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Distributional and economy-wide effects of post-conflict policy in Colombia

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Abstract

The aim of this paper is to evaluate the effects of agricultural policies that, as part of the peace accord in Colombia, have been proposed for the rural regions most affected by the armed conflict. Specifically, we are interested in their economy-wife and distributional effects. To that end, we use a newly built 2014 social accounting matrix for Colombia to calibrate an extended version of the well-known PEP 1-1 computable general equilibrium model. The policies we consider comprise an increase in total factorial productivity due to greater technical assistance and infrastructure construction, and production and employment subsidies in order to promote the substitution of illicit crops. It is found that value added, demand for labor, and factor incomes increase in the areas most affected by the conflict, while the opposite occurs in the other areas. Moreover, total rural income increases as long as the financing mechanism does not consider an increase in the taxation of rural incomes. In fact, we found that the distributional effects are strongly conditional on the financing mechanism that the government adopts.

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1. Introduction

The armed conflict in Colombia during the 20th century had three major milestones. First, the assassination of a presidential candidate in 1948 was followed by violent disputes between two traditional political parties that extended for about ten years. Then, in the 1960s, two left-wing groups emerged: the Revolutionary Armed Forces of Colombia (FARC) and the National Liberation Army (ELN). In the 1980s, right-wing paramilitary groups emerged to fight these guerrillas (Arias et al., 2019). By the end of this century, Colombia was one of the most politically violent countries in the world (WHO, 2002).

The armed conflict developed mainly in rural areas, away from urban centers (González and Lopez, 2007). Moreover, difficult access to these areas and violence have restrained investments in road and productive infrastructure. In turn, this caused greater isolation and obsolescence in production techniques reducing the productivity and efficiency of farm households (González and Lopez, 2007). Consequently, poverty in those areas increased. In fact, according to the multidimensional poverty index of the National Planning Department (DNP), for 2014 rural poverty was around 44.1%, urban poverty reached 15.4%, and the rural-urban income gap widened.

In 2016, the government of president J.M. Santos reached a peace agreement with FARC, with which this armed group would end its armed operations. Nowadays, with the signing and implementation of the peace agreement, it is expected that much of the obstacles to rural development can be removed, and rural households' wellbeing can be improved. This peace agreement contains six points, two of which refer to a "Comprehensive Rural Reform" (Point 1), and the "Substitution of Illicit Crops" (Point 4). Both points contain a package of policies that seek the recovery of the rural areas most affected by the conflict. For instance, it is expected that rural populations will have access to production and labor subsidies, and access to technical assistance for the implementation of new crops and substitution of illicit crops. In addition, planned investments in road infrastructure will facilitate access to markets and urban centers. The objective of this research is to assess the overall economic impacts of these government policies that, it is expected, will be implemented in the post-conflict era. This assessment includes analyses of sectorial impacts and distributional effects.

This report is organized as follows. After this introduction, a brief review of the literature is presented. Section 3 presents the methodology and data used, including the main characteristics of our computable general equilibrium model. The simulations are presented and analyzed in Section 4. The last section presents the main conclusions.

2. Literature review

2.1 Conflict and agriculture

The history of Colombia is marked, from its independence in 1819, by internal conflicts of diverse nature. For the recent history, Pinto et al. (2005) estimated that the cost of the armed conflict over the Colombian economy,

between 1999 and 2003, could be equivalent to a 7.4% of GPD of 2003. Around 28% of Colombian municipalities have been affected by the armed conflict. Of those municipalities with the highest incidence of armed conflict, the National Planning Department shows that 88% are largely rural (DNP, 2017).

For the Colombian rural sector, Hernández et al. (2014) show that small-scale agriculture and family farming represent 54% of the agricultural value added, and 72% of the remuneration of wage-earners in the sector. They also show that rural non-agricultural activities affect 41.3% of rural employment and 43.2% of rural income, mainly in the services sector. There is also an important gap between rural and urban areas in terms of income; rural households receive 11.4% of total income, which is much lower than the participation of the rural population in the total population (25%) in 2011. Moreover, 75% of the employed population in the rural area has an income below the legal minimum wage in Colombia, whereas in the urban area this proportion is 39.4% (DNP, 2015).

Arias et al. (2019) find that rural households in conflict areas of Colombia are pushed onto a lower income trajectory. This is due not only to the lower intensity of land use, but especially due to changes in the portfolio of activities that these households engage in. Particularly, these authors show that small farmers engage in activities with short-term yields and lower profitability, specifically in subsistence activities as violence intensifies. In general, the international literature has pointed out this negative effect of conflict on agricultural production (Messer et al., 1998; Ksoll et al., 2010), effect that may be transmitted through different channels such as human mobility, access to markets of inputs, location of the agricultural activity or extortion by armed groups (Kimenyi et al., 2014; Rockmore, 2015).

Ibañez and Jaramillo (2006) point out that an adequate policy for the Colombian post-conflict must include: (a) capital recovery to increase the stock of productive capital, and (b) a policy of rural education promotion that narrows the gap in levels of school attendance between the rural and the urban sectors. Nevertheless, it should be complemented by proactive social policies with short and long-term gains from economic production, considering also the flows of population returning to rural areas and their physical and human capital (Arias et al., 2019). In addition to this, Longley et al. (2006) suggest that the agricultural policy for rural people who have been affected by conflict, should consider the transition from supply-led programming to the establishment of market-driven systems that leads to the promotion rural livelihoods.

This vision entails an explicit rebuke of what has been called the "yeoman farmer fallacy" (Farrington and Bebbington, 1994), according to which virtually all rural poor strive to alleviate poverty through increased or more effective investment in agricultural activities. To the contrary, there is the realization that a significant proportion of the rural poor earn sizeable parts of their income from outside of the farm (i.e., they diversify their income sources either for supplementing or substituting for agricultural income). It is estimated that a large share of rural households' income comes from agriculture, although some evidence points to an increasing importance of non-agricultural activities, as they may provide between 35 and 50 percent of rural income in developing countries.[1] In general, there is evidence that poor rural households tend to engage in subsistence level activities, on and off-farm, unable to provide for reinvestment or capital accumulation, leading to what can be termed survival diversification (Little et al., 2011).

An analysis of income diversification patterns for Colombian rural households (Argüello and Poveda, 2016), shows that it has been a persistent characteristic of rural income, positively associated with the income level of

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[1] See Barrett et al (2001) for evidence on Africa, Reardon & Berdegué (2001) for Latin America, and Davis et al. (2010) for an overview.

the household, and that the share of agricultural income arising from agricultural salaries has declined. Additionally, as income increases, households tend to depend more on non-agricultural salaries and less on agricultural income directly generated in the farm. This dynamic shows the importance of simultaneously considering the interaction between the different sources of income that rural households have, not only in terms of the linkages mentioned above but also in terms of the way households can take advantage of the different income sources, and the different markets they are involved: products, inputs and labor.

2.2 CGE modelling of agricultural policy

The CGE modelling approach has been previously used in the analysis of the impact of different economic policies on the agricultural sector. On one hand, the previous literature comprises the analysis of policies that are targeted to the agricultural sector such as price polices, subsidies, and taxes (e.g., de Janvry and Sadoulet, 1987; Hertel and Tsigas, 1988; Parry, 1999; Ding and Rebessi, 2019). A common finding in this literature is that those different policies may affect income across different social groups, "with few instances where net gains are derived by all groups" (de Janvry and Sadoulet, 1987, p. 244). Besides price polices, this tool has been useful in the study of the effect that rural road improvement may have on poverty incidence (Warr, 2008), and the welfare implications of improvements in irrigation efficiency worldwide (Calzadilla et al., 2011). On the other hand, another set of literature has sought to estimate the impact that trade policies may have on the agricultural sector of different countries (e.g., Blake et al., 1999; Bach et al., 2000; Holland et al., 2005; Warr, 2005; Ding and Rebessi, 2019). In addition to this, CGE modelling has been used to estimate the differential effects of subsidies and trade policy on food production and poverty in developing countries (e.g., Warr and Yusuf, 2014).

For the case of Colombia, Argüello and Valderrama-Gonzalez (2015) and Pinzón (2015) assessed the impact of a change in the agricultural policy in Colombia in the last decade. Namely, the Agriculture Secure Income Program (AIS, Spanish acronym). This policy was implemented the 2000s with the aim of triggering competitiveness of the agricultural sector after the negotiated free trade agreement with the United States. In both works, the authors found a rather small effect of this policy on agricultural production. Considering both the objective of this research and the usefulness of this tool, by following a CGE modelling approach, in our paper we aim to assess the impact of policies proposed in the frame of the implementation of the Colombian peace agreement with FARC in 2016. This policies are focused on small farms in the most affected zones by the armed conflict. Our research adds to this previous literature by considering a different target of the change in the agricultural policy. Thus, we make a contribution – both in terms of data and modeling -- by distinguishing agricultural production by region and farm size.

3. Data

A SAM was built for the year 2014. An initial SAM was built with information of the Integrated Economic Accounts (IEA) and the Supply and Use Tables (DANE, 2014a, 2014b). Together, the IEA and the SUT provide information on production, value added, intermediate consumption, income, exports, imports, taxes and government consumption. In a second stage, the resulting – and relatively simple SAM and with only two crops -- was expanded to gain focus on the rural sector, and also considering the incidence of the armed conflict. This was done by combining data from the 2014 national agricultural census (DANE, 2016) with data on the

Incidence Index of the Armed Conflict of the National Planning Department at the municipality level.[2] Specifically, from the 2014 national agricultural we obtained estimates on cost structures for selected crops of the Agricultural Production Units (UPA). Besides, a national household survey was used to single out two representative households, one rural and one urban. We used the RAS technique (Trinh and Viet, 2013) to balance our SAM. Specifically, we used this method to single out cost structures that differ across the different production technologies (small, medium, large). In fact, we used information on cost structures by firm size and imposed two constraints: (a) known totals from the supply and use tables (i.e., total intermediate input and factor demand by aggregated activities), and; (b) the value of output by firm size.

The SAM with agricultural sector disaggregation allows us to focus on the policy effects on five particular crops: coffee, corn, cassava, rice, and potato. The choice of these crops is due to the share of each crop in the total crops output. Coffee, the most planted crop, is used as input of the coffee products sector which has an important part of its production being oriented to exports. Corn, cassava, potato, and rice are Colombia's main staple foods. As can be seen in Figure 1, these crops represent around 55% in total crops output. To sum up, our SAM splits agricultural production by crop, farm size, and the incidence of the armed conflict at the municipality level.

Figure 1: Share by crop in total crops output.
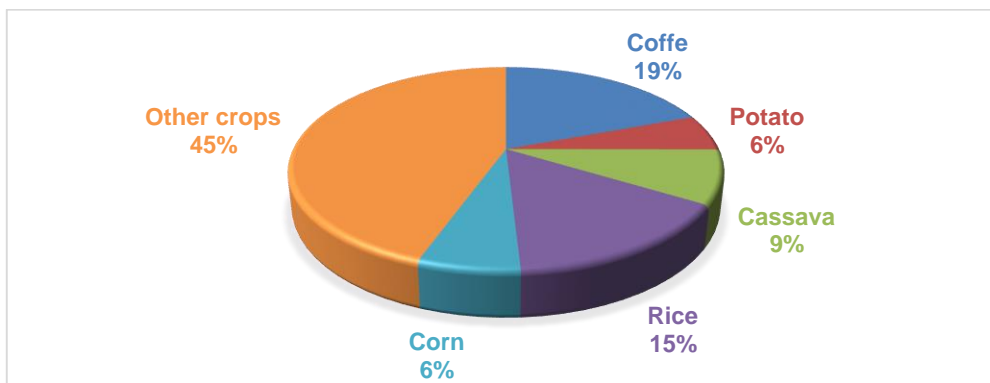
The production of these agricultural activities (coffee, corn, cassava, rice and potato) was divided into zones of conflict and non-conflict zones. This division was made based on the statistical information available in the national agricultural census. The National Planning Department (DNP, 2016) constructed an incidence rate for the armed conflict for 2013 (IICA index). This index categorized the 1121 municipalities of Colombia according to the degree of incidence of the conflict[3]. In this index, it was found that in 81 municipalities (7%)

[2] Illicit crops are not included in this census.

[3] This index was created by the Colombian National Department of Planning, and was computed for the 2002-2013 period. It was computed for each municipality, by considering the standard deviation of the

the conflict has a very high incidence, in 106 (9%) it has a high incidence, in 141 (12%) the IICA index was moderate, in 411 (36%) it has a low IICA index, and in the remaining 382 (34%) a very low incidence. The split of agricultural activities into small, medium and large UPA was done by using information from the Colombian Institute of Agrarian Reform (resolution No. 041 of 1996) and the Colombian Institute Agustín Codazzi (IGAC). With it, we employ a comprehensive approach in which the size of the UPA varies according to economic activity and region.

This approach made possible to identify the size of the UPA and the agricultural activities carried out by the UPAs most affected by the conflict, and thus establish the way in which the shocks will be introduced in the model. For this identification we bore in mind that subsidies to the agricultural sector in the post-conflict will be directed to the most affected UPAs. Hence, the information on the agricultural activities was classified according to the intensity of the conflict as very high (vh), high (h), moderate (m), low (l), very low (vl), and to UPA's size as large (l), medium (m), small (s).

Finally, we used information from the national household survey and income and expenditure surveys, to divide the labor factor in the SAM into skilled and unskilled labor, and each of this divisions into either rural or urban households. According to the demographic census of 2005, 24% of the households are rural and 76% live in urban areas. The gross exploitation surplus of the original SAM was divided into capital, land and natural resources used in livestock, fishing and forestry, by using information derived from the GTAP database. For the division of the gross operating surplus into skilled and unskilled labor, capital and land, we also turn to the Colombian SAM built by GTAP. In this database, there is no information at the crop level; therefore, the same labor-capital ratio is present in all crops (see Table 1).

Annex 1 shows the different activities, production factors and agents included in the SAM. Coffee, corn, cassava, rice and potato are presented according to the five conflict categories and the three sizes of UPA. In addition, we have other activities classified as primary, agroindustry, other industries, and services. This disaggregation allows us to identify the sectoral effects of post-conflict policies that target small and medium sized UPAs located in zones of very high, moderate and high conflict. Finally, we have four institutions: enterprises, government, households, and the rest of the world.[4]

The data shows that Colombia is an economy oriented to the services sector; more than 72% of the value added is generated in this sector. In addition, this sector is responsible for more than 70% of payments to skilled and unskilled labor and capital. Another important sector is the primary, and inside this category the mining activity. This sector generates 13.45% of the value added and makes 4.47%, 12.62% and 12.53% of the total payments to skilled and unskilled labor and capital, respectively. Finally, coffee, corn, cassava, rice and potato crops have

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average of six variables: (i) armed actions such as combats and attacks; (ii) homicides; (iii) kidnapping; (iv) land mine victims; (v) forced displacement; (vi) coca crops. The index has five categories according to the rank of this standard deviation as follows: very low (s.d. < -0.5); low (s.d. $\in$(-0.5, 0)), moderate (s.d. $\in$(0, 0.5)), high (s.d. $\in$(0.5, 1.5)), very high (s.d. > 1.5) (DNP, 2016).

[4] Annex 1 shows SAM 2014 - Accounts in a schematic way.

a participation of only 1.6% in the total added value. Coffee is relatively intensive in unskilled labor with a labor-capital ratio of 27.21, followed by corn, cassava, rice and potato with 9.024% (see Table 1).

Table 1: Sectorial composition of the Colombian economy, 2014

Sector	VA	Skilled Labor Share	Unskilled Labor Share	Capital Share	LS/K	LU/K
Coffee	0.73	0.09	2.42	0.06	1.07	27.214
Corn	0.25	0.11	0.64	0.05	1.66	9.024
Cassava	0.33	0.15	0.86	0.06	1.66	9.024
Rice	0.59	0.26	1.55	0.12	1.66	9.024
Potato	0.22	0.10	0.58	0.04	1.66	9.024
Primary	13.45	4.47	12.62	12.53	0.26	0.681
Agroindustry	2.93	2.83	2.96	3.26	0.64	0.615
Other industries	9.50	6.60	7.08	14.23	0.34	0.337
Services	72.01	85.40	71.28	69.65	0.91	0.692
Total	100	100	100	100		

Source: the authors

Figure 2 shows how the value added of coffee, corn, cassava, rice and potato is distributed by farm size (S, M, L) and conflict. The production of coffee, corn, cassava, rice and potato is concentrated mostly in small UPAs, and is present in areas with all levels of armed conflict. In turn, production of coffee, corn, cassava and potato in medium (m) and small (s) UPAs located in areas of very high (vh), high (h) and moderate (m) conflict, generate on average 30% of the total value added. In these same zones and type of UPA, an 18% of the added value of rice is produced.

Figure 2: Share Value Added for different crops by conflict and size.
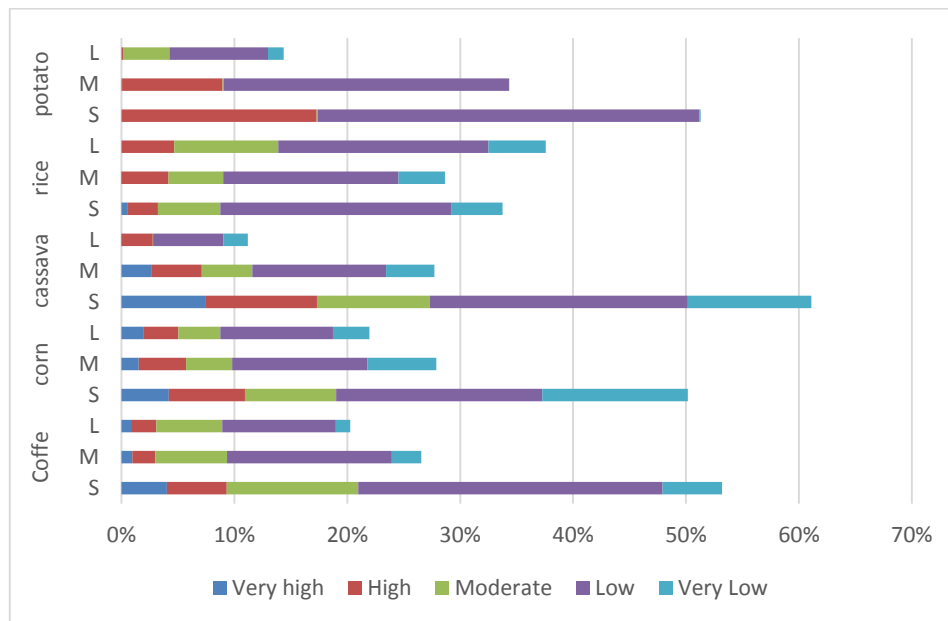
Table 2 shows that the basket of goods exported by Colombia has a low diversification, with a great dependence on the primary sector. In fact, primary products make more than 59% of Colombian exports; inside this sector, the main exports correspond to mining activities. The export intensity -- i.e., the relationship between exports and domestic production --, shows that the sector most oriented to exports in the economy is primary sector (fourth column in Table 2), thus showing important dependence on exports from this sector.

Table 2 : Colombian international trade at the sectorial level, 2014.

Sector	Share Export	Share Import	Intensity Exports	Import Dependence
Coffee	0.00	0.00	0.00	0.00
Corn	0.27	0.26	0.04	0.06
Cassava	0.37	0.35	0.06	0.08
Rice	0.66	0.63	0.10	0.14
Potato	0.25	0.23	0.04	0.05
Primary	59.63	2.10	9.24	10.96
Agroindustry	7.99	5.70	1.24	1.58
Other Industries	24.65	81.27	3.82	5.24
Services	6.18	9.44	0.96	1.12
	100	100		

Table 2 also shows that agroindustry products have a 7.99 share in total exports and an export intensity of 1.24. Corn, cassava, rice and potato jointly have a low participation in exports (1.55%), because most of their production is for domestic consumption. In turn, coffee beans are not exported but used as an input into the agroindustry sector (i.e., coffee products). In terms of exports, petroleum products and chemicals, included in Other Industries, are also important.

On the imports side, 57% of imports correspond to the primary sector and 27.2% to other industries. Moreover, the domestic industry presents a high dependence on imports of capital goods. In terms of import intensity, measured as the ratio of imports with respect to domestic absorption (both valued at purchase prices), it can be observed that the largest is primary, and the second corresponds to other industries (fifth column Table 2).

In sum, the SAM that was built partially accounts for regional differences by considering the degree of incidence of the armed conflict at the municipality level. This regional aspect of the SAM is complemented with the split in agricultural production, by considering only the production of five of the most important crops in Colombia, in each municipality, by farm size.

4. The methodology

In this paper, we used the single-country static CGE model known as PEP 1-1 as the starting point for developing our model. Specifically, we introduced the following extensions related to the modeling of the agricultural sector: extended production function by considering fertilizers as substitutes for land in the production of crops, endogenous unemployment modeled through a wage curve, imperfect substitution between similar products produced by different activities[5], and allowing for wages that differ across activities. Besides, we also introduced other modifications related to the model closure rule.

The production structure for agriculture has the form showed in Figure 3, so that fertilizer can have an explicit role in generating value added as it impinges upon soil fertility.

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[5] In the original mode, it is assumed that all activities produce the same variety of a given commodity. Thus, coffee from municipality A is the same as coffee from municipality B.
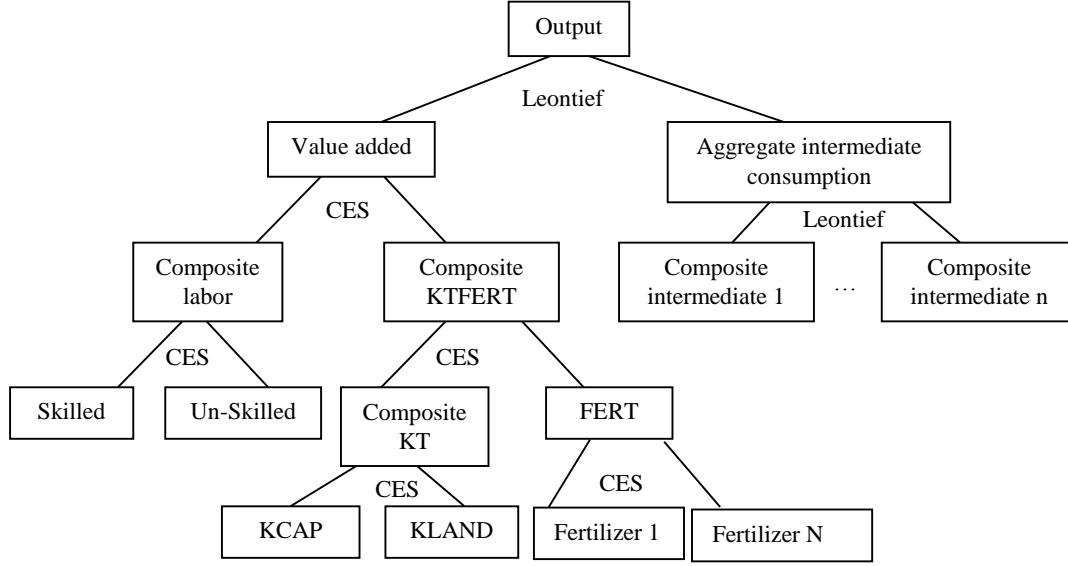
We change the behavioral equations that determine the production function of the crop sectors. Specifically, we allow for the substitution between the use of fertilizers and agricultural land. The production function is organized in various nests (Figure 3). We start with the top nest that determines the composition of value added VA_j. On the other hand, the combination of value added with intermediate inputs is modeled as for non-agricultural activities.

Nest 1. Equation (1) computes the value added of agricultural activities from combining: (i) an aggregate of capital-land-fertilizer (KTFERT), and; (ii) an aggregate of labor. The demand for each of them is determined in equations (2) and (3), respectively. A CES function is used to combine labor and capital-land-fertilizer. In fact, all aggregations in this block of equations are performed using CES functions. The elasticity of substitution between labor and capital is 0.8; i.e., there is a weak degree of substitutability between these factors.

$$VA_j = \varphi_j^{VA} \left(\sum_{l \in L} \delta_{l,j}^L \cdot LD_{l,j}^{-\rho_j^{VA}} + \delta_j^{KTFERT} \cdot KTFERT_j^{-\rho_j^{VA}} \right)^{\frac{-1}{\rho_j^{VA}}} \qquad 1$$

$$KTFERT_j = \left(\frac{PVA_j}{PKTFERT_j} \right)^{\sigma_j^{VA}} \left(\delta_j^{KTFERT} \right)^{\sigma_j^{VA}} VA_{j,t} \left(\varphi_j^{VA} \right)^{\sigma_j^{VA}-1} \qquad 2$$

$$LD_{l,j} = \left(\frac{PVA_{j,t}}{WFA_{l,j,t}}\right)^{\sigma_a^{VA}} \left(\delta_{l,j}^L\right)^{\sigma_j^{VA}} VA_{j,t}\left(\varphi_j^{VA}\right)^{\sigma_j^{VA}-1} \qquad 3$$

Nest 2. The composition of the capital-land-fertilizer aggregate is determined in equations (4) for capital-land (KT) and (5) for fertilizer (FERT). The price of the capital-land-fertilizer aggregate is calculated in equation (6).

$$KT_j = \left(\frac{PKTFERT_j}{PKT_j}\right)^{\sigma_j^{KTFERT}} \left(\delta_j^{KT}\right)^{\sigma_j^{KTFERT}} QKTFERT_j\left(\varphi_j^{KTFERT}\right)^{\sigma_j^{KTFERT}-1} \qquad 4$$

$$FERT_j = \left(\frac{PKTFERT_j}{PFERT_j}\right)^{\sigma_j^{KTFERT}} \left(\delta_j^{FERT}\right)^{\sigma_j^{KTFERT}} KTFERT_j\left(\varphi_j^{KTFERT}\right)^{\sigma_j^{KTFERT}-1} \qquad 5$$

$$PKTFERT_j \cdot KTFERT_j = PFERT_j \cdot FERT_j + PKT_j \cdot KT_j \qquad 6$$

Nest 3a. The composition of the capital-land aggregate is computed in equations (7) for capital and (8) for land. The price of said the capital-land is calculated in equation (9).

$$KD_{k,j} = \left(\frac{PKT_j}{WFA_{k,j}}\right)^{\sigma_a^{KT}} \left(\delta_{k,j}^K\right)^{\sigma_j^{KT}} KT_j\left(\varphi_j^{KT}\right)^{\sigma_j^{KT}-1} \quad k \in KCAP \qquad 7$$

$$KD_{k,j} = \left(\frac{PKT_j}{WFA_{k,j}}\right)^{\sigma_j^{KT}} \left(\delta_{k,a}^T\right)^{\sigma_j^{KT}} KT_j\left(\varphi_j^{KT}\right)^{\sigma_j^{KT}-1} \quad k \in KLAND \qquad 8$$

$$PKT_j \cdot KT_j = \sum_{k \in KLAND} WFA_{k,j} \cdot KD_{k,j} + \sum_{k \in KCAP} WFA_{k,j} \cdot KD_{k,j} \qquad 9$$

Nest 3b. The composition of the fertilizer aggregate is determined in equation (10); all its elements are commodities singled out in the SAM. Finally, equation (11) calculates the price of the fertilizer aggregate. In our case, the SAM we built identifies a single good that is classified as a fertilizer (i.e., "chemical products").

$$DI_{i,j} = \left(\frac{PFERT_j}{PC_i}\right)^{\sigma_j^{FERT}} \left(\delta_{i,j}^{CFERT}\right)^{\sigma_j^{FERT}} FERT_j \left(\varphi_j^{FERT}\right)^{\sigma_j^{FERT}-1} \quad i \in IFERT \qquad 10$$

$$PFERT_j \cdot FERT_{j,t} = \sum_{i \in IFERT} PC_i \cdot DI_{i,j} \qquad 11$$

Other important changes incorporated in the model are the following:[6]

(I) The "pure" form of the small-country hypothesis is introduced. Under this form it is assumed that producers can always sell as much as they want in the world market at the current price. It takes into account that Colombia is a price taker in the world market. In the PEP 1-1 Standard Model, the world demand for exports of product is:

$$EXD_i = EXDO_i \left(\frac{e\,PWX_i}{PE_i^{FOB}}\right)^{\sigma_i^{XD}} \qquad 12$$

In case $\sigma_i^{XD} = \infty$, equation (62) in Decaluwé et al (2013) simplifies to

$$ePWX_i = PE_i^{FOB} \qquad 13$$

which represents the "pure" form of the small-country hypothesis; producers can always sell as much as they want on the world market at the (exogenous) current price, PWX_i.

(II) The remuneration depends on the type of labor paid by each activity. It allows us to see the income gaps of rural and urban households. In PEP-1-1 model, it is assumed that all sectors pay the same wage. In the extended PEP-1-1, the analyst can complement the SAM

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[6] Annex 2 shows the extensions we did to the model PEP 1-1.

with data on number of workers by sectors. To do so, the remuneration to labor type i paid by the activity j, is computed as

$$WTI_{l,j} = W_l wdist_{l,j} \left(1 + ttiw_{l,j}\right)$$ 14

where $wdist_{l,j}$ is a "distortion" factor applied to for labor type I in industry j, that allows modeling cases in which the factor remuneration differs across activities. In other words, each activity pays an activity-specific wage that is the product of the economy-wide wage and an activity-specific wage (distortion) term. The equations that are modified by this distortion term are presented in Annex 2.

(III)   Wage curve: this curve is obtained by endogenizing the unemployment rate (UERAT), which presents a negative relationship between unemployment and wages. In the case of Colombia, the unemployment rate for skilled and unskilled labor corresponds to 11% and 8%, respectively (DANE 2014).

Demand for l type labor by industry j is represented as:

$$\sum_j LD_{l,j} = LS_l * (1 - UERAT_l)$$ 15

The curve wage equation is:

$$\frac{W_l}{PIXCON} = \frac{WO_l}{PIXCONO} * \frac{UERAT_l}{UETATO_l} * eta^{W_l}$$ 16

Parameters of the model were calibrated using the SAM built for the benchmark year, 2014, described in section 3. The elasticities were calibrated by using information from different sources: Sadoulet & de Janvry (1995), Annabi et al. (2006), Muhammad et al. (2011), Flórez & Ramírez (2016). In addition, capital and land are assumed fixed and specific for each sector. It is assumed that capital and land are fixed and specific by farm-size, region and crop. At the farm level, we assume that the production technology varies across different farm-sizes and crops. Additionally, for the model we consider that the production of each crop requires of certain natural conditions that are specific to each site and regionally distributed. This feature is represented in our model by the spatial division of the country into municipalities according to the armed conflict. This means, for instance, that large farms in low-conflict areas cannot change land allocation to alternative crops.

Labor is assumed perfectly mobile between sectors. These assumptions on the mobility of capital and labor, means that the analysis refers to a short-run to intermediate-run period of adjustment; in the very short-run, labor is not fully mobile (Warr, 2008). The closure rules were the following:

i. External balance: real exchange rate
ii. Government budget: direct tax rate on households
iii. Savings-investment: household savings

These closure rules make it possible to measure the impact of the effects of post-conflict policies on the income and consumption of rural and urban households, bearing in mind that we must prevent inter-temporal or welfare leakages from occurring (Warr, 2008). Thus, the increase in real government spending and subsidies are financed with direct taxes either on households or specific firms, so as the budget deficit and the real investment demand are kept at its base level. The nominal exchange rate is the numeraire, therefore, the current account is exogenous. Finally, the balance of savings and investment is achieved through household savings.

In this sense, we adapt PEP 1-1 model by making a focus on the agricultural sector, considering three sizes of industries in this sector (large, medium and small), and classifying industries according to the way they have been affected by the intensity of the armed conflict in Colombia: very high (vh), high (h), moderate (m), low (l), very low (vl). In addition, two types of households are also introduced, rural and urban, and two labor classifications, skilled and unskilled. These modifications make possible to have an appropriate scenario for simulations of post-conflict policies and their impact on the distribution of income.

5. Application and results

In this section, we present the results of the simulations of the policy that is proposed in the framework of the implementation of the Colombian Peace Agreement. According to this agreement, the policy should target on crops for medium and small agricultural production units located in areas of very high, moderate and high conflict. These areas are located in 158 out of the 1122 municipalities in which the country is divided.

In the simulations, we consider the work of Junguito et al. (2017) who estimate that the implementation of the rural reform of this peace agreement would have a total average fiscal cost of 0,49% of GDP, from 2017 until 2031. It includes the cost of policies such as transfers to peasants older than 65 years old, construction of tertiary roads, technical assistance, and the construction of physical infrastructure for irrigation, drainage or flood protection. Each of these policies has a different cost, and they are included in our simulations.

Our simulations are meant to capture two main aspects or points that are part of the peace agreement. On the one hand, Point 1 of the peace agreement, namely the "Comprehensive Rural Reform", is aimed at increasing the productivity of the factors employed in the production of crops. It includes different programs such as technical assistance that small and medium farmers would receive from the government, for the adoption of good agricultural practices. It also includes more investment in the construction of infrastructure such as irrigation systems, which would increase the productivity of land (Lozano and Restrepo, 2016), and tertiary rural roads. Considering the estimation of Junguito et al. (2017), we estimate that the implementation of this point would represent a rise of the public final consumption by 1.4%; i.e., 0.24% of GDP.

Naturally, the impact of this policy on productivity may well depend on the type of program and of the type of crop. For instance, for the case of Colombia, Lozano and Ramírez-Villegas (2016) found that irrigation and drainage systems may positively impact the productivity of rice over 20%, whereas the effect on coffee crops is much lower at 11%. In general, Argüello and Valderrama-Gonzalez (2015) estimated that a rise of land under irrigation and drainage systems may lead to yield gains that range between 0.2% and 17%, with an average of 4.5%. On the other hand, Lozano and Ramírez-Villegas (2016) found that planted areas of municipalities with relatively more of rural roads is about 2.9 percentage points higher than municipalities with less tertiary roads. When it comes to credits, its impacts on yields range from 6% to 24%, depending on the source of the credit (Echavarría et al., 2018). Considering this, that the information of public domain does not specify the features of the set of programs that the implementation of the peace agreement involves, and that the programs may affect several crops simultaneously, in our simulations we assume a conservative increase in total factor productivity of 4%. In the last part of this section, we conduct a sensitivity analysis in order to know the range of possible effects of the policy on the economy, given a set of feasible effects of the policy on factors productivity.

The other main aspect of the peace agreement regards to Point 4, which corresponds to an illicit crop substitution program. According to Junguito et al. (2017), in this program it will be necessary to invest COP$375,667 million pesos annually, of which COP$145,667 million correspond to direct subsidies for peasants and COP$230,000 million correspond to transfers to rural households. Taking into account Junguito et al. estimates, to simulate the implementation of Point 4 we consider a subsidy of 5.8% to peasant farmers' production, a 12.5% increase in the transfer of government to rural households in the form of a subsidy on labor subsidy, and a 0.3% increase in government consumption (0.05% of GDP), to support this program of subsidies.

These shocks are introduced in the following equations and parameters[7]:

- Scale parameter φ_j^{VA}, in the CES value added equation. (see equation 1)

    This shock corresponds to greater technical assistance, and the construction of irrigation systems and tertiary roads. Therefore, we see that it directly affects the added value.

- Tax rate on type l worker compensation in industry j, ttiw, which enters into the equation that determines government's revenue from payroll taxes on type l labor in industry j (TIW):

$$TIW_{l,j} = ttiw_{l,j} W_l wdist_{l,j} LD_{l,j} \qquad\qquad 17$$

Therefore, a reduction of this tax in the areas most affected by the conflict does cause an increase in the demand for labor and wages in these regions, especially for unskilled labor in rural areas.

- Tax rate on the production of industry j, ttip: a reduction of this tax in the areas most affected by the conflict causes a reduction in production costs and, therefore, an increase in production:

$$TIP_j = ttip_j PP_j XST_j \qquad\qquad 18$$

Needless to say, the results that we get from the simulation (partly) depend on how the government finances its higher expenditures to implement the peace agreement. On the one hand, the government may charge direct taxes to on either rural and urban households, or any of both type of households, or specific economic sectors. On the other hand, the government has the option an indirect taxation that is levied on commodities. Therefore, we first analyze the general effects of implementation of Points 1 and 4 of the peace agreement, considering some different options that the government may have to finance this policy. These different options are as follows:

(I) A rise in the direct tax rate on urban and rural households (Direct).
(II) A rise in the direct tax rate just on urban households (Direct-urban).
(III) Indirect tax on commodities (Indirect).
(IV) A rise in the tax rate on the financial sector (Tax-financ). In 2018, the Colombian congress passed a tax reform that includes a higher rate in the income tax that the financial sector must pay. This change was motivated in the growth rates that this economic sector has had in the previous years. Particularly, in 2017 its growth rate was four times higher than the growth of Colombian GDP (Guevara, 2018). Moreover, Villabona and Quimbay (2017) point out that this economic sector has been the most benefited from tax exceptions. Bearing in mind this policy change and the ongoing implementation of the peace accord, we simulate a scenario in which the implementation of points 1 and 4 of the peace accord in financed with taxes directly charged to the financial sector.
(V) A rise in the tax rate on the mining sector (Tax-min). Villabona and Quimbay (2017) estimated that the mining sector in Colombia benefited from tax exceptions during 2000-2015, of up to US$14.8 billion, being the most benefited sector from tax exceptions after financial sector. In practice, this rise in the tax rate that we propose could also be seen as a reduction in these tax benefits.

Table 3 shows the impacts of these different financing options on macroeconomic indicators. In regards to consumption, Tax-financ and Tax-min positively affect rural households, while the opposite is observed for consumption of urban households because this policy causes a fall in income from capital, main source of income of urban households, while income from labor, main source of income for rural households, increases with the policy. Tax-financ and Tax-min, therefore, generate a drop in the disposable income of urban households while the disposable income of rural households increases. On the GDP, under the different scenarios the effect tends to be null; with Indirect and Tax-financ having a small negative effect (-0.1%), whereas with direct taxes on households and Tax-min the effect is positive and around 0.1%. The impact on GDP of the Tax-financ option is presented as a consequence of the reduction in capital income that families receive, which negatively affects the disposable income of urban households and therefore their consumption, negatively affecting the GDP.

With Indirect, commodity prices and taxes paid by both urban and rural household increase. However, as the policy also significantly increases the income of rural household, the final effect on consumption and disposable income is positive. On the other hand, despite the increase in the disposable income of urban households, the increase in prices outweighs this effect what leads to a fall in their consumption.

Finally, with Direct, the tax burden to finance the policy is twice higher for urban households than for rural households. However, the increase in total income of urban household is greater than the increase in paid taxes. Despite this increase in their disposable income, the higher effect of the rise in prices makes the consumption of urban household to fall. In the case of rural households, their total income increases but lower than the increase in the taxes they must pay.

All the financing options but Direct, not only increase the disposable income of rural households but also reduce the income disparity urban and rural areas. The later effect is stronger for Direct-urban and Tax-financ (see Table 4). Considering this result and the effect on household consumption (Table 3), we conclude that the financial sector may be a suitable option to finance the implementation of Points 1 and 4 of the peace agreement. Henceforth, hereinafter we explain in detail, the effects of the peace accord's agricultural policy on the economy, assuming that the higher government spending is financed with direct taxes on the financial sector.

Table 3 : Macroeconomic indicators of different government's financing options.

Variable	Benchmark[a]	Tax-Min*	Tax-financ*	Direct*	Indirect*	Direct-urban*
Fiscal						
Public consumption	130.13	1.70	1.70	1.70	1.70	1.70
YG (gov. Income)	163.30	0.95	1.42	1.19	1.41	1.18
Direct Taxes	55.11	-0.54	0.08	4.17	0.24	4.16
National accounts						
Urban-Household consumption	422.84	-0.18	-0.12	-0.07	-0.49	-0.20
Rural-Household consumption	40.76	0.37	1.12	-0.40	0.45	0.93
Exports	107.44	0.95	1.42	0.29	0.09	0.30
Imports	154.19	-0.54	0.08	0.19	0.03	0.19
Investment	180.76	0.08	0.24	-0.01	0.00	-0.01
GDP at market prices	757.07	0.12	-0.08	0.17	-0.05	0.16

[a] **Trillion Colombian pesos**
* % change w.r.t. base scenario

Source: the authors.

Table 4 : Percentage changes in disposable income of type h households under different government's

	Tax-Min	Tax-financ	Direct	Indirect	Direct-Urban
Households -rural	1.12	2,40	-0.79	1.97	2.70
Households -urban	-0.01	-0.002	0.19	0.26	0.05

Source: the authors

As can be seen in table 5, at the sector level we find that coffee production increases in all municipalities, including those that are not benefited by the policy, generating a fall in their basic prices, which stimulates the intermediate consumption of coffee in the local market. In municipalities that directly benefit from the policy, the average increase is of 28%, and in those that do not, the average increase is of 0.9%. This subsector produces coffee beans, which are not exported, but are the main production input of the coffee products subsector. Hence, with an increase of 9.8% domestic production and 11% in exports, coffee products is the non-agricultural sector that benefited the most from the policy (see table 5). The growth in the production and exports of coffee products stimulates the intermediate consumption of coffee beans in such a way that it exceeds the increase in production in the municipalities that received the shock, for this reason coffee output is also increased in the municipalities that did not receive the shock.

With the increase in productivity, there is a higher value added for all the agricultural products (see Figure 3), what causes an increase of the same proportions in the intermediate consumption and in the production of the crops in the industries beneficiaries of the policy (see Table 5). On average, the policy especially impact output and the value added of coffee, rice, potato and corn, with growths above 25% (see Figure 3).

Table 5: Aggregate output of crops and municipalities that receive the shock, in the base and policy scenario (Trillion COP$)

Size	Product	Municipalities that receive the shock			
		Base			Policy - Average change (%)
		M	H	VH	
Small & Medium	Coffe	1.06	0.43	0.30	28.28
	Corn	0.28	0.25	0.13	25.04
	Cassava	0.447	0.443	0.375	22.801
	Rice	0.548	0.351	0.375	25.845
	Potato	0.076	0.017	0.007	15.185
Large	Coffe	0.873	0.966	0.046	0.904
	Corn	0.099	0.083	0.052	-3.588
	Cassava	0.071	0.094	0.052	-4.596
	Rice	0.627	0.263	0.057	-2.361
	Potato	0.068	0.022	0.004	-0.660

Source: the authors

Figure 4: Change in the value added of crops that receive the shock (COP$).
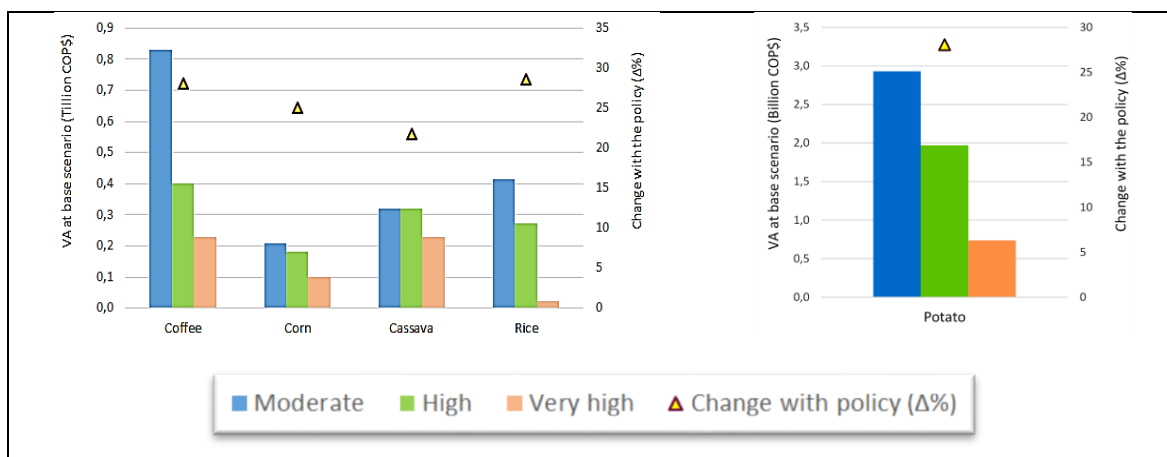
The positive impact only occurs in the municipalities that receive the shock for potato, corn, rice and cassava. In municipalities that do not receive the shock, aggregate output of crops falls between 0.4 and 4.7 percent (see Table 6 and Figure 4). As explained above, the production of corn, cassava, potato and rice is largely oriented to the domestic market. As production increases in the municipalities that receive the shock, besides the drop in the internal price the demand of these crops from municipalities that do not receive the shock falls.

Table 6: Aggregate output of crops in municipalities that do not receive the shock, in the base and policy scenario (Trillion COP$)

Size	Product	Municipalities that do not receive the shock		
		Base		Average change (%)
		l	vl	
Small & Medium	Coffee	2.45	0.47	0.93
	Corn	0.69	0.44	-3.72
	Cassava	1.015	0.430	-4.762
	Rice	2.055	0.409	-2.668
	Potato	0.472	1.231	-0.961
Large	Coffee	0.548	0.069	0.913
	Corn	0.268	0.088	-3.562
	Cassava	0.187	0.089	-4.468
	Rice	1.099	0.287	-2.463
	Potato	0.090	0.150	-0.451

* Average percentage change (%) for both types of municipalities.

Figure 5: Benchmark and change in the value added of industries in municipalities with low conflict.
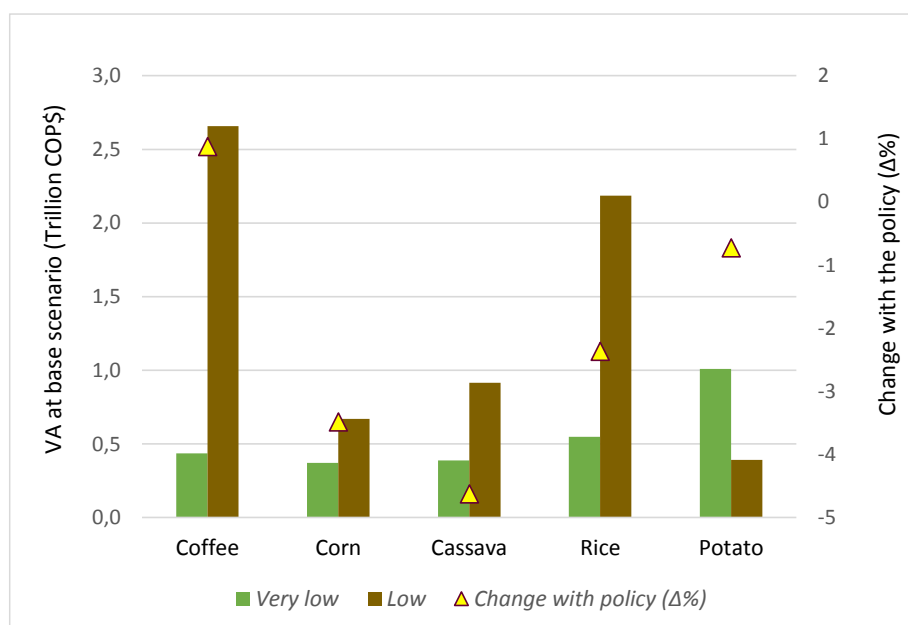
Crops of coffee, corn, cassava and potato are unskilled labor- intensive. Therefore, as a result of the increase in aggregate output of these crops, an increase in the demand for labor is expected. As can be seen in Table 7, the demand for unskilled labor located in rural and urban areas of the municipalities that received the shock showed a significant increase. In rural and urban areas, the demand grew by 27% and 15%, respectively. Likewise, an increase in the demand for skilled labor can be seen in the municipalities that receive the shock. In the municipalities that do not receive the shock, because of the fall in output there is a decrease in the demand for labor, except in the coffee sector where the impact, although small, is still positive.

Table 7: Percentage changes in the demand for labor (%)

Products	Municipalities receiving the shock				Other municipalities			
	Skilled		Un-skilled		Skilled		Un-skilled	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Coffee	21.6	21.2	21.6	33.8	1.3	1.0	1.3	0.6
Corn	16.5	16.1	16.5	28.2	-4.0	-4.3	-4.0	-4.6
Cassava	14.6	14.3	14.6	26.1	-5.4	-5.7	-5.4	-6.0
Rice	16.9	16.5	16.9	28.6	-3.9	-4.3	-3.9	-4.9
Potato	5.7	5.4	5.7	16.3	-0.4	-0.8	-0.4	-1.1

Given the significant increase in the demand for labor in the municipalities that receive the shock, a significant increase in wages is also expected. However, the impact on wages is rather modest and the most significant increase occurs in rural unskilled labor, with an increase of 1.09% (see table 8). The response to this insignificant growth in salary rates can be explained in the high unemployment rates of skilled and unskilled

labor of 11% and 8%, respectively. Additionally, taking into account that labor is assumed to be a perfect mobile factor, labor moves towards areas where there is an increase in the demand for labor.

Table 8: Percentage changs in wages.

Wage rate		% change w.r.t. base scenario
Urban labor	Skilled	0.220
	Unskilled	0.227
Rural Labor	Skilled	0.631
	Unskilled	1.087

Source: the authors

We also find that there is an increase in the remuneration of land, especially in the municipalities that receive the shock (vh, h, m), what may be explained by the fact that this type of capital is essential in the production processes of the considered crops. The most significant increase is observed in coffee, rice and corn, with an average increase of 8.4, 4.3 and 3.8 percent, respectively. In the municipalities that did not receive the shock (l, vl), there is a drop in land rent, except in coffee crops where the impact is positive (see Table 9). The increase in coffee production throughout the country, both in the municipalities that receive the shock and those that do not, causes an increase in the demand and rental rate of land.

Table 9:Percentage changes in rental rate of land

Crop	IICA index				
	vh	**h**	**m**	**l**	**vl**
Coffee	8.20	8.90	8.10	1.20	1.20
Corn	3.79	3.81	3.88	-2.16	-2.16
Casssava	2.01	3.08	4.10	-3.10	-3.09
Rice	1.99	5.58	5.22	-1.28	-1.23
Potato	1.02	0.31	-0.63	0.10	0.08

Source: the authors

Table 10 shows some of the main sectoral changes for the economy in general. From this table, we observe that the value added of coffee and crops is triggered by the policy that impacts the municipalities with some conflict. Moreover, the strong linkage of the agroindustry (coffee products) with the production of coffee makes the production of this agroindustry to increase, and its exports by 0.53% as well. We see the contrary effect in the value added of primary goods and other industries. With this policy, there would be a slightly decrease in the value added of primary goods and other industries of 0.37 and 0.35 percent, respectively. With respect to exports, an average increase of 13.5% is observed in exports of cassava, corn, and potatoes. However, it is important to recall that these crops only have an average participation of 1.55% in total exports (see table 2).

Table 10: Aggegate changes in the sectors of the economy under policy, w.r.t. benchmark (%)
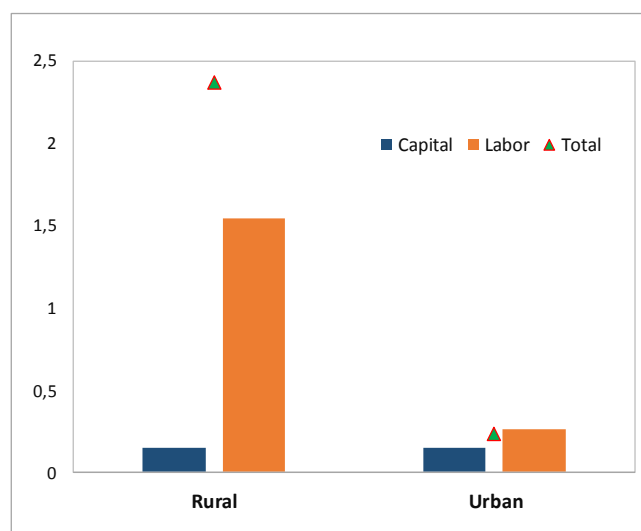
	Value Added	Exports	R Capital	LD			
				Skilled-Urban	Skilled – Rural	Unskilled-Urban	Unskilled-Rural
Coffee	11.86	--	5.52	9.42	9.06	9.41	13.87
Corn	7.83	15.36	1.43	4.24	3.90	4.23	8.51
Cassava	6.34	17.53	0.38	2.62	2.29	2.62	6.82
Rice	8.83	12.98	2.06	5.20	4.86	5.20	9.48
Potato	5.63	4.92	0.18	2.04	1.70	2.03	5.86
Primary	-0.37	-1.36	0.40	-0.08	-0.41	-0.09	-0.77
Agroindustry	0.86	0.53	2.62	3.65	3.75	3.64	3.38
Other industries	-0.35	-0.94	-0.15	-0.61	-0.94	-0.61	-1.29
Services	-0.06	-0.21	0.08	-0.24	-0.56	-0.24	-0.92

Source: the authors

On the other hand, the capital factor in the coffee sector are the most benefited, with an increase in their remuneration of 5.52%. This is a consequence of the positive impacts of the policy both in the municipalities that received the shock and in those that did not. Agroindustry also presents a significant increase in capital income of 2.62%, what is explained by the performance coffee products due to its connection with the production of coffee. The total effect on the demand for labor for the different crops is positive, that is, the positive effect that occurs in the sectors that receive the shock prevails. On the other hand, the primary sector, services and other industries show a reduction in the demand for labor.

Finally, the policy has a positive effect on the different sources of income of rural and urban households. Figure 5 shows that the most important change is in the labor income of rural households, as a result of the increase in demand for labor, particularly un-skilled labor (see Table 8). Moreover, the total increase in rural income is higher than the increase the income of urban households, what may be explained by the fact that to finance this policy, direct taxes are increased on firms of the financial services sector, which are skilled labor-intensive. Thus, the demand for skilled labor decreases in the services sector, which is the sector that demand most of the skilled labor in the economy, predominantly in urban areas, causing a quite small increase in the wages of urban workers. Furthermore, the increase in the rental rate of capital is quite similar in urban and rural areas, and close to 0,1%. The impact on the remuneration to capital is not very significant because the sectors that receive the shock are not capital intensive.

**Figure 6:** Percentage changes in Income of type h households

6. Sensitivity analysis

In our simulations, one of the first channels through which the effects of programs proposed under Point 1 of the peace accord, are transmitted to the economy, is the total factor productivity (TFP). As mentioned above, the effect of the policy on productivity depends on the type of program and the type of crop. In order to assess how the previous simulation results change for different possible effects of the policy on TPF, we provide a sensitivity analysis. The aim of this analysis is to understand the effect of the policy on some variables at the aggregate level, due to different possible changes in the productivity of factors. The variables that we analyze are disposable income, consumption, labor demand and added value. The impacts are as follows:

- In general, the impact on the demand for labor at an aggregate level is negative, independent of the level of productivity and especially for skilled labor. Increments in the level of productivity do not generate significant changes in demand for labor, essentially because the policy has only a positive impact on the demand for unskilled labor in crops that receive the shock; in the other sectors the impact is negative. However, since these crops have only a 2.12% share in the aggregate production, the impact on aggregate demand for both skilled and unskilled labor was expected to be negative. Nonetheless, the effect is lower the higher is the change in TPF (see Figure 6a).
- Similarly, a higher effect on TFP has a negative impact on total added value. The added value only exhibits positive behavior for TFP changes over 10% (see Figure 6b). As mentioned above, this is a consequence of the fact that crops have a very small share of GDP and total added value.
- The disposable income of urban and rural households is directly related to changes in productivity levels. In the case of urban households, the impact is always positive and this is a consequence of the increase in the demand for rural labor. However, the disposable income of urban households only shows a positive effect for TPF changes above 4% (see Figure 6c).
- The consumption budget of urban and rural households also has a direct relationship with the changes in productivity levels. For urban households, the impact is always positive and very similar to that of disposable income although with a lower growth rate. The consumption budget of urban households, on the other hand, has a negative behavior for all levels of TFP changes (see Figure 6d).

Figure 7: Sensitivity analysis for TFP changes

(a)

(b)

(c)

(d)
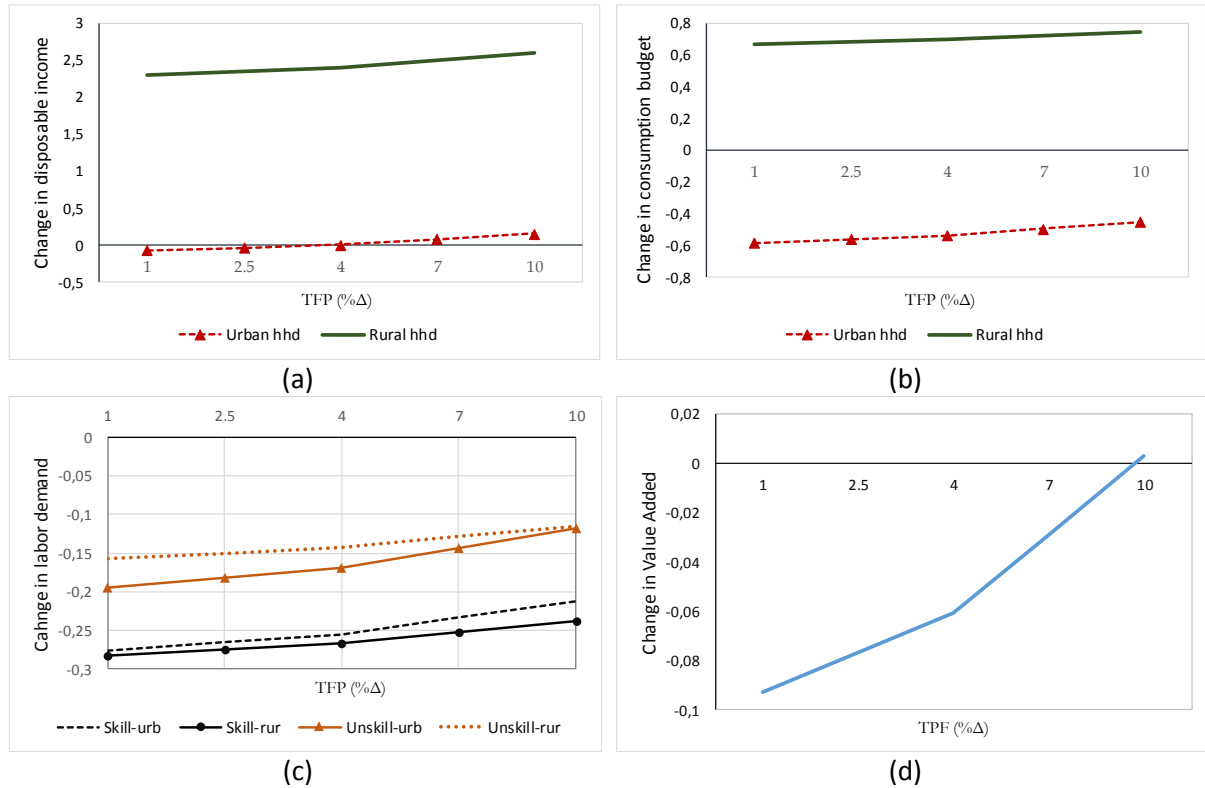
Source: the authors

7. Concluding Remarks

Colombia is experiencing a social and economic transition. After several decades of armed conflict that has been particularly present in the rural sector, it is expected that with the recent peace agreement between the leftist guerrilla FARC and the Colombian government, many of the obstacles to rural development can be overcome, and the wellbeing of these communities and of the nation in general is improved. As part of this transition, the peace agreement assigned an important role to the agricultural sector. In this paper, by using a computable general equilibrium approach, we have analyzed the impact of the main programs that the under the plan for implementation of the peace agreement, have been proposed in order to deal with the Point 1 of the accord concerning a "Comprehensive Rural Reform," and the Point 4, "Substitution of Illicit Crops."

The policy that was analyzed is effective in the goals it pursues. The package of activities proposed for it might have a positive impact the agricultural production in the target zones; i.e., the municipalities that have had been intensely affected by the armed conflict. The increments ranges from 15 to 28% in the agricultural production of most representative crops.

However, the benefits of this set of policies may come at a cost. On one hand, the production in other sectors such as other industries and other primary goods may fall. Moreover, depending on the mechanism to finance the implementation of the policy, rural income may even fall because of the increase in taxes that is required to finance the rise in government consumption, and income in urban areas may actually increase, thus increasing inequality between rural and urban areas.

Then, a key message from this research is that in order to reduce the opportunity costs that the implementation of the agricultural policy of the peace agreement may bring, it would critical to carefully think on the financing options of this policy, due to the effect that on disposable income these options may have. Furthermore, the opportunity cost of the policy can be mitigated the higher the effect on the productivity of factors this policy brings. Ways of achieving it can come through a provision of public goods that effectively increases the productivity in the zones that are the target of the policy, specifically in the construction of public infrastructure such as tertiary roads and irrigation systems. The quality of the technical assistance and the source of the credit might be also key in this attempt.

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Annexes

Annex 1. Accounts of SAM 2014

SAM 2014 – Accounts				
Activities by conflict and size				
coffee-l-l	corn-l-l	cassava-l-l	rice-l-l	potato-l-l
coffee-l-m	corn-l-m	cassava-l-m	rice-l-m	potato-l-m

coffee-l-s	corn-l-s	cassava-l-s	rice-l-s	potato-l-s
coffee-vl-l	corn-vl-l	cassava-vl-l	rice-vl-l	potato-vl-l
coffee-vl-m	corn-vl-m	cassava-vl-m	rice-vl-m	potato-vl-m
coffee-vl-s	corn-vl-s	cassava-vl-s	rice-vl-s	potato-vl-s
coffee-m-l	corn-m-l	cassava-m-l	rice-m-l	potato-m-l
coffee-m-m	corn-m-m	cassava-m-m	rice-m-m	potato-m-m
coffee-m-s	corn-m-s	cassava-m-s	rice-m-s	potato-m-s
coffee-h-l	corn-h-l	cassava-h-l	rice-h-l	potato-h-l
coffee-h-m	corn-h-m	cassava-h-m	rice-h-m	potato-h-m
coffee-h-s	corn-h-s	cassava-h-s	rice-h-s	potato-h-s
coffee-vh-l	corn-vh-l	cassava-vh-l	rice-vh-l	potato-vh-l
coffee-vh-m	corn-vh-m	cassava-vh-m	rice-vh-m	potato-vh-m
coffee-vh-s	corn-vh-s	cassava-vh-s	rice-vh-s	potato-vh-s

Other activities

Primary	Agroindustry	Other industries	Services
Rest of agriculture	meat fish	Textiles	Electricity, gas and water
Rest of livestock	vegetable oils	Petroleum refinery	Construction
Forestry	dairy	Chemical	Trade
Fishing	milling	rubber plastic	Restaurants and hotels
Mining	coffee product	non-metallic mineral products	Transport
Cattle	sugar	Basmet	Public administration
	cocoa	machinery	Other services
	oth food	Vehicles	
	Beverages and tobbaco	other manufactures	

Factors of production	Agents
Unskilled labor	Entrepreneur
Skilled labor	Government
Capital	Households-rural
Land	Households-urban
Natural resource livestock	Rest of the world
Natural resource Forestry	
Natural resource Fishing	

Source: Colombia SAM 2014

Annex 2. Extensions to PEP-1-1 v2.1

In this appendix we present the modifications introduced to the single-country static PEP-1-1 v2.1 model. The number of some of the equations in this annex corresponds to the one that appears in Decaluwé et al. (2013).

Exports

In the PEP 1-1 Standard Model, the world demand for exports of product i is:

$$EXD_i = EXDO_i \left(\frac{e.PWX_i}{PE_i^{FOB}}\right)^{\sigma_i^{XD}} \qquad (62)$$

In case $\sigma_i^{XD} = \infty$, equation (62) simplifies to $e.PWX_i = PE_i^{FOB}$, which represents the "pure" form of the small-country hypothesis; producers can always sell as much as they want on the world market at the (exogenous) current price, PWX_i.

Current Account

Equation (A1) defines the current account balance in foreign currency. Equations (A2) and (A3) define the index for domestic producer prices and the real exchange rate, respectively. Subsequently, variables CAB^{FCU} and $REXR$ are used to select the macroeconomic closure rule for the model.

$$CAB^{FCU} = \frac{CAB}{e} \qquad (A1)$$

$$DPI = \sum_i dwts_i \cdot PL_i \qquad (A2)$$

$$REXR = \frac{e}{DPI} \qquad (A3)$$

where

CAB^{FCU}: current account balance in foreign currency units

DPI: index for domestic producer prices (PL-based)

$REXR$: real exchange rate

$dwts_i$: domestic sales price weights

Government

In the PEP Standard Model, government consumption of commodity i is determined by the following equation (see equation (55) in Decaluwé et al. 2013).

$$PC_i \cdot CG_i = \gamma_i^{GVT} \cdot G \qquad (55)$$

with G (i.e., current government expenditures on goods and services) fixed and equal to its initial value (i.e., $G = GO$). As an alternative, we modified the government behavior assuming that the real government spending can be exogenous (i.e., all the CG_i variables) while G is endogenous. Specifically, we dropped equation (55) from the model and added the following equations:

$$CG_i = cgbar_i \cdot CGADJ \qquad (A4)$$

$$G = \sum_i PC_i \cdot CG_i \qquad (A5)$$

where

$CGADJ$ = adjustment factor for CG

$cgbar_i$ = base-year CG_i

Equation (A6) defines real government savings (SG^{REAL}), as the ratio between nominal government savings (43) and the GDP deflator.

$$SG^{REAL} = \frac{SG}{PIBGDP} \qquad \qquad \text{(A6)}$$

Tax Rates

Equation (A7) and (A8) define the direct (income) tax rates for household and firms, respectively. In turn, equation (A9) defines the tax rates on commodities. As indicated by equations (A7)-(A9) initial tax rates are scaled by the variable $TTDADJ$ and/or $TTICADJ$. In practice, this set of equations allows us to expand the available policy instruments to finance the government budget.[8]

$$TTDH1_h = \overline{ttdh1}_h \cdot (1 + ttd01_h \cdot TTDADJ) \qquad \qquad \text{(A7)}$$

$$TTDF1_f = \overline{ttdf1}_f \cdot \left(1 + ttd01_f \cdot TTDADJ\right) \qquad \qquad \text{(A8)}$$

$$TTIC_i = \overline{ttic}_h \cdot TTICADJ \qquad \qquad \text{(A9)}$$

where

$TTDADJ$ = adjustment factor for $TTDH1_h$ and $TTDF1_f$

$TTICADJ$ = adjustment factor for $TTIC_i$

$\overline{ttdh1}_h$ = exogenous (base-year) $TTDH1_h$

$\overline{ttic}_h$ = exogenous (base-year) $TTIC_i$

$ttd01_c$ = binary (1/0) parameter used to select households and/or enterprises that face an endogenous income tax rate.

Household Savings

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[8] Note, however, that in the simulations shown in Section 3 we are assuming that tax rates are constant; i.e., $TTDADJ$ and $TTICADJ$ do not change.

Equation (A10) defines the marginal propensity to save of households. Its structure is the same as that of equations (A7) and (A8) for tax rates and (A4) for government consumption. In fact, whether $MPSADJ$ is flexible depends on the closure rule for the savings-investment balance.

$$sh1_h = \overline{sh1}_h \cdot (1 + sh01_h \cdot MPSADJ) \qquad (A10)$$

where

$MPSADJ$ = savings rate scaling factor

$\overline{sh1}_h$ = base-year $sh1_h$

$sh01_h$ = binary (1/0) parameter used to select households with endogenous marginal propensity to save.

Calibration with Employment by Sector

In PEP-1-1 it is assumed that all sectors pay the same wage. In contrast, our model allows complementing the SAM with satellite data on the number of workers by sectors. To do so, the remuneration to labor type l paid by the activity j is computed as

$$W_l \cdot wdist_{l,j}\left(1 + ttiw_{l,j}\right) \qquad (A11)$$

where $wdist_{l,j}$ is a distortion factor applied to for labor type l employed in industry j that allows modeling cases in which the factor remuneration differs across activities. In other words, each activity pays an activity-specific wage that is the product of the economy-wide wage and an activity-specific wage (distortion) term. To calibrate $wdist_{l,j}$, the model dataset must provide physical labor quantities. In implementing this extension, the following equations of the original model were modified.

$$YHL_h = \sum_l \lambda_{h,l}^{WL} \sum_j W_l \cdot wdist_{l,j} \cdot LD_{l,j} \qquad (11)$$

$$TIW_{l,j} = ttiw_{l,j} \cdot W_l \cdot wdist_{l,j} \cdot LD_{l,j} \qquad (37)$$

$$YROW = e \cdot \sum_i PWM_i \cdot IM_i + \sum_k \lambda_{row,k}^{RK} \sum_j R_{k,j} \cdot KD_{k,j} + \sum_l \lambda_{row,l}^{WL} \sum_j W_l \cdot wdist_{l,j} \cdot LD_{k,j} + \sum_{agd} TR_{row,agd} \qquad (44)$$

$$WTI_{l,j} = W_l \cdot wdist_{l,j}\left(1 + ttiw_{l,j}\right) \qquad (70)$$

$$GDP^{IB} = \sum_{l,j} W_l \cdot wdist_{l,j} \cdot LD_{l,j} + \sum_{k,j} RK_{k,j} \cdot KD_{l,j} + TPRODN + TPRCTS \qquad (92)$$

Wage Curve

The PEP-1-1 Standard Model assumes full employment of the labor force. We introduced endogenous unemployment by means of a wage curve. Specifically, we add to the model equation (A12) and the

endogenous variable $UERAT_l$ (unemployment rate). The value of the η_l parameter (i.e., the wage curve elasticity) was set at -0.1 based on international evidence documented in Blanchflower and Oswald (2005). The equilibrium condition for labor market, equation (85) in Decaluwé et al. (2013), was adjusted accordingly.

$$\frac{W_l}{PIXCON} = \frac{WO_l}{PIXCONO} \left(\frac{UERAT_l}{UERATO_l}\right)^{\eta_l} \tag{A12}$$

$$LS_l(1 - UERAT_l) = \sum_j LD_{l,j} \tag{A13}$$

where

$UERAT_l$ = unemployment rate for type l labor

η_l = elasticity of real wage with respect to unemployment rate (<0)

Imperfect Substitution between Domestic Products from Different Activities, and between Exports from Different Activities

$$EX_{j,i} = \left(\frac{1-\beta_{j,i}^X}{\beta_{j,i}^X} \cdot \frac{PEJI_{j,i}}{PLJI_{j,i}}\right)^{\sigma_{j,i}^X} DS_{j,i} \tag{A14}$$

$$P_{j,i} \cdot XS_{j,i} = PEJI_{j,i} \cdot EX_{j,i} + PLJI_{j,i} \cdot DS_{j,i} \tag{A15}$$

$$DD_i = \varphi_i^{dd} \left(\sum_{j \in J} \delta_{j,i}^{dd} \cdot DS_{j,i}^{-\rho_i^{dd}}\right)^{\frac{-1}{\rho_i^{dd}}} \tag{A16}$$

$$DS_{j,i} = \left(\frac{PL_i}{PLJI_{j,i}}\right)^{\sigma_i^{dd}} \left(\delta_{j,i}^{dd}\right)^{\sigma_i^{dd}} \left(\varphi_i^{dd}\right)^{\sigma_i^{dd}-1} DD_i \tag{A17}$$

$$EXD_i = \varphi_i^{exd} \left(\sum_{j \in J} \delta_{j,i}^{exd} \cdot EX_{j,i}^{-\rho_i^{exd}}\right)^{\frac{-1}{\rho_i^{exd}}} \tag{A18}$$

$$EX_{j,i} = \left(\frac{PE_i}{PEJI_{j,i}}\right)^{\sigma_i^{exd}} \left(\delta_{j,i}^{exd}\right)^{\sigma_i^{exd}} \left(\varphi_i^{exd}\right)^{\sigma_i^{exd}-1} EXD_i \tag{A19}$$

where

PEJI(j,i)   price received for exported commodity i by industry j

PLJI(j,i)   price of local product i sold by industry j

phi_dd(i)   shift parameter for domestic goods from different activities

delta_dd(j,i) share parameter for domestic goods from different activities

rho_dd(i)   exponent related to sigma_dd

sigma_dd(i)   elasticity of substitution between domestic goods from different activities

phi_exd(i)   shift parameter for exports from different activities

delta_exd(j,i) share parameter for exports from different activities

rho_exd(i)   exponent related to sigma_exd

sigma_exd(i)   elasticity of substitution between exports from different activities

Annex 3. Definition of variables and parameter

Value added

$$VA_j = \varphi_j^{VA} \left(\sum_{l \in L} \delta_{l,j}^L \cdot LD_{l,j}^{-\rho_j^{VA}} + \delta_j^{KTFERT} \cdot KTFERT_j^{-\rho_j^{VA}} \right)^{\frac{-1}{\rho_j^{VA}}} \tag{3}$$

where:

VA_j Value added of industry j

φ_j^{VA} Scale parameter (CES – value added)

δ_j^{VA} Share parameter (CES – value added)

$LD_{l,j}$ Industry j demand for labor type l

$KTFERT_j$ Industry j demand for composite of capital-land-fertilizer

ρ_j^{VA} Elasticity parameter (CES – value added)

Tax rate on type l worker compensation in industry j

$$TIW_{l,j} = ttiw_{l,j} W_l wdist_{l,j} LD_{l,j} \tag{37}$$

Where:

$TIW_{l,j}$ Government revenue from payroll taxes on type l labor in industry j

$LD_{l,j}$ Demand for type l labor by industry j

W_l Wage rate of type l labor

$ttiw_{l,j}$ Tax rate on type l worker compensation in industry j

Tax rate on the production of industry j

$$TIP_j = ttip_j PP_j XST_j \qquad\qquad (39)$$

where

TIP_j Government revenue from taxes on industry j production (excluding taxes directly related to the use of capital and labor)

$ttip_j$ Tax rate on the production of industry j

PP_j Industry j unit cost, including taxes directly related to the use of capital and labor, but excluding other taxes on production.

XST_j Industry j production of commodity i