usage equals provided:

```
 !  TRADE CHECK: VIM = SUMS VIMS !
Coefficient
(all,i,COMM)(all,r,REG) VIM(i,r) # Value of imports of com.  i in r at domestic mkt prices #;
(all,i,COMM)(all,r,REG)(all,s,REG) VIMS(i,r,s) # Imports of i from r to s valued at domestic mkt prices
#;
(all,i,COMM)(all,s,REG) VIMCHK(i,s) # Imports of i to s valued at domestic mkt prices #;
Read
VIMS from file BASEDATA header "VIMS";
Formula
(all,i,COMM)(all,r,REG) VIM(i,r) = sumj,ACTS, VIFM(i,j,r) + VIPM(i,r) + VIGM(i,r);
(all,i,COMM)(all,s,REG) VIMCHK(i,s) = VIM(i,s) - sumr,REG,VIMS(i,r,s);
(all,i,COMM)(all,s,REG) VIMCHK(i,s) = 100*VIMCHK(i,s)/ID01[VIM(i,s)]
Write
VIMCHK to file SUMMARY header "VMCH" longname "VIMCHK as % - MUST be Tiny";
 !  IMPORTS SUPPLY AND DEMAND !
Coefficient
(all,c,COMM)(all,r,REG) CHKMKClIMP(c,r) # Check the accounting on imports sup.  and dem.  #;
Formula
(all,c,COMM)(all,r,REG) CHKMKClIMP(c,r) = sum{s,REG, VIMS(c,s,r)} - sum{a,ACTS, VIFM(c,a,r)} - VIPM(c,r)
- VIGM(c,r);
(all,c,COMM)(all,r,REG) CHKMKClIMP(c,r) = 100*CHKMKClIMP(c,r) / [sum{s,REG, VIMS(c,s,r)} + sum{a,ACTS,
VIFM(c,a,r)}];
Write
```

```
CHKMKClIMP to file SUMMARY header "MPCK" longname "ImpCheck - Must be Tiny";
CHKMKClIMP to file SUMMARY header "MPCP" longname "CHKMKClIMP as %" ;
  !  MARGIN CHECK !
Coefficient
(all,m,MARG)(all,i,COMM)(all,r,REG)(all,s,REG) VTMFSD(m,i,r,s) # Int'l margin usage, by margin, freight,
source, and destination #;
(all,i,COMM)(all,r,REG)(all,s,REG) VTFSD(i,r,s) # Aggregate value of svces in the shipment of i from
r to s #;
(all,m,MARG) VTMUSE(m) # International margin services usage, by type #;
(all,m,MARG) VTMPROV(m) # International margin services provision #; (all,m,MARG) VTMCHK(m) # VTMUSE(m)
- VTMPROV(m) #; Read
VTMFSD from file BASEDATA header "VTWR"; Formula
(all,m,MARG) VTMUSE(m) = sum{i,COMM, sumr,REG, sum{s,REG, VTMFSD(m,i,r,s)}};
(all,m,MARG) VTMPROV(m) = sum{r,REG, VST(m,r)};
(all,r,REG) VTRPROV(r) = sum{m,MARG, VST(m,r)};
(all,m,MARG) VTMCHK(m) = VTMUSE(m) - VTMPROV(m);
(all,m,MARG) VTMCHK(m) = 100*VTMCHK(m) / VTMUSE(m);
Write
VTMCHK to file SUMMARY header "VTCK" longname "Margin Check - Must be Tiny";
VTMCHK to file SUMMARY header "VTCP" longname "VTMCHK as %";
  !  TRADE CHECK !
Coefficient
(all,c,COMM)(all,s,REG)(all,d,REG) TRDCHK(c,s,d) # VIWS (c,s,d)-[VXWD(c,s,d)+VTFSD(c,s,d)] #;
(all,c,COMM)(all,s,REG)(all,d,REG) VCIF(c,s,d) # Imported Value at World Price (c.i.f) #;
Formula
(all,c,COMM)(all,s,REG)(all,d,REG) TRDCHK(c,s,d) = VIWS(c,s,d) - [VXWD(c,s,d) + VTFSD(c,s,d)];
(all,c,COMM)(all,s,REG)(all,d,REG) TRDCHK(c,s,d) = VIWS(c,s,d) - [VXWD(c,s,d) + VTFSD(c,s,d)];
(all,c,COMM)(all,s,REG)(all,d,REG) VCIF(c,s,d) = VIWS(c,s,d);
(all,c,COMM)(all,s,REG)(all,d,REG:VCIF(c,s,d)=0) VCIF(c,s,d)= TINY;
(all,c,COMM)(all,s,REG)(all,d,REG) TRDCHK(c,s,d) = 100*TRDCHK(c,s,d) / VCIF(c,s,d);
Write
TRDCHK to file GTAPSUM header "TRCK" longname "Trade Check - Must be Tiny";
TRDCHK to file GTAPSUM header "TRCP" longname "TRDCHK as %";
```

E.5.1.4 *Zero Profit Check*

In a balanced base data the costs must equal sales:

```
  !  COST SUMMARY !
Set
COSTS = "IntDom" + "IntImp" + ENDW + "PTAX" # Industry cost summary #;
Coefficient
(all,a,COMM)(all,r,REG)(all,c,COSTS) COSTSUM(a,r,c) # Industry cost summary #;
```

```
Formula
(all,a,COMM)(all,r,REG) COSTSUM(a,r,"IntDom") = sum{c,COMM, VDFA(c,a,r)};
(all,a,COMM)(all,r,REG) COSTSUM(a,r,"IntImp") = sum{c,COMM, VIFA(c,a,r)};
(all,a,COMM)(all,r,REG)(all,e,ENDW) COSTSUM(a,r,e) = EVFA(e,a,r);
(all,a,COMM)(all,r,REG) COSTSUM(a,r,"PTAX") = PTAX(a,r);
Write
COSTSUM to file GTAPSUM header "COST";
  !  SALE SUMMARY !
Set
SALES # Commodity Sales Summary #
(Intermediate,Household,Investment,Government,Exports,IntnlMargins);
Coefficient
(all,c,COMM)(all,r,REG)(all,s,SALES) SALESUM(c,r,s) # Commodity sales summary #;
(all,c,COMM)(all,r,REG) VXDM(c,r) # Basic value of com.  c exports to all dest.  (tradeables only)
#;
Formula
(all,c,COMM)(all,r,REG) VXDM(c,r) = sum{d,REG, VXMD(c,r,d)};
(all,c,COMM)(all,r,REG) SALESUM(c,r,"Intermediate") = sum{a,COMM, VDFM(c,a,r)};
(all,c,COMM)(all,r,REG) SALESUM(c,r,"Household") = VDPM(c,r);
(all,c,COMM)(all,r,REG) SALESUM(c,r,"Investment") = VDFM(c,"CGDS",r);
(all,c,COMM)(all,r,REG) SALESUM(c,r,"Government") = VDGM(c,r);
(all,c,COMM)(all,r,REG) SALESUM(c,r,"Investment") = VDFM(c,"CGDS",r);
(all,c,COMM)(all,r,REG) SALESUM(c,r,"Exports") = VXDM(c,r);
(all,c,MARG)(all,r,REG) SALESUM(c,r,"IntnlMargins") = VST(c,r);
(all,c,NMRG_COMM)(all,r,REG) SALESUM(c,r,"IntnlMargins") = 0;
Write
SALESUM to file GTAPSUM header "SALE";
  !  COST - SALE = 0 !
Coefficient
(all,c,COMM)(all,r,REG) ZPP(c,r) # Costs - sales #;
Formula
(all,c,COMM)(all,r,REG) ZPP(c,r) = sumq,COSTS, COSTSUM(c,r,q) - sum{s,SALES, SALESUM(c,r,s)};
Write
ZPP to file GTAPSUM header "ZPP" - Must be Tiny;
```

E.5.1.5 *Gross Domestic Product Check*

In a balanced base data the Gross Domestic Product from Income side must the must same as Expenditure side:

```
 !  GDP EXPENDITURE SIDE SUMMARY ! Set
GDPEX (Household,Investment,Government,Exports,IntnlMargins,Imports);
Coefficient
```

```
(all,r,REG)(all,g,GDPEX) GDPEXP(r,g) # GDP expenditure side summary #;
Formula
(all,r,REG) GDPEXP(r,"Household") = sum{c,COMM, VPA(c,r)};
(all,r,REG) GDPEXP(r,"Government") = sum{c,COMM, VGA(c,r)}
(all,r,REG) GDPEXP(r,"Investment") = sum{k,CGDS, VOA(k,r)};;
(all,s,REG) GDPEXP(s,"Exports") = sum{c,COMM, sum{d,REG, VXWD(c,s,d)}};
(all,r,REG) GDPEXP(r,"IntnlMargins") = sum{m,MARG, VST(m,r)}
(all,d,REG) GDPEXP(d,"Imports") =- sum{c,COMM, sum{s,REG, VIWS(c,s,d)}};
Write
GDPEXP to file GTAPSUM header "GDPE";
 !  GDP INCOME SIDE SUMMARY !  GDPIN = ENDW + "IndTaxes" # Income-side GDP # ;
Coefficient
(all,r,REG)(all,g,GDPIN) GDPINC(r,g) # Income-side GDP #;
Formula
(all,r,REG)(all,e,ENDW) GDPINC(r,e) = sum{a,ACTS, EVFA(e,a,r)};
(all,r,REG) GDPINC(r,"IndTaxes") = INDTAX(r) - TFU(r);
Write
GDPINC to file GTAPSUM header "GDPI";
 !  GDP CHECK !
!  GDPEXP - GDPINC = 0 !
Coefficient
(all,r,REG) GDPDIFF(r) # GDP check #;
Formula
(all,r,REG) GDPDIFF(r) = sumg,GDPEX, GDPEXP(r,g) - sum{g,GDPIN, GDPINC(r,g)};
Write
GDPDIFF to file GTAPSUM header "GDIF";
```

E.5.2 Nominal and real homogeneity test

Neoclassical General Equilibrium Model has, as important property, the condition of zero degree homogeneity in prices. Starting from any solution it is possible to double all prices, leaving quantities unchanged — still having a solution of the model. That is, the agents respond only to price ratios and are unaffected by a uniform price change (raise in this example). Thus, the uniform increase in all prices does not affect any quantity variables. In a percentage change equation of labour demand with Constant Elasticity of Substitution:

```
(all,c,COM)(all,r,RBRA)(all,s,SKLL) qlab(c,r,s) = qfe("lab",c,r)
                                   - ESUSKL(c,s)*[plab(c,r,s) - plab_s(c,r)];
```

Must have the property that the sum of all coefficients of price variables on the *Left Hand Side* is the same as that on the *Right Hand Side*. This is the Nominal Homogeneity property. If that is not true, the equation is probably not well defined.

Also, CGE models present constant returns to scale. If all real exogenous variables (but ratios or prices) are shocked by x%, all endogenous real variables should also move by x%, leaving prices unchanged - still having a solution. The sum of all coefficients of quantity variables on the *Left Hand Side* is the same as that on the *Right Hand Side* in order to comply with real homogeneity property.

For value equations (*price* × *quantity*), as:

```
(all,c,COMM)(all,r,BRA) wfmbra(c,r) = qlab_s(c,r) + plab_s ;
```

The Nominal Homogeneity implies that the sum of all coefficients of price and value variables *Left Hand Size* is the same as *Right Hand Side*. And the Real Homogeneity implies that the sum of all coefficients of quantities and value variables on the *Left Hand Side* is the same as that on the *Right Hand Side*.

The equation is rearranged by TABLO so that all terms are on the *Left Hand Size*, becoming:

```
(all,c,COMM)(all,r,BRA) wfmbra(c,r) - (qlab_s(c,r) + plab_s) = 0;
```

E.5.2.1 *Automated homogeneity testing*

Checking such homogeneity properties is one important way of verifying that you have implemented your model correctly. And, release 12 of GEMAPCK[3] allows to perform a automatic check on model's homogeneity proprieties (either nominal or real). It is possible to:

1. Check homogeneity of each equation block;
2. Carry out an automatic homogeneity simulation;

For this propose it is necessary to specify on the TABLO input file the different types of variable - values, prices, quantity, or none of them - **VPQType** specification:

```
Variable (begins p default VPQType Price);
Variable (begins q default VPQType Quantity);
Variable (begins y default VPQType Value);
Variable (begins v default VPQType Value);
Variable (begins w default VPQType Value);
Variable (begins a default VPQType None);
Variable (begins d default VPQType None);
Variable (begins t default VPQType None);
Variable (begins c default VPQType None);
```

The automated test shows if the model is homogeneous in price (nominal) or quantity (real). And, in the case of a not homogeneous model, the row sums report file will identify the problem by showing you exactly which equation block(s) in your TABLO Input file are incorrectly specified (since only these will fail the coefficient-sum test).

The TABLO – generated program to carry out a homogeneity check performs the coefficient-sum check of each equation block. The program creates a Homogeneity Report File that tells which Equation blocks seem to be homogeneous and which seem not to be. Then it is

[3] See GEMPACK Manual - https://www.copsmodels.com/gpmanual.htm

necessary to look carefully at those which seem not to be homogeneous, fix them (if they need fixing) and rerun the test.

I'd checked the homogeneity of the DAYANE model using the files (based on GEMPACK users manual's automatic hemeogeneity check section) :

- -NHOMO-CHECK.CMF - the Nominal Homogeneity Report file is called -NHOMO-CHECK.HAR;
- -RHOMO-CHECK.CMF - the Real Homogeneity Report file is called -RHOMO-CHECK.HAR

E.5.3 Change in GDP should be the same from both sides

It is important to ensure that at the end of a simulation the GDP from expenditure side and from income side be the same. If not so, it is necessary to check the equation blocks, once we've already checked the databse GDP(s) and, they match. Also it is important to be sure that we can explain the results, i.e. we must have what Horridge calls as 'eye-balling' to understand undesirable results that the other 'checks' are not detecting. The GDP check is also important on explain the 'drive' of shocks, and better explain the results.

The DAYANE model presents an equation to check the GDP match. Before assign the equation for both GDP, we add:

```
Variable
(VPQType = none) (all,r,REG) wgdpdiff(r) # Diff GDP expenditure - income #;
Equation
E_wgdpdiff (all,r,REG) wgdpdiff(r) = wgdpexp(r,"GDP") - wgdpinc(r,"GDP");
```

It is important to observe that, the changes on each variable that determines the GDP are different (and it is likely to be). What must be the same is the changes on both GDP.

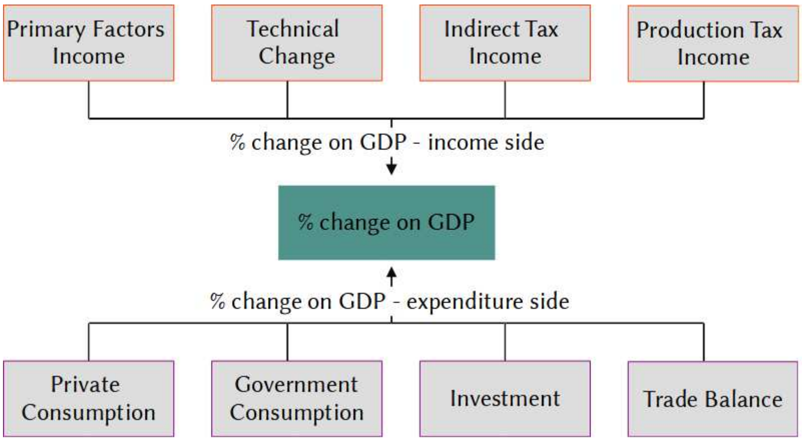

Figure E.8 – Change in GDP should be the same from both sides

E.5.4 Model flows

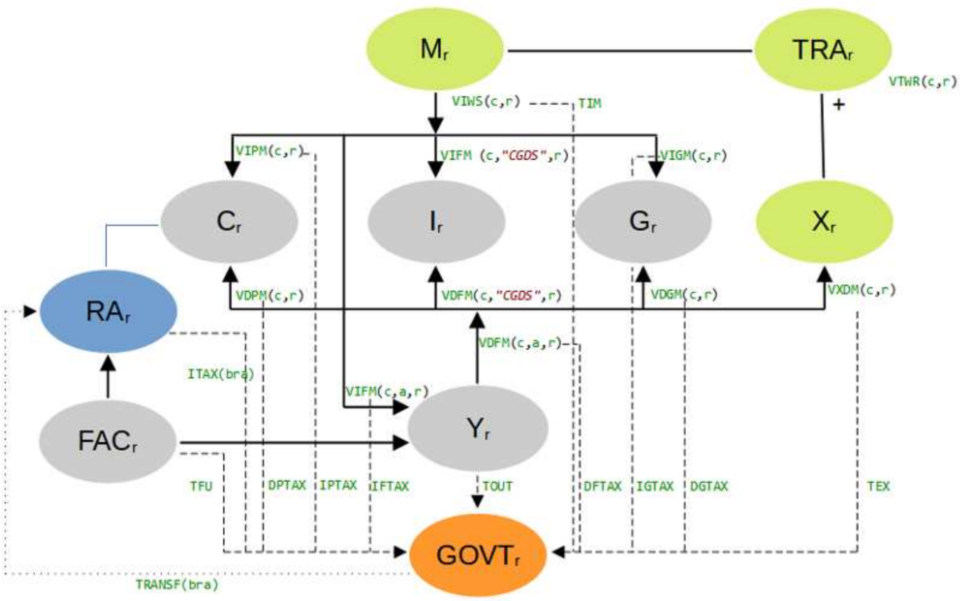

Figure E.9 – Flows on DAYANE model

APPENDIX F – Shocks Estimates

Table F.1 – First Simulation

					S5					
	F1	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**
NOR	9856	21138	16245	7793	4834	1934	1399	1347	476	1308
NDE	46963	95596	63032	27260	12956	6496	3612	3100	1492	4204
MDE	1627	6507	8633	5548	3716	2441	1330	1410	655	902
SDE	8426	30667	34476	27401	16664	10078	6487	6286	2300	5488
STH	2046	8197	10925	9587	7211	4577	2954	2937	1087	2350
					S3					
NOR	-9856	-21138	-16245	-7793	-4834	-1934	-1399	-1347	-476	-1308
NDE	-46963	-95596	-63032	-27260	-12956	-6496	-3612	-3100	-1492	-4204
MDE	-1627	-6507	-8633	-5548	-3716	-2441	-1330	-1410	-655	-902
SDE	-8426	-30667	-34476	-27401	-16664	-10078	-6487	-6286	-2300	-5488
STH	-2046	-8197	-10925	-9587	-7211	-4577	-2954	-2937	-1087	-2350
					Bolsa Família Program Withdraw					
NOR	-5.2%	-1.6%	-1.9%	1.1%	-5.2%	-3.3%	-9.8%	-15.5%	2.5%	8.4%
NDE	-2.0%	-0.9%	-0.8%	-0.2%	-0.7%	-0.8%	-3.1%	-9.2%	1.7%	-1.6%
MDE	-30.0%	-4.1%	-3.0%	-2.0%	-3.0%	-4.1%	-5.6%	-6.2%	-17.8%	-6.6%
SDE	-9.1%	-2.9%	-2.1%	-2.0%	-2.1%	-3.2%	-1.0%	-1.3%	-11.2%	-5.2%
STH	-37.4%	-6.5%	-2.0%	-1.4%	-0.9%	-3.0%	-2.4%	-5.6%	-7.7%	-3.9%
					Skill Movement					
					Workers					
			NOR	**NDE**	**MDE**	**SDE**	**STH**			
			66329 (9.76%)	264712 (12.64%)	32769 (4.96%)	148272 (4.10%)	51871 (3.38%)			
					% of total families					
NOR	1,42%	0,65%	0,50%	0,51%	0,53%	0,35%	0,22%	0,20%	0,12%	0,11%
NDE	1,90%	0,72%	0,47%	0,44%	0,30%	0,20%	0,17%	0,11%	0,09%	0,08%
COE	0,80%	0,31%	0,24%	0,22%	0,20%	0,17%	0,13%	0,09%	0,07%	0,02%
SDE	0,92%	0,29%	0,18%	0,24%	0,16%	0,10%	0,11%	0,07%	0,04%	0,03%
SUL	0,82%	0,28%	0,19%	0,21%	0,20%	0,13%	0,11%	0,08%	0,05%	0,04%
					% of total workers					
NOR	2,06%	1,76%	1,48%	1,17%	1,17%	0,89%	0,84%	0,83%	0,45%	0,51%
NDE	2,24%	2,13%	1,82%	1,45%	1,21%	1,06%	0,95%	0,73%	0,65%	0,60%
COE	0,99%	0,86%	0,81%	0,66%	0,57%	0,53%	0,45%	0,39%	0,38%	0,18%
SDE	1,01%	0,76%	0,64%	0,58%	0,45%	0,40%	0,34%	0,31%	0,21%	0,16%
SUL	0,90%	0,68%	0,62%	0,53%	0,46%	0,44%	0,40%	0,34%	0,25%	0,22%

where:
S3 and **S4** presents number of workers moving across skills S3 and S5;
Skill movement totals shows the total number of employed people being trained by Government – this is the `workrs_c(FAM,"BRA","SKL")` shock value;
Bolsa Família Progrma Withdraw are the reduction on Transfers from Government to Families via Bolsa Família Withdraw according to increasing on labour income – this is the `shock wtransf("FAM","BRA","BolsaFam")`

Table F.1 – Second Simulation

					S5					
	F1	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**
NOR	4359	9982	9407	5121	2439	975	676	757	328	1124
NDE	26211	49926	35902	17684	8338	3369	1746	2032	544	2004
MDE	651	4197	5312	4417	2349	1880	805	963	231	481
SDE	3293	16015	20146	14160	9296	5975	4549	3790	1155	3116
STH	659	4245	5426	4906	3334	2330	1319	1722	346	1044
					S4					
NOR	-4359	-9982	-9407	-5121	-2439	-975	-676	-757	-328	-1124
NDE	-26211	-49926	-35902	-17684	-8338	-3369	-1746	-2032	-544	-2004
MDE	-651	-4197	-5312	-4417	-2349	-1880	-805	-963	-231	-481
SDE	-3293	-16015	-20146	-14160	-9296	-5975	-4549	-3790	-1155	-3116
STH	-659	-4245	-5426	-4906	-3334	-2330	-1319	-1722	-346	-1044
					Bolsa Família Program Withdraw					
NOR	-3.6%	-1.3%	-2.0%	0.1%	-4.0%	-2.9%	-6.8%	-11.7%	1.7%	2.3%
NDE	-1.7%	-0.7%	-0.7%	-0.4%	-1.0%	-0.3%	-2.3%	-6.9%	2.6%	-0.1%
MDE	-13.3%	-3.2%	-2.2%	-1.9%	-2.4%	-3.8%	-4.2%	-4.9%	-9.3%	-4.5%
SDE	-5.9%	-2.3%	-1.9%	-1.6%	-1.9%	-2.7%	-3.1%	-1.7%	-8.0%	-4.5%
STH	-19.5%	-4.9%	-1.5%	-1.2%	-0.7%	-2.5%	-1.7%	-5.7%	-4.6%	-2.5%
					Skill Movement					
					Workers					
			NOR	**NDE**	**MDE**	**SDE**	**STH**			
			35168 (9.76%)	147756 (12.64%)	21286 (4.96%)	81497 (4.10%)	25333 (3.38%)			
					% of total families					
NOR	0,63%	0,31%	0,29%	0,33%	0,27%	0,18%	0,11%	0,11%	0,08%	0,10%
NDE	1,06%	0,38%	0,27%	0,29%	0,19%	0,10%	0,08%	0,07%	0,03%	0,04%
COE	0,32%	0,20%	0,15%	0,17%	0,12%	0,13%	0,08%	0,06%	0,02%	0,01%
SDE	0,36%	0,15%	0,11%	0,12%	0,09%	0,06%	0,07%	0,04%	0,02%	0,02%
SUL	0,26%	0,14%	0,09%	0,11%	0,09%	0,06%	0,05%	0,05%	0,02%	0,02%
					% of total workers					
NOR	0,91%	0,83%	0,86%	0,77%	0,59%	0,45%	0,41%	0,47%	0,31%	0,44%
NDE	1,25%	1,11%	1,03%	0,94%	0,78%	0,55%	0,46%	0,48%	0,24%	0,28%
COE	0,40%	0,56%	0,50%	0,53%	0,36%	0,41%	0,27%	0,27%	0,14%	0,10%
SDE	0,40%	0,40%	0,38%	0,30%	0,25%	0,23%	0,24%	0,19%	0,10%	0,09%
SUL	0,29%	0,35%	0,31%	0,27%	0,21%	0,22%	0,18%	0,20%	0,08%	0,10%

where:
S3 and **S4** presents number of workers moving across skills S3 and S5;
Skill movement totals shows the total number of employed people being trained by Government – this is the `workrs_c(FAM,"BRA","SKL")` shock value;
Bolsa Familía Progrma Withdraw are the reduction on Transfers from Government to Families via Bolsa Família Withdraw according to increasing on labour income – this is the `shock wtransf("FAM","BRA","BolsaFam")`

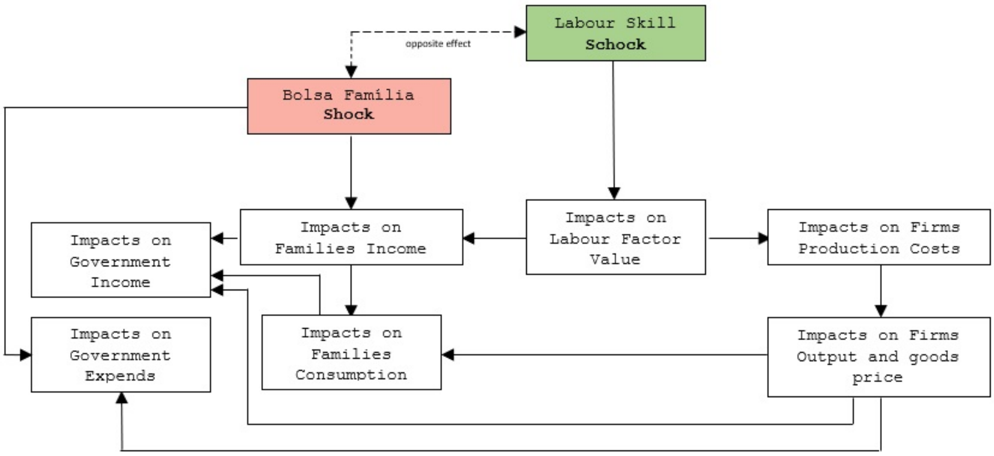

Figure F.10 – Shocks causal effects

APPENDIX G – Auxiliary Tables

Table G.1 – Wages costs in sectors - Brazilian regions

First Scneario						*Second Scneario*					
wfmbra	**NOR**	**NDE**	**MDE**	**SDE**	**STH**	wfmbra	**NOR**	**NDE**	**MDE**	**SDE**	**STH**
1 pdr	8.61	5.95	2.6	3.97	3.38	1 pdr	2.44	4.18	6.33	1.48	1.81
2 gro	6.97	1.69	2.77	2.55	4.65	2 gro	1.75	1.75	2.02	1.50	1.39
3 osd	2.48	2.82	0.71	1.53	1.92	3 osd	1.46	2.15	0.66	0.79	0.93
4 c_b	4.75	9.2	2.05	1.69	0.5	4 c_b	2.42	8.42	0.73	1.05	0.26
5 oap	-0.75	1.3	-0.47	2.56	1.82	5 oap	-0.59	1.24	-0.41	1.85	1.12
6 rmk	4.47	2.1	1.92	2.03	-0.92	6 rmk	3.25	0.76	1.42	1.24	-0.71
7 agr	0.74	2.41	-1.73	0.31	0.53	7 agr	0.38	1.91	-1.99	0.31	0.45
8 foo	2.08	-0.98	1.09	0.45	1.45	8 foo	1.22	-0.32	0.52	0.21	0.86
9 tex	0.43	1.74	0.46	1.33	0.75	9 tex	0.11	0.91	0.52	0.79	0.39
10 wap	12.39	-2.11	2.55	-1.51	0.75	10 wap	9.22	-1.1	2.36	-1.14	0.4
11 lum	-1.48	2.53	0.92	1.62	2.17	11 lum	-1.13	1.66	0.54	0.92	1.41
12 ppp	-3.97	3.83	0.14	2.28	1.71	12 ppp	-2.83	2.64	0.21	1.37	0.88
13 crp	0.07	2.4	0.49	1.57	0.96	13 crp	-0.07	1.56	0.32	0.92	0.52
14 man	1.2	2.63	-0.39	1.14	-0.14	14 man	0.8	1.78	-0.27	0.67	-0.17
15 siu	1.4	3.14	1.64	2.36	1.54	15 siu	0.91	2.17	1.24	1.43	0.92
16 cns	2.62	1.98	1.87	1.2	1.92	16 cns	1.69	1.24	1.06	0.7	1.04
17 trd	1.47	1.51	0.68	1.79	1.33	17 trd	0.92	0.97	0.31	1.06	0.68
18 otp	1.13	1.36	0.86	1.44	1.14	18 otp	0.77	0.83	0.43	0.86	0.62
19 ser	0.82	0.62	0.62	0.73	0.73	19 ser	0.54	0.34	0.31	0.44	0.34

Table G.2 – % change on value of factors (wfacinc) in Brazilian regions

First Scneario					*Second Scneario*				
wfacinc	1 lab	2 capital	3 land	4 natres	wfacinc	1 lab	2 capital	3 land	4 natres
BRA	0.521338	0.299757	0.544777	0.869876	**BRA**	0.884625	0.529305	0.971596	1.461084
NOR	0.57019	0.622181	0.559193	1.391253	**NOR**	0.903725	0.962353	1.100404	2.10017
NDE	0.63602	-0.0481	0.516276	2.348478	**NDE**	1.049232	0.070581	0.737521	3.452753
MDE	0.398866	0.371433	0.365166	-0.41926	**MDE**	0.707499	0.671006	0.973928	-0.5177
SDE	0.529669	0.331179	0.387305	0.872362	**SDE**	0.871066	0.550914	0.766794	1.502455
STH	0.45835	0.348461	1.272134	-0.26652	**STH**	0.895639	0.62196	1.944663	-0.25322

Table G.3 – % change on total families factors income (wfactinc) in Brazilian regions

First Scneario						*Second Scneario*					
wfmbra	**NOR**	**NDE**	**MDE**	**SDE**	**STH**	wfactinc	**NOR**	**NDE**	**MDE**	**SDE**	**STH**
1 F1	1.8460	0.9588	4.1868	0.7215	3.38	**1 F1**	1.1253	0.7395	1.5298	0.2140	0.4721
2 F2	0.8494	0.3770	1.1735	0.8610	4.65	**2 F2**	0.5595	0.2085	0.7319	0.5157	0.4946
3 F3	0.9233	0.2067	1.0150	0.5175	1.92	**3 F3**	0.7944	0.1283	0.5930	0.4080	0.3791
4 F4	0.1853	-0.2025	0.4041	0.5111	0.5	**4 F4**	0.2145	-0.1241	0.2712	0.2647	0.2662
5 F5	1.1970	0.0031	0.3848	0.3127	1.82	**5 F5**	0.8110	0.1479	0.1229	0.1765	0.0925
6 F6	0.7981	-0.0658	0.6088	0.6800	-0.92	**6 F6**	0.5479	-0.2364	0.4410	0.4487	0.2605
7 F7	1.9850	0.5422	0.8808	-0.1152	0.53	**7 F7**	1.2968	0.2732	0.4675	0.3372	0.1497
8 F8	2.2958	2.0013	0.7788	-0.0384	1.45	**8 F8**	1.6511	1.4291	0.4619	-0.0118	0.7945
9 F9	0.2846	-0.7862	1.8190	2.1396	0.75	**9 F9**	0.1246	-1.0513	0.7435	1.3556	0.6955
10 F10	0.1004	0.1289	0.7688	0.6815	0.75	**10 F10**	0.2070	-0.1749	0.3728	0.4508	0.3983

Table G.4 – % changes on sectors output - Brazilian regions

	First Scneario						*Second Scneario*				
qo	**NOR**	**NDE**	**MDE**	**SDE**	**STH**	qo	**NOR**	**NDE**	**MDE**	**SDE**	**STH**
1 pdr	-0.11	-0.42	0.67	-0.73	0.55	1 pdr	0.28	-0.33	-0.41	-0.13	0.56
2 gro	-1.27	0	0.45	-0.34	0.25	2 gro	-0.48	-0.11	0.2	-0.21	0.2
3 osd	-1.66	-1.19	-0.66	-1.43	-0.2	3 osd	-1.04	-0.91	-0.38	-0.78	-0.08
4 c_b	0.22	0.32	0.41	0.67	0.48	4 c_b	0.24	0.09	0.32	0.39	0.37
5 oap	0.58	-0.9	0.38	-0.13	0.41	5 oap	0.34	-0.31	0.19	-0.13	0.26
6 rmk	0.22	1.67	0.4	-0.02	0.59	6 rmk	0.05	1.18	0.18	-0.04	0.42
7 agr	0.07	0.56	0.7	0.29	0.21	7 agr	-0.01	0.33	0.54	0.14	0.13
8 foo	1.98	-3	0.09	-0.61	0.41	8 foo	1.13	-1.26	-0.14	-0.43	0.33
9 tex	-0.73	1.39	-0.42	0.37	-0.04	9 tex	-0.71	0.61	0.16	0.22	-0.09
10 wap	15.26	-3.39	2.57	-2.78	-0.14	10 wap	11.49	-1.81	2.7	-1.97	-0.15
11 lum	-4.54	1.96	-0.05	0.33	1.15	11 lum	-3.24	1.35	-0.06	0.01	0.82
12 ppp	-8.04	2.74	-1.73	1.38	0.69	12 ppp	-5.67	1.8	-0.61	0.82	0.36
13 crp	-0.32	2.62	-0.23	0.77	0.26	13 crp	-0.27	1.76	-0.06	0.43	0.15
14 man	2.25	4.53	-1.32	1.64	-0.87	14 man	1.51	2.98	-0.93	0.96	-0.65
15 siu	1.67	2.18	0.6	1.1	0.53	15 siu	1.1	1.41	0.17	0.68	0.2
16 cns	0.59	1.58	0.73	0.67	0.78	16 cns	0.38	1.02	0.42	0.4	0.42
17 trd	1.31	2.13	-0.06	1.34	0.79	17 trd	0.82	1.45	-0.09	0.8	0.37
18 otp	0.2	1.44	0.07	1.41	0.77	18 otp	-0.01	0.87	-0.05	0.84	0.4
19 ser	1.92	2.73	0.96	1.72	1.46	19 ser	1.29	1.8	0.59	1.04	0.69

Table G.5 – % changes in aggregate sector exports - Brazilian regions

First Scneario						*Second Scneario*					
qxw	**NOR**	**NDE**	**MDE**	**SDE**	**STH**	qxw	**NOR**	**NDE**	**MDE**	**SDE**	**STH**
1 pdr	-1.40	-3.06	0.72	-1.17	0.66	1 pdr	0.127	-2.388	-1.483	0.095	0.952
2 gro	-1.95	-0.33	0.29	-0.96	-0.21	2 gro	-0.823	-0.451	0.168	-0.556	-0.035
3 osd	-1.73	-1.44	-0.80	-1.46	-0.70	3 osd	-1.095	-1.163	-0.415	-0.792	-0.395
4 c_b	-0.26	-1.23	1.08	1.18	0.72	4 c_b	0.188	-1.690	1.077	1.283	0.674
5 oap	0.06	-0.16	0.18	-0.21	0.32	5 oap	0.005	0.000	0.179	-0.149	0.158
6 rmk	-0.99	1.69	0.10	-0.25	1.10	6 rmk	-0.837	1.278	0.095	-0.128	0.667
7 agr	0.77	-0.16	0.72	-1.15	-0.34	7 agr	0.462	-0.376	0.886	-0.715	-0.249
8 foo	2.38	-8.95	-0.58	-2.90	0.43	8 foo	1.259	-4.235	-0.625	-1.847	0.439
9 tex	-7.09	1.56	-3.35	-0.06	-0.29	9 tex	-5.535	0.463	-0.617	0.034	-0.194
10 wap	24.47	-9.54	2.92	-7.01	-0.02	10 wap	19.172	-5.581	4.860	-4.802	-0.058
11 lum	-8.68	3.33	-2.55	-2.10	1.73	11 lum	-6.196	2.368	-1.415	-1.702	1.351
12 ppp	-16.22	3.26	-5.17	1.35	0.50	12 ppp	-11.460	2.008	-1.974	0.793	0.315
13 crp	-2.62	3.15	-1.59	0.35	0.05	13 crp	-1.863	2.018	-0.596	0.180	0.099
14 man	2.59	7.40	-2.47	2.05	-2.26	14 man	1.731	4.742	-1.550	1.243	-1.501
15 siu	2.14	3.55	0.86	0.34	0.29	15 siu	1.402	2.055	-0.029	0.345	-0.059
16 cns	-2.12	4.73	0.51	0.35	0.93	16 cns	-1.406	3.259	0.503	0.113	0.559
17 trd	1.73	2.87	-2.98	1.81	0.47	17 trd	1.032	1.973	-1.773	1.069	0.034
18 otp	-0.53	1.66	-1.50	1.75	0.60	18 otp	-0.591	0.893	-0.976	1.070	0.303
19 ser	4.79	7.23	-0.01	2.52	1.75	19 ser	3.239	4.959	0.326	1.533	0.763

Table G.6 – % changes in aggregate sector imports - Brazilian regions

	First Scneario						*Second Scneario*				
qiw	**NOR**	**NDE**	**MDE**	**SDE**	**STH**	qiw	**NOR**	**NDE**	**MDE**	**SDE**	**STH**
1 pdr	1.095	0.952	0.024	0.553	-0.252	1 pdr	0.435	0.962	0.827	0.006	-0.076
2 gro	0.849	0.155	0.182	0.305	0.370	2 gro	0.533	0.296	0.103	0.205	0.221
3 osd	0.813	0.220	0.216	0.022	0.350	3 osd	0.557	0.385	0.117	0.001	0.231
4 c_b	0.636	1.099	0.070	0.183	-0.194	4 c_b	0.186	1.306	-0.149	0.052	-0.465
5 oap	0.813	0.273	0.197	0.201	0.196	5 oap	0.560	0.323	0.080	0.137	0.140
6 rmk	1.089	-0.277	0.133	0.522	0.000	6 rmk	0.789	-0.110	0.086	0.321	0.007
7 agr	0.057	0.349	0.208	0.432	0.621	7 agr	0.023	0.430	-0.017	0.303	0.390
8 foo	-0.789	2.042	0.433	0.902	0.403	8 foo	-0.310	0.997	0.304	0.653	0.181
9 tex	2.463	0.479	1.179	1.028	0.895	9 tex	1.880	0.391	0.400	0.528	0.529
10 wap	-2.160	1.088	-1.817	0.828	2.205	10 wap	-1.577	0.587	-1.940	0.532	1.405
11 lum	4.604	-0.718	0.078	0.419	-2.783	11 lum	3.172	-0.493	-0.153	0.336	-2.135
12 ppp	6.056	1.415	1.686	-0.483	0.650	12 ppp	4.133	0.974	0.759	-0.430	0.307
13 crp	1.255	1.117	0.729	1.323	0.711	13 crp	0.835	0.746	0.364	0.826	0.397
14 man	0.940	0.390	1.141	0.582	1.115	14 man	0.658	0.267	0.638	0.388	0.663
15 siu	0.204	0.445	0.909	0.923	1.236	15 siu	0.106	0.441	0.811	0.396	0.884
16 cns	1.288	-0.800	1.142	0.974	0.428	16 cns	0.924	-0.459	0.537	0.583	0.233
17 trd	0.753	0.925	2.616	1.162	1.579	17 trd	0.480	0.523	1.559	0.750	1.056
18 otp	1.172	0.584	1.236	0.144	0.412	18 otp	0.856	0.478	0.738	0.096	0.288
19 ser	0.848	-1.130	1.201	0.732	1.363	19 ser	0.442	-0.811	0.514	0.401	0.879