Climate change, labour markets and poverty in Bolivia: Why does gender matter?

Luis Escalante Ochoa[1]

Abstract

This study aims to analyse the effects of climate change on labour markets and women's poverty in Bolivia using a Computable General Equilibrium model (CGE) as methodology. Although CGE models are increasingly used to assess the effects of climate change, all studies focus exclusively on the market economy, leaving aside the domestic market, so there is a tendency to overestimate or underestimate macroeconomic effects, as the models assume that the labour categories are homogeneous. We propose an endogenous labour supply which will depend not only on the time that households devote to their formal market activities, but also to domestic activities. This paper contributes to the application of CGE models by introducing domestic production in a gender-skilled disaggregated labour market to assess the impact of climate change. In addition, it will allow Bolivian authorities to know the extent of the effects of climate change, how it affects labour markets and poverty. We propose two scenarios. The first scenario refers to damages and losses due to climatic events in the agricultural and livestock sectors in Bolivia, while the second one analyses the decrease in production yields in two types of agriculture: modern and traditional. Likewise, the CGE model will be linked to a micro simulation module that integrates gender decomposition.

The results in both simulations indicate a decrease in domestic burdens that mainly favours the urban population. However, domestic burdens on women in the rural sector increase which reduces their participation in the formal market. This situation reflects the fact that climate change contributes to reducing women's participation in the formal labour market, and widens the inequality gaps in the labour market. The evolution of poverty indicators confirms the dynamics of macroeconomic results. In fact the two climate change scenarios studied in this document show increases in all poverty indicators. The results also indicate that in the urban population it is moderate poverty that is worsening, while in the rural population it is extreme poverty, with women being more affected than men

Keywords: Climate change, Labour market, Poverty, Women

[1] PhD student, EDEHN - Equipe d'Economie Le Havre Normandie, Université du Havre, 25 Rue Philippe Lebon, F-76600 Le Havre, France.

1. Introduction

The Plurinational State of Bolivia, hereinafter referred to as "Bolivia" in this document, a South American country that, given its socio-economic as well as geographical conditions, is highly sensitive in a context of climate change. In this way, compared to other countries in the region, Bolivia is considered as one of the most vulnerable nations to disasters caused by adverse natural events. Kreft et al (2016), in a report published for Germanwatch, indicate that Bolivia ranks eighth among the countries most affected by extreme weather events in 2014, while in 2013, the country ranked 33rd. As for the effects caused by climate change, these are reflected in different ways in Bolivia; however, UDAPE[2] points out that floods are the most frequent natural event, followed by droughts. Although these effects are observable in this country, the empirical evidence of these impacts, both statistically and causally, is somewhat limited and few studies estimate the implications of the effects of climate change.

An analysis of the direct and indirect effects associated with meteorological events by events occurring in 2013 and 2014 conducted by UDAPE (2015) indicates that the events caused losses of approximately 3132 million BOB (or 405.50 million euros, applying the Boliviano/Euro conversion to the year 2014) and affected more than 300 000 people. In addition, the agricultural sector would have been the hardest hit. Andersen et al (2014) estimate that the effects of climate change on the agricultural sector would represent a total loss of US$ 106 billion over the period 2010-2100, corresponding to an average loss of 2.1% of the net present value of total GDP over the same period.

In other respects, Bolivia is characterized by problems such as poverty and inequality, although it is one of the countries that most reduced poverty from 59.6% in 2005 to 34.6% in 2018 (WDI, 2019), this rate is still high compared to poverty in neighbouring countries. Likewise, the great diversity of the population throughout Bolivian territory is accompanied by a high level of inequality with cultural characteristics and economic realities that are not necessarily the same. In general, the consensus in the literature highlights that rural areas and in particular rural women are the most exposed to poverty and are therefore the most vulnerable in a context of climate change. This hypothesis is confirmed for Bolivia, where the rural population has the highest levels of poverty and inequality. In fact, the poverty gap at the rural poverty line level is 30.5%, while the gap at the urban poverty line level is of the order of 10.4% (WDI, 2014). Likewise, the indicators are heterogeneous according to gender and population groups. According to data obtained from the Households 2018 survey, poverty among women is globally higher than among men (33.3% vs. 31.9%). As for moderate poverty, the highest poverty rate affects rural women (52%), while the lowest rate affects urban men (26.4%). Extreme poverty follows the same trend and mainly affects rural women (31.2%), while the level for urban women is only 8.3%. In terms of inequality, the Gini index frequently used to measure the level of inequality reached 0.44 in 2017. This index decreased from 0.61 in 2000 to 0.581 in 2005 and to 0.44 in 2017 (WDI, 2018).

However, inequality in Bolivia surpasses income inequality, and can be observed in sectors such as education or the labour market where significant gender gaps exist. From this perspective, according to data from the continuous employment survey (ECE, 2017), women are more representative at the lowest levels of education (No education, Primary school start

[2] Unidad de Análisis de Políticas Sociales y Económicas (UDAPE)

and Completed primary school), while men are more representative at the highest levels of education (Secondary beginning, Completed high school, and Superior). Likewise, for both men and women, the rural population clearly has lower levels of education than the urban population. On the other hand, according to the International Labour Organization (ILO) estimates for Bolivia, unemployment is one of the lowest levels in 2019 (3.3%). However, it should be noted that the unemployment rate is higher among women than men (4.0% as against 2.8%), furthermore, the rate is 6% for high-skilled workers (ILO, 2018).

Gender biases can also be found in the labour market, where women tend to be less involved. According to the World Development Indicators WDI (2018), women's labour force participation rate is lower than men's (57% versus 79%). Although women's participation in the labour force in Bolivia is relatively higher than the average in the Latin America and the Caribbean (LAC) region (52%), the Bolivian women are much more likely than men to work in jobs denominated as vulnerable (63% vs. 53.7%). In addition, women work in a narrow range of sectors. Based on data from the ECE (2017), the intensity of female labour surpasses that of male labour in only 7 out of 21 sectors, where Accommodation and Meal Service Activities, Education Services, Health and Social Services, and Private Household Activities are the most intensive sectors for women (see table 1). In turn, gaps can be observed within women according to their level of qualification; in fact, unskilled women work mainly in agriculture (36.71%), construction (12.71%) and unskilled work (10%); while skilled women work mainly in scientific and intellectual professions (30%), services (32.5%) and intermediate technicians (10.6%). So far, statistics indicate that women's participation in the Bolivian labour market is systematically lower than that of men in most sectors of the formal economy. In contrast, in the non-commercial sphere, women's participation far surpasses that of men. Indeed, according to ECE 2017, the intensity of female work is higher than male in two categories: family worker or unpaid apprentice (66.1%) and household employee (95%). Likewise, the poorest women do the unpaid work more. Based on the time use survey (2001), the Economic Commission for Latin America and the Caribbean (EACL) indicates that women spend 23.5% of 24 hours a day on unpaid household and care work, while men spend 12.6%. Canelas and Salazar (2014) indicate that women in the Bolivian rural sector spend four times more time doing household chores than men. The high participation of women in the non-commercial sphere and particularly in domestic tasks could explain their low participation in the formal labour market; hence they would spend more time working if they spent less time on domestic tasks. In short, gender gaps in the labour market, as well as gaps in poverty and education levels, particularly affect the poor population, whose majority live in the rural areas. This situation could worsen even more in a context of climate change, where sectors such as agriculture or livestock, could suffer the most severe consequences, but distortions in the labour market could also be generated, compromising the well-being of the most vulnerable workers.

This study aims to analyse the effects of climate change on the agricultural sector and poverty in Bolivia. To this end, we present a CGE model that integrates domestic work and is also linked to a microsimulation module to assess the effects on poverty and inequality, particularly among women in the rural sector. The reminder of the paper is organized as follows. The second section presents a review of the literature on the impact of climate change on agriculture, poverty and modelling of domestic work. The third section discusses the

methodological framework and data used to conduct this study. The fourth section presents the study scenarios and the results. Finally, the conclusions are presented in section five.

2. Literature review

A broad literature review indicates that the effects of climate change have different consequences on economic activities; most studies agree that economic growth will be negatively affected. Some authors argue that the effects of climate change will reduce economic growth in different sectors, but that it is the agricultural sector that will suffer most (Thurlow et al. 2009; Fischer et al. 2005; Hertel and Rosh, 2010; Samaniego et al. 2017). In addition, Mendelsohn (2008) found that agriculture in developing countries would be affected more intensely. We will examine the evidence of climate change in the agricultural sector in a context of climate change, as well as the links in poverty, then present the CGE models applied in Bolivia and other countries to assess the effects of climate change.

2.1. Climate change, agriculture and poverty: A gender perspective

Agriculture is an economic activity that is highly dependent on weather and climate conditions. It is not surprising that it is considered an economic activity that should be vulnerable to the effects of climate variability. Hertel and Rosh (2010) point out that agricultural productivity is particularly sensitive to weather conditions. With regard to the Latin American region, Field et al. (2014) argue that the effects on agriculture would be very diverse due to the great diversity of economic, demographic and geographical terms in the countries of this region. The authors conclude that productivity in Central America could be reduced over the next 15 years, while in South America it could be maintained or even increased. More specific studies for the different countries in the LAC region also report a variety of effects. In Chile, Ponce et al (2014) report a variation of 7.4 to 40% in agricultural yield losses across regions and crops; Vargas et al (2017), report negative results in Guatemalan agricultural production and exports and also estimate a 1.2% decline in real GDP. In the case of Bolivia, there are some studies assessing the effects of climate change. For example Andersen et al (2014), indicate that the direct and indirect effects of climate change affected agricultural productivity in Bolivia, generating significant losses. In addition, the analysis of the agricultural sector is important for Bolivia because of the importance of agriculture in the economy, accounting for 26% of total employment according to ILO estimates (2018).

Regarding poverty, some authors argue that the impact of the agricultural sector has a very strong influence on poverty. Some studies highlight the evidence of the effects of climate change on agriculture and poverty due to the existence of vulnerable population groups, mainly in the Bolivian case. Valdés and Foster (2007) argue that sustained agricultural growth is a necessary condition for poverty reduction, particularly rural poverty, since rural families depend mainly on agriculture. While poverty in the Latin American region has declined in recent years, a significant proportion of the most intense poverty remains concentrated in rural areas (Byerlee et al., 2005; Christiaensen et al., 2011). With regard to people's exposure to climate change, there is an abundant literature indicating the existence of vulnerable groups, most studies agree that the rural population often living in poverty is the most vulnerable, which is constantly highlighted in the permanent reports submitted by the Intergovernmental Panel on Climate Change (IPCC). For example, Field et al (2014) indicate that climate change

disproportionately affects the well-being of the poor, mainly in rural areas. In the particular case of Bolivia, this country is one of the Latin American countries with the highest levels of inequality. Gasparini et al (2014) state that this country has the highest levels of inequality in Latin America when using quintile gaps, and ranks fifth when measuring inequality using the Gini coefficient. Corral (2017) reports that about 75% of the total population of rural Bolivia is employed in agricultural activities, where women and the elderly have had to participate more. Similarly, given that the highest levels of poverty are concentrated mainly in the rural sector (55% according to INE, 2017), any possible impact on the agricultural sector could further worsen the situation of vulnerable populations in the rural sector, particularly women.

2.2.Climate change and poverty with CGE models

Studies using CGE models with focus on the effects of climate change on agriculture and poverty have increased in number and have gained international importance. Chalise et al. (2017) study the effects of climate change in Nepal, indicating that the effects are negative on the economy as a whole but especially on poor households. The authors also point out that climate change could increase the likelihood of falling into a cycle of poverty. Montaud et al. (2017) study the potential for medium- and long-term changes in agricultural production following climate change, finding significant reductions in agricultural yields. In Latin American countries, the applications of CGE models to assess the effects of climate change have been relatively scarce and the effects on poverty and vulnerable populations are often omitted. The use of CGE models is recent in the analysis of the Bolivian economy (Jemio et al. 2014, Andersen et al. 2014, Vizcarra 2014, Morales 2017). Furthermore, most studies present results on aggregated agents and do not explore the effects on specific population groups, such as women, children or the elderly, which according to the literature review would be more vulnerable to climate change. Morales et al (2017) use a CGE to evaluate the impact of labour and wage policy, finding that a reduction in the price of exports favours household consumption but reduces GDP in Bolivia. Vizcarra (2014) builds a dynamic CGE model to evaluate the effects of climate change in Bolivia, finding negative effects in the agricultural sector, the reductions in national GDP are about 10%. Similarly, Jemio et al (2014) propose a CGE to assess IPCC climate projections in the Bolivian economy. Their results indicate that the losses from direct effects are 0.96% of GDP, however they ascend to 3.69% if the indirect effects transmitted to other sectors by intermediate consumption are added. In a more recent study Aliaga and Aguilar (2019) propose a CGE and a pessimistic scenario for the agricultural sector, which would lead to a decrease in the growth rate of -0.33% annually.

As we can see, CGE models are increasingly being used to assess the effects of climate change. However, all of these focus exclusively on the market economy, leaving aside the domestic market, so there is a tendency to overestimate or underestimate macroeconomic effects, as the models assume that the categories of work are homogeneous. Only a limited number of studies with CGE integrate domestic work, particularly studies on trade liberalization. In this sense, the exclusion of domestic work from the analysis hides a fundamental aspect, mainly in developing countries, where a large part of the population carries out domestic tasks.

2.3.Unpaid work and domestic labour in CGE models

Few models address or integrate unpaid work, and the reason for the lack of research is the difficulty of collecting gender-based data. This requires data on the distribution of household time use in different paid and unpaid activities. Fontana and Wood (2000) develop one of the first CGE models incorporating domestic work and leisure to assess the effects of trade policies in Bangladesh. Fontana (2004) then expands on the CGE model for Zambia, and analyses the effects of macroeconomic policies and trade expansion on women's work in the market and at home. The results of these two studies show that trade liberalization expands women's work and income, but this could have perverse consequences on women's leisure time. In addition, in terms of gender inequalities, the results show more favourable effects in Bangladesh than in Zambia. Fofana et al. 2003 in a model applied to Nepal, analyse the effects of trade liberalization on the work of men and women, the authors find that by adding domestic production to market production, the contribution of women and children to the household (in terms of working time) is greater than that of men. The authors also point out that when women enter the labour market, it is their free time that is reduced rather than hours of production at home. This suggests that the expansion of women's paid employment through trade liberalization has been accompanied by a reduction in their free time.

In other studies the integration of domestic production is done through the compilation of satellite accounts in the national accounting system (SNA). For example, Cockburn, et al. (2007) build a macroeconomic framework that integrates market and non-market activities in order to assess the impacts of tariff elimination on men and women in South Africa. The authors reveal a strong gender bias against women with a decline in their labour market participation relative to men. Likewise, female labour market participation decreases particularly for African women, who have an increase in domestic work following trade liberalization. Similarly, Mitik (2007) disaggregates the satellite accounts of non-SCN production to distinguish between the non-commercial work of adults (men and women) and the non-commercial work of children (girls and boys). The author confirms the results of Cockburn et al. (2007) pointing out that trade liberalization in South Africa benefits men more than women. The author further argues that even when women's participation in the labour market increases more than men's, their domestic workload decreases relatively less and the increase in this participation is due in part to the replacement of children by their parents in domestic work at the expense of their education, especially that of girls. For his part, Siddiqui (2005) proposes a CGE that incorporates household work and leisure into a comprehensive study of the gendered effects of the macroeconomic crises in Pakistan.

With regard to studies using CGE models to assess the effects of climate change, although the application of these models has spread, most are limited to addressing the effects on the agricultural sector, and only a few extend the effects on other sectors, such as the inclusion of the water sector (Vargas et al. 2018) or the inclusion of international price variation and migration (Chitiga et al. 2019). However, to the best of our knowledge, no work has included the modelling of domestic work. Likewise, not including the gender dimension could be a serious bias when introducing domestic work. A World Bank study by Rubiano-Matulevich and Viollaz (2019) on the time spent on domestic activities, adult care and leisure in different countries of the world, estimates that the participation of women, mainly in less developed countries, is greater than that of men in unpaid activities. Moreover, the time devoted to these activities is greater when the household is poorer. The paper in hand contributes to the

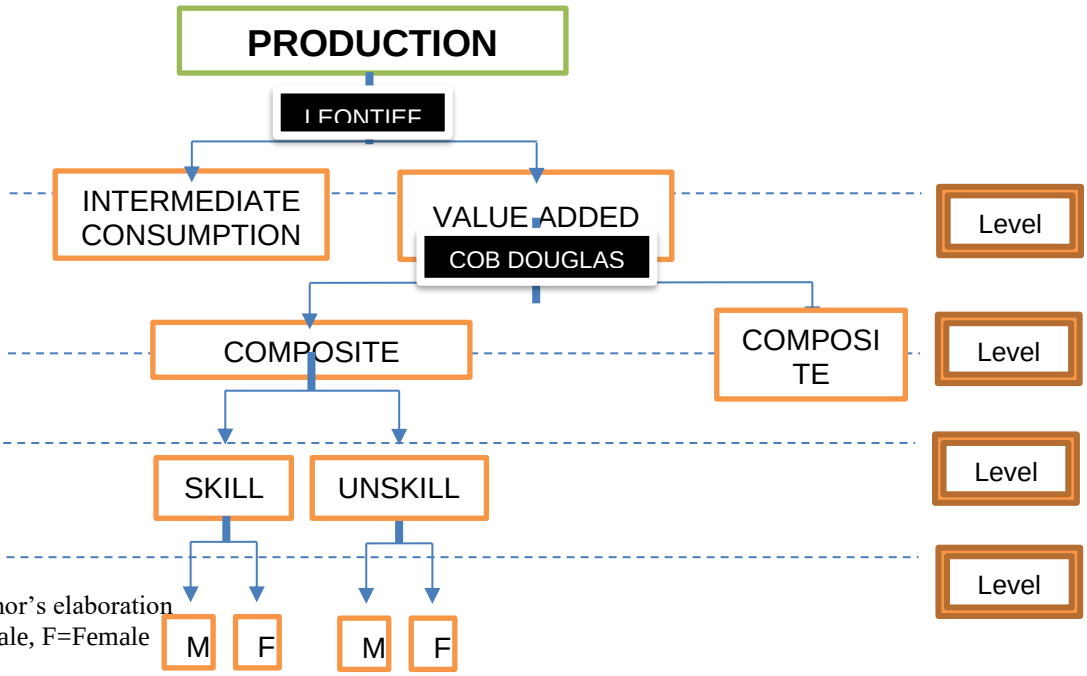
application of CGE models by introducing domestic production to assess the impact of climate change in Bolivia.

3. Methodological framework

To evaluate the impacts of climate change on women's poverty, we use the PEP 1-1 model from Decaluwé et al (2013), that incorporates the classic specificities of general equilibrium modelling. He postulates that we are dealing with a small open economy that has no influence on international pricing. As a result, world prices in the model are exogenous. However several assumptions have been adjusted to adapt to the focus of our paper on gender and to the case of Bolivia. In line with the Social Accounting Matrix (SAM) we used, the model has 20 activities and commodities. The production function technology presupposes constant returns to scale presented in a four-level production process.

At the first level, for each activity, production is a Leontief type of function of value added and intermediate consumption. At the second level, we assume that composite labour can be substituted with capital following a Constant Elasticity of Substitution (CES) type of function. At the Third level we disaggregated labour input by skill level. As a result, the different production sectors have the possibility to use two categories of labour (skilled and unskilled) that constitute the composite work. Finally, to take into account the gender inequalities in the Bolivian labour market, each sectoral labour demand is disaggregated by gender. Therefore, at the fourth level and for each skill category, the labour demand is a CES function between male and female workers.

Figure 1: Labour Market



Source: Author's elaboration
Notes: M=male, F=Female

The model distinguishes four different institutions: households, firms, the government and the rest of the world. Households are also disaggregated into a total of four representative households: male-headed households in the rural and urban sector and female-headed households in the rural and urban sector. In the model, the sources of income of representative households are derived from remuneration of labour inputs (wages), remuneration of capital (dividends) and transfers from other agents. These resources are used for consumption and savings, their consumption behaviours are specified with a linear expenditure system (LES) of

the Stone (1954) type. Firms' income is based on transfers from other institutions and mainly on capital income. They pay income taxes, dividends and the remaining income constitutes firms' savings. Government's income comes from three different sources; it collects direct taxes from households and firms, transfers received from other agents and indirect taxes (import duties, taxes on commodities and taxes on production). These resources will be used for public expenditure and for the payment of transfers to non-governmental agents. Government consumption spending is mainly on the non-tradable sector's production. Its savings is equal to its income minus its consumption and transfers paid to other institutions.

3.1.Endogenous labour supply and domestic work (home production)

For the purposes of the study and in order to be as close as possible to the realities of the Bolivian economy, it has been decided to integrate the modelling of domestic work in the labour market, for which modifications were made to the basic PEP 1-1 model. First, as in the basic model, full employment is assumed for all segments of the labour market. However, unlike the basic model in which the labour supply is fixed and therefore exogenous, in this model the labour supply is endogenous. Thus, thanks to the interrelationships between labour supply in the formal and domestic markets, it is possible to analyse the effects of our climate scenarios on total employment. In addition, since domestic tasks are mainly carried out by women in the Bolivian case, the specifications of the model will reflect this situation, affecting more important proportion of the female labour force in the domestic market.

We propose an endogenous labour supply which will depend not only on the time that households devote to their formal market activities, but also to domestic activities. So, in order to endogeneize the labour supply, we follow the methodology proposed by Fofana et al. (2005) that integrates a time constraint, which consists of establishing a time limitation to determine a maximum time available for the representative households of our model. It is worth pointing out that the maximum time denominated as MAXHOUR_h includes the time dedicated to commercial and domestic activities. Likewise, this time is calculated for each type of household by adding the labour supply according to the levels of qualification and gender of the workers.

$$Eq(1)\ MAXHOUR_h = LST_h + LZ_h$$

$$Eq(2)\ LSS_h = LSQ_h + LSNQ_h$$

$$Eq(3)\ LSQ_h = LSHQ_h + LSFQ_h$$

$$Eq(4)\ LSNQ_h = LSHNQ_h + LSFNQ_h$$

$$Eq(5)\ LZ_h = LZQ_h + LZNQ_h$$

$$Eq(6)\ LZQ_h = LZHQ_h + LZFQ_h$$

$$Eq(7)\ LZNQ_h = LZHNQ_h + LZFNQ_h$$

Where:

- LST_h = Market labour supply available to the household
- LZ_h = Domestic labour supply available to the household
- LSQ_h = Market skilled labour supply available to the household
- $LSNQ_h$ = Market unskilled labour supply available to the household
- $LSHQ_h$ = Market skilled male labour supply available to the household
- $LSFQ_h$ = Market skilled female labour supply available to the household
- $LSHNQ_h$ = Market unskilled male labour supply available to the household
- $LSFNQ_h$ = Market unskilled female labour supply available to the household

- LZQ_h = Domestic skilled labour supply available to the household
- $LZNQ_h$ = Domestic unskilled labour supply available to the household
- $LZHQ_h$ = Domestic skilled male labour supply available to the household
- $LZFQ_h$ = Domestic skilled female labour supply available to the household
- $LZHNQ_h$ = Domestic unskilled male labour supply available to the household
- $LZFNQ_h$ = Domestic unskilled female labour supply available to the household

The supply of domestic labour obtained from estimates of the time devoted to domestic activities has the particularity of being disaggregated according to gender and two types of qualifications of the household member (skilled and unskilled). For this we use specific estimates for Bolivia based on three sources: The World Bank report on women's empowerment by Lundvall et al. (2015), studies by Medeiros et al., (2010) and Canelas and Salazar (2014). Women's domestic shifts are estimated to be up to 4 times longer than men's shifts, 3 times more in the study by Medeiros et al. (2010) and Lundvall et al. (2015) and finally 4 times according to Canelas and Salazar (2014). To complete the allocation estimates on the use of time and given to an absence of data disaggregated by level of qualification for the Bolivian case, we used estimates of gender differences in the use of time from the World Bank report by Rubiano-Matulevich and Viollaz (2019), calculated for Peru, which is a country with similar characteristics in terms of domestic work by skills. In this sense, it was estimated on the one hand that unskilled women allocate seven hours to domestic activities, compared to four and a half hours for skilled women. On the other hand, skilled men allocate only one and a half hours to domestic tasks, compared to three hours for unskilled men.

In practical terms, the introduction of time limitation makes it impossible to increase the labour supply to infinity because this labour supply is limited by the distribution between domestic and commercial tasks. In addition, the consideration of domestic work introduces a new element in the profit of households, since a new production called domestic will be created, which is made up solely of the labour factor. This model will make it possible to determine to what extent the domestic burdens attributed mainly to women in the Bolivian case influence the evolution of the available labour supply. To this end, we propose a CET-type function between formal and domestic labour. Likewise, domestic production is in turn a two-tier function involving first the qualification level (skilled and unskilled) and second the gender dimension. The value of home produced goods is equal to the value of the labour devoted to its production where non-market labour is valued at its opportunity cost as measured by the market wage rates.

$$EQ(8)\ P_h^z Z_h = W_q LZQ_h + W_{nq} LZNQ_h$$

Where:

- $P^z\ and\ Z_h$: Represent the price and volume of domestic production.
- $W_q\ and\ W_{nq}$: Represent the wage rate for skilled and unskilled labour, respectively.
- $LZQ_h\ and\ LZNQ_h$: Represent the domestic skilled and unskilled labour supply available to the household

Of course, neither intermediate goods nor capital are required, since as previously stated domestic production is carried out only with labour factor. In addition, households fully consume the goods produced in the domestic market, since there is no market for these goods, in other words domestic production is equal to the consumption of domestic goods.

$$EQ(9)\ Z_h = CZ_h$$

Where:

- $CZ_h and\ Z_h$: Represent the consumption ant the production in the domestic market.

Subsequently, the total available labour supply determined by households presents a matching between the different types of labour through CET-type functions, firstly between the formal labour market and the domestic labour market (Equation 10). Then, supply functions are also adapted according to the skill levels of both the formal labour market and the domestic market (Equations 11 and 12).

$$EQ(10)\ LSS_h = B_h * [\beta_h * LST_h^{\tau_h} + (1-\beta_h) * LZ_{jh}^{\tau_h}]^{1/\tau_h}$$

$$EQ(11)\ LST_h = B\_T_h * [\beta_{th} * LSQ_h^{\tau q\_h} + (1-\beta_{Th}) * LSNQ_j^{\tau_{q\_h}}]^{\frac{1}{\tau q}\_h}$$

$$EQ(12)\ LZ_h = BZ_h * [\beta_{zh} * LZQ_j^{\tau zh} + (1-\beta Z_h) * LZNQ_j^{\tau zh}]^{1/\tau zh}$$

Where:

- LSS_h: Total composite labour supply for each household type,
- LST_h: Market labour supply available to the household
- LZ_h: Domestic labour supply available to the household
- $B_h, B\_T_h \ and \ BZ_h$: Represent the scale parameter of the CET function for composite labour supply, market labour supply and domestic labour supply, respectively.
- $\beta_h, \beta_{th} \ and \ \beta_{zh}$: Represent the distribution parameter of the CET function for composite labour supply, market labour supply and domestic labour supply, respectively.
- $\tau_h, \tau q_h \ and \ \tau z_h$: Represent the transformation elasticity parameter for composite labour, market labour and domestic labour, respectively.
- $LSQ_h and \ LSNQ_h$: Represent the skilled and unskilled market labour supply available to the household
- $LZQ_h and \ LZNQ_h$: Represent the skilled and unskilled domestic labour supply available to the household

Finally, the last two equations describe the gender dimension for skilled labour supply in both the formal market (Equation 13) and the domestic market (Equation 14). The same applies to unskilled labour supply.

$$EQ(13)\ LSQ_h = B\_Q_h * [\beta TQ_h * LSHQ_h^{\tau sq\_h} + (1-\beta TQ_h) * LSFQ_j^{\tau_{sq\_h}}]^{\frac{1}{\tau sq}\_h}$$

$$EQ(14)\ LZQ_h = BZ_h * [\beta ZQ_h * LZHQ_j^{\tau zqh} + (1-\beta ZQ_h) * LZFQ_j^{\tau zqh}]^{1/\tau zqh}$$

Where:

- $B\_Q_h \ and \ BZQ_h$: Represent the scale parameter of the CET function for the market skilled labour supply, and the domestic skilled labour supply, respectively.
- $\beta TQ_h \ and \ \beta ZQ_{th}$: Represent the distribution parameter of the CET function for the market skilled labour supply, and the domestic skilled labour supply, respectively.
- $\tau sq_h \ and \ \tau zq_h$: Represent the transformation elasticity parameter for the market skilled labour supply, and the domestic skilled labour supply, respectively.
- LSQ_h: Represent the skilled market labour supply available to the household
- LZQ_h : Represent the skilled domestic labour supply available to the household
- $LSHQ_h \ and \ LSFQ_h$: Market skilled labour supply available to the household for male and female, respectively.
- $LZHQ_h \ and \ LZFQ_h$: Domestic skilled labour supply available to the household for male and female, respectively.

3.2.Micro simulation module

In recent years, different approaches have been presented using CGE models to analyse poverty. We developed a microsimulation module that integrates gender decomposition. The objective of developing this module is to determine the impact of CGE macroeconomic outcomes on the evolution of poverty and inequality. Therefore, in addition to measuring the intersectoral effects between different sectors of the economy and the interactions between institutions thanks to the CGE model, the Top-Down approach of our micromodule will allow us to carry out microeconomic analysis to assess the effects of climate change on poverty in men and women using standard monetary techniques. Specifically, we will calculate the FGTT poverty incidence and depth indicators and the Gini index to measure inequality.

3.3.Data

Like all CGE models, we use a social accounting matrix (SAM) as our primary data. We disaggregated the SAM of Lykke et al. (2012) to include a gender-skilled labour market. Since we are mainly studying the effects of climate change on the agricultural sector, labour markets and poverty, it is important to disaggregate agricultural sectors and products, therefore we maintain nine categories for agricultural activities. However, although we tried to keep the detailed disaggregation in the agricultural sector we also had to suppress and/or combine some sectors in the initial SAM. The reasons for adding sectors were, on the one hand, the lack of information on factor remuneration, and on the other hand the fact that the values recorded in some sectors were quite low and we decided to group sectors together. In this sense we merged sectors such as beverages and tobacco, the wood and paper sector, as well as the commercial and real estate industries. The rest of the excluded activities were added to avoid having a negative national production (the variation of their stocks is high for the base year), in particular we have a first group that regroups the chemical and oil industry, and a second group that regroups metal products, non-metallic minerals, machinery and other manufacturing products. As a result, the SAM has 20 sectors or activities, nine of which are agricultural activities: cereals, vegetables, tubers, fruits, other non-industrial agriculture, soybeans, sugar cane, coca and livestock. At the same time, we also have 20 products in the SAM. In terms of production factors, we have 3 accounts: capital, land, and labour. The capital has an aggregate account, the land has 3 accounts for 3 regions (Highlands, Valleys and Lowlands), and finally we have 12 accounts for the labour factor in order to include a labour market disaggregated according to the level of skills and gender of the workers. Taxes include four types of taxes: direct taxes, indirect taxes, import taxes, and producer taxes. The different institutional accounts are: households, businesses, government and the rest of the world. As far as households are concerned, a breakdown also provided by the basic MCS is retained, however we chose to retain a breakdown between rural and non-rural households instead of a breakdown between indigenous and nonindigenous households. Likewise, for each of these household categories we include gender subcategories distinguishing between men and women, making a total of 4 household categories.

Another database we will use is the National Household Survey (2017), particularly for the micro simulation module. In turn, income elasticity of demand was estimated using microdata from Morales et al. (2017). Finally, for production and for the Armington and CET elasticity, we used the estimations based on Sevillano Cordero (2012).

4. Simulations and results

The first simulation also called "DAM-Px" is based on an analysis of the direct and indirect effects associated with meteorological phenomena for events occurring in 2013 and 2014 carried out by Design et al (2017). We take into account the damages and losses due to climatic events in the agricultural and livestock sector of Bolivia. In the model this shock is introduced exogenously affecting the capital production factor. In addition, this simulation takes into account the variation of world prices on agriculture and livestock as a consequence of climate change, for this we will use the NCAR (National Center for Atmospheric Research) model forecasts based on scenario A2[3] of the IPCC report. The price variation will be introduced as exogenous values in the closure of the model.

In the second simulation also called "TPF-Px", we analyse a reduction in agricultural production as a consequence of climate change. For this, we will specifically rely on the IPCC projections, and the CEPAL 2014 estimations for Bolivia for considering a decrease in production yields in two types of agriculture: Modern (which decreases by 5 %) and Traditional (which decreases 12%). As in the first simulation this scenario will take into account the variation in international prices.

4.1.Macro results

In the following table we present the macroeconomic results of our simulations. As for the first simulation, the impact of external weather events combined with the increase in international prices leads to a drop in real GDP by 0.13%. Likewise, we see that this effect is accompanied by a general increase of 2.08% in the level of prices of goods that affect economic agents. Consequently for the household agent real consumption decreases by 0.5%. As to the second simulation, the incorporation of falls in the level of agricultural productivity intensifies the negative impacts reaching a fall of the real GDP of 0.81%. There is also a general increase in the level of prices greater than that of the previous simulation (3.01%) and the real consumption of the household agent decreases even more (1.33%). Finally, we see a positive impact in the total investment in both simulations, however this increase is higher in the first simulation than in the second one (1.76% vs 1.10%).

Table 2 - Macro Results

	Sim 1 "DAM_PX"	Sim 2 "TPF_PX"
Real GDP at basic prices	-0.13	-0.81
Consumer price index	2.08	3.07
Real consumption budget of households	-0.50	-1.33
Total investment expenditures	1.76	1.10
Public expenditures price index	1.23	1.22

Source: Calculations based on the CGE model

4.2.Sectoral effects

[3] The scenario is one described in Nakicenvoic et al. (2000) in the Special Report on Emissions Scenarios (SRES) that was commissioned by the IPCC.

In the first simulation, the scenario involves damage and losses in the capital production factor due to climatic events in Bolivia's agricultural sector and an increase in international agricultural prices. Hence, we expect that the level of agricultural production should be affected but not much since they are highly labour intensive and not capital intensive. Likewise, agricultural producers will be interested in producing more to sell both in the local and external markets taking advantage of the price increase. The results confirm this hypothesis and show a decrease in production in only 2 of the 8 agricultural sectors. For the non-agricultural sectors we have a decrease in production, except for only three industries: food processing, commercial services and water-gas-electricity industry (See table 3). In terms of exports, only two agricultural sectors benefit from increases (cereals and coca). On the import side, since prices have increased, it is more expensive for the consumer to buy imported agricultural products, which is why there is a decrease in agricultural imports, amongst the most affected agricultural products are cereals, vegetables and fruits. For the rest of the non-agricultural sectors we see the opposite effect, and therefore an increase in non-agricultural imports excepting only the food processing and livestock industry. It should be noticed that the agricultural sectors are rather intensive in labour factor using on average around 70% of the labour force in their production process, so to ensure a higher level of production more workers are needed. As a result, we expect the workforce to increase mainly in the agricultural sectors. It should be emphasised that in the model, the workforce is determined by households. In this regard, the introduction of an endogenous labour supply allows us to appreciate effects linked to domestic work and formal household work. Globally this scenario shows a reduction in domestic burdens of -0.048% and an increase in the formal market of 0.009% (See table 4).

In the second simulation, we expect the level of agricultural production to be affected more severely as the scenario involves a drop in agricultural productivity, affecting value added and in turn the labour factor. The results confirm this hypothesis and show a drop in agricultural production of all crops with the exception of sugarcane. However, it should be noted that the drop in agricultural production affects more traditional agricultural crops, and in a smaller proportion, modern agricultural crops (See table 3). The effects also extend to the non-agricultural sectors. Indeed, we have a production decline in all sectors except two industries (livestock and food processing). As for the effects on trade, we see that the level of exports in the second simulation falls for all sectors, being the traditional agricultural sectors the most affected, followed by the modern agricultural sectors and to a smaller extent the non-agricultural sectors. On the import side, since prices have increased, it is more expensive for the consumer to buy imported products, which is why we have a decrease in agricultural imports, amongst the most affected agricultural products we have cereals, vegetables and fruits. For the rest of the non-agricultural sectors we have the opposite effect, and therefore an increase in non-agricultural imports except the food processing and livestock industry. Then, as in the first simulation, the introduction of an endogenous labour supply allows us to appreciate effects linked to domestic work and formal household work. This scenario shows a reduction of the domestic load greater than that had in the first simulation (-0.093%) and an increase in the formal market of 0.019%. However, we found that the reduction of burdens does not benefit rural women who, on the contrary, increase their domestic burdens, widening the gaps between men and women. Table 4 summarizes the results on the labour market both in the formal sector and in the domestic sphere.

Table 4 – Formal versus Domestic Market

	Sim1 « DAM_PX »		Sim 2 « TPF_PX »	
	LST	LZ	LST	LZ
Rural male	0.001	-0.006	0.020	-0.105
Rural female	-0.012	0.072	-0.006	0.042
Urban male	0.014	-0.069	0.039	-0.182
Urban female	0.007	-0.037	0.026	-0.126
Total	**0.009**	**-0.048**	**0.019**	**-0.093**

Source: Calculations based on the CGE model
Notes: LST=Formal labour market, LZ=Domestic labour

In the table we can see the effects linked to domestic and formal work carried out by households. The results of the first simulation indicate that the reduction of domestic work occurs mainly among the urban population, which in turn increases their participation in the formal market. In contrast, for the rural population, domestic tasks decrease in a smaller proportion and only for the male population, in the case of the female population, domestic burdens increase by 0.072% and therefore they have a lower participation in the formal market. In the second simulation, the reduction of domestic tasks is more significant but the results follow the same trend, three of the four representative households reduce their domestic burdens. However, once again there is an increase in domestic burdens on rural women which reduces their participation in the formal market falling by -0.006%.

4.3.Impacts on agents

The effects of climate change can be observed at the level of the different economic agents of the Bolivian economy, namely, businesses, the Government and households. In our two simulations the most affected agents are households, while the results are rather favourable for the rest of agents, especially in the first simulation.

In this way, for the first simulation, we observe that the income and savings of the companies both increased by 1.25% and 1.26% respectively, a result that is explained by the increase in production in agricultural sectors that increased their production encouraged by more attractive prices abroad. As far as the government agent is concerned, we have an increase in all sources of income except those corresponding to taxes on imported goods. In sum, total public revenue and savings increase by 0.72% and 0.96%, respectively. In the second simulation, the effects for these agents remain positive but less considerable. Indeed, companies increase their income and savings both 1.08%. For the government agent, total public revenues increase by 0.51% and the level of savings remains constant.

As for the effects on households, we probably have the most prominent effects. The results indicate an increase in disposable income and in the level of savings for all categories of households, we should expect these increases to be reflected in increases in consumption, however the increases are proportionally lower than the price increases. Consequently, this translates into a loss of household purchasing power. This suggests that the effects of climate

change in Bolivia affect the well-being of households that see their consumption decline. In addition the introduction of an endogenous labour supply allows us to appreciate effects linked to domestic work and formal household work. Globally, both scenarios show a reduction in domestic burdens of -0.048% in the first simulation and -0.093% in the second. However, the results are heterogeneous for the different household categories by skills. We confirm that formal employment of unskilled workers tends to increase while formal employment of skilled workers contracts. On the contrary, in the field of domestic work, there is a reduction in the labour supply for unskilled household members and increases in skilled members. This result is in line with the employment statistics previously observed for Bolivia. (See table 5)

Table 5 – Formal vs domestic Market

Households catecory	Sim 1 DAM_PX				Sim 2 TPF_PX			
	Skilled		Unskilled		Skilled		Unskilled	
	Domestic	Formal	Domestic	Formal	Domestic	Formal	Domestic	Formal
Rural male	0.36	-0.15	-0.23	0.02	0.74	-0.35	-0.63	0.08
Rural female	0.38	-0.18	-0.12	0.01	0.74	-0.40	-0.39	0.05
Urban male	0.62	-0.10	-0.50	0.07	1.29	-0.23	-1.11	0.20
Urban female	0.67	-0.11	-0.47	0.07	1.35	-0.26	-1.05	0.18

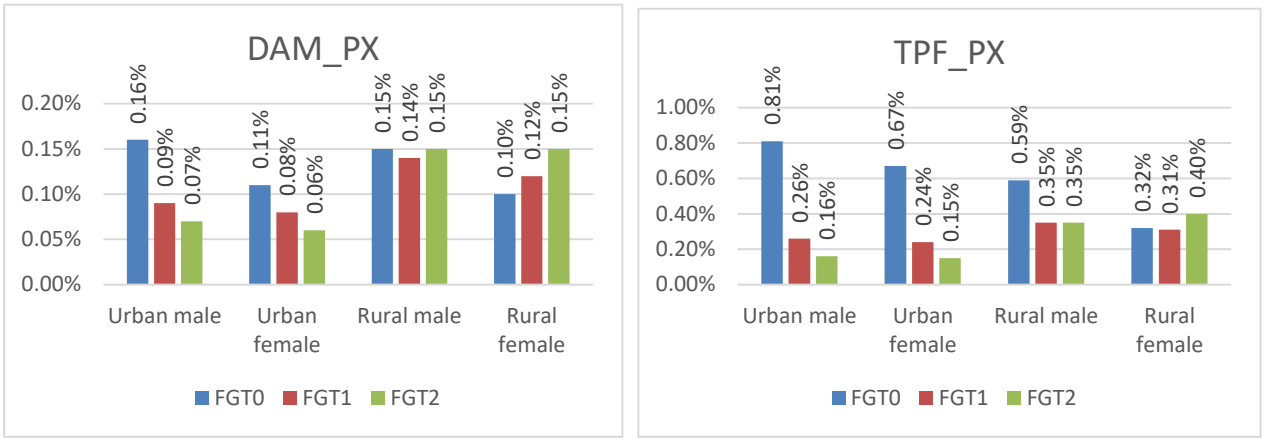
Source: Calculations based on the CGE model

Although at the global level in both simulations we have a decrease in domestic burdens, but it increases for the rural population and mainly for rural women, reducing their participation in the formal market. This situation reflects the fact that climate change contributes to reducing female participation in the formal labour market, and widens inequality gaps in the labour market. As a result, women's role in the domestic sphere prevents them from participating more in the labour market. In view of these statistics, the loss of household purchasing power due to price increases, coupled with perverse effects on employment, which are generally unfavourable for women mainly in the rural sector, should reflect an increase in poverty levels.

4.4.Poverty impacts

To assess the evolution of poverty, we analysed the evolution of the FGT0, FGT1 and FGT2. This indicators reflect changes in the incidence of poverty, the depth of poverty measured by the poverty gap, and the severity of poverty. The following table summarizes the results obtained from the microsimulation module.

Figure 2 – Poverty effects (% change from base scenario)



Source: Calculations based on the Microsimulation model
Notes: DAM_PX=Simulation 1, TPF_PX=Simulation 2

With regard to the effects on poverty, starting from the base scenario we already observed that poverty levels are higher in the rural sector than in the urban sector, in addition poverty levels are higher among women than men in the 3 indicators. The results in the first simulation report increases in all three indicators, but we can observe some differences. In fact, the first indicator FGT0 presents high results in the urban population, while indicators FGT1 and FGT2 are related to the rural population. These results suggest that climate change affects moderate poverty in urban households and extreme poverty in rural households, with rural women being the most affected (0.15%). With respect to the second simulation, the results also show an increase in all three poverty indicators. However, overall these effects are proportionally greater than in the previous simulation, suggesting that this scenario affects poverty levels more. The analysis of the poverty indicators follows the same trend and therefore the results suggest that the climate shock affects moderate poverty in the urban sector, while extreme poverty in the rural sector, with women being more affected than men (0.40% vs 0.35%).

5. Conclusion

This study provides some insights into the effects that climate change may have on the labour market and poverty levels in Bolivia. We found that the most negative effects would be concentrated on households. Despite having increases in income in some categories of households, the increases in price levels end up being proportionally more important and affect their purchasing power severely. The first simulation that plays on capital indicates that the results turn out to be favourable for 10 out of 20 sectors, benefiting mainly the labour-intensive agricultural sectors that increase their production, and an increase in exports in the specific case of cereal and coca crops. However, overall the macroeconomic impact is negative and is reflected in a 0.13% drop in real GDP. The second simulation affecting agricultural productivity shows even more negative impacts for the economy as a whole. As expected, the agricultural sector is the most affected, with production losses ranging from 1% to 8% and agricultural exports being negative for all crops. Likewise, the effects also extend to the rest of the sectors in less proportion. In this simulation only 3 of the 20 sectors show increases in production. At the macroeconomic level, the effects on real GDP reach 0.81% and the general increase in the

price level is greater than that of the previous simulation by 1%, which affects real household consumption.

Although at the global level in both simulations we have a decrease in domestic burdens, these increase for the rural population and mainly for rural women, reducing their participation in the formal market. This situation reflects the fact that climate change contributes to reducing female participation in the formal labour market, and widens inequality gaps in the labour market. As a result, women's role in the domestic sphere prevents them from participating more in the labour market. In view of these results, the loss of household purchasing power, coupled with perverse effects on employment, which are generally unfavourable for women mainly in the rural sector, should reflect an increase in poverty levels.

The fluctuations of poverty indicators confirms the dynamics of macroeconomic results. The latter already highlighted the fact that the purchasing power of households was declining, and in turn, their consumption. This suggested a deterioration in their well-being, which confirmed with the present result. The two climate change scenarios studied in this document show increases in poverty indicators; it should be noted that these increases are more significant in the second simulation than in the first. Likewise, we find that in the urban population it is the moderate poverty that worsens while in the rural population it is the level of extreme poverty that increases, which suggests that the scenarios studied in our two simulations increase poverty levels and harm the well-being of households, affecting the poorest women in the rural sector.

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7. Annexes

Table 1 - Gender patterns in sectoral disaggregation employment, 2018 (%)

	Male employment	Female employment	Female Intensity
Agriculture, Livestock, Hunting, Fishing and Forestry	20.36	19.30	45
Mining and Quarrying	2.83	0.29	8
Manufacturing Industry	12.08	10.75	43
Electricity, gas, steam and air conditioning supply	0.32	0.07	16
Water supply, sewage disposal, waste management	0.25	0.06	17
Construction	15.66	0.62	3
Wholesale and retail, automotive repair	13.72	27.59	63
Transport and Storage	12.73	0.83	5
Accommodation and meal service activities	3.11	14.13	79
Information and Communications	1.09	0.56	30
Financial Intermediation and Insurance	0.66	0.91	54
Real estate activities	0.31	0.62	62
Professional and Technical Services	2.12	1.62	39
Administrative and Support Services Activities	1.51	1.80	50
Public Administration, Defence and Social Security	4.14	2.78	36
Education Services	3.74	6.74	61
Health and Social Services	1.51	4.23	70
Artistic, Entertainment and Recreational Activities	1.23	0.39	21
Other service activities	2.40	2.87	50
Private Household Activities	0.18	3.86	95
Extraterritorial Organisms Service	0.02	0.00	0
TOTAL	100.00	100.00	

Source: Calculated from ECE 2018, Encuesta continua de empleo
Note: 'Female intensity' is defined as the percentage of the female labour force in a specific sector. A share higher than 50 per cent indicates that the sector is female-intensive

Table 3 – Sectoral effects

Sector	Sim 1 DAM_PX			Sim 2 TPF_PX		
	CI	DIT	VA	CI	DIT	VA
Cereals	6.66	2.40	6.66	-2.11	-0.16	-2.11
Vegetables	0.49	1.11	0.49	-6.54	-1.12	-6.54
Root crops	0.28	1.07	0.28	-4.20	-0.59	-4.20
Fruits	4.05	1.85	4.05	-2.98	-0.35	-2.98
Other non-industrial agriculture	-0.27	0.95	-0.27	-7.14	-1.26	-7.14
Soybeans	0.53	1.56	0.53	-0.91	0.41	-0.91
Sugarcane	2.08	1.87	2.08	0.78	0.75	0.78
Coca	0.92	0.91	-0.08	-1.95	-1.94	-1.95
Livestock	1.60	1.76	1.60	0.71	0.70	0.71
Forestry and fishing	-0.22	-0.30	-0.22	-0.57	-0.81	-0.57
Hydrocarbon and mining Industry	-1.07	-0.84	-1.07	-0.99	-0.87	-0.99
Food processing industry	1.85	0.37	1.85	0.76	-0.46	0.76
Tobacco and beverages industry	-0.54	-0.54	-0.54	-0.71	-0.71	-0.71
Textile industry	-1.09	-0.40	-1.09	-1.26	-0.73	-1.26
Machinery and other industry	-1.03	-0.26	-1.03	-1.03	-0.62	-1.03
Water gaz and electricity industry	0.19	-0.15	0.19	-0.10	-0.51	-0.10
Commercial and financial services industry	0.04	0.04	0.04	-0.36	-0.60	-0.36
Restaurants and hotels	-1.53	-0.24	-1.53	-2.28	-0.56	-2.28
Domestic and social services	-0.24	0.01	-0.24	-0.61	-0.38	-0.61
Public administration	-1.03		-1.03	-1.10	-1.10	-1.10

Source: Calculations based on the CGE model
Note: CI= Intermediate consumption, DIT=Total intermediate demand, VA= Value added

Table 6 – Effects on trade

Sector	Sim 1 DAM_PX		Sim 2 TPF_PX	
	EX	IM	EX	IM
Cereals	0.04	-56.27	-15.55	-43.70
Vegetables	-2.21	-60.86	-16.92	-48.14
Fruits	-0.66	-58.88	-15.51	-46.31
Other non-industrial agriculture	-2.41		-17.00	
Soybeans	-5.55		-7.46	
Coca	1.78		-6.94	
Livestock	-2.33	-29.59	-3.46	-29.06
Forestry and fishing	-1.24	2.27	-1.33	1.69
Hydrocarbon and mining Industry	-1.19	1.16	-1.09	0.91
Food processing industry	-2.39	-34.17	-3.99	-32.75
Tobacco and beverages industry	-1.53	2.72	-1.47	2.09
Textile industry	-1.54	1.39	-1.55	0.89
Machinery and other industry	-1.21	0.71	-1.11	0.32
Commercial and financial services industry	-1.01	2.20	-1.04	1.44
Restaurants and hotels	-2.91	3.51	-3.69	3.60
Domestic and social services	-1.62	2.98	-1.73	2.42

Source: Calculations based on the CGE model
Note: EX=Exports, IM=Imports