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Distributional and Economy-Wide Effects of Post-Conflict Policy in Colombia

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Abstract

As part of the 2016 peace accord in Columbia, agricultural policies were proposed for rural regions most affected by an armed conflict that had gone on for decades. We evaluated the effects of these policies with particular attention to their economy-wide and distributional effects. We used 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 considered were an increase in total factorial productivity because of infrastructure construction and greater technical assistance and employment subsidies intended to promote the substitution of illicit crops. We found that value added, demand for labor, and factor incomes increased in the areas most affected by the conflict while the opposite occurred in the other areas. Moreover, total rural income increased as long as the financing mechanism did not involve an increase in the taxation of rural incomes. In general, distributional effects were strongly conditional on the financing mechanism adopted by the government.

JEL: Q18, C68, D58, R12
Keywords: post-conflict; agricultural policy; CGE modeling; distributional effects.

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I. Introduction

Three major milestones occurred during armed conflict in Colombia during the twentieth century. First, the assassination of a presidential candidate in 1948 was followed by violent disputes, which continued for about ten years, between two traditional political parties. 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, Ibañez & Zambrano, 2019). By the end of the century, Colombia was one of the most politically violent countries in the world (World Health Organization, 2002).

Armed conflict developed mainly in rural areas and away from urban centers (González & Lopez, 2007). Violence and the difficultly of access to these areas restrained investments in road and productive infrastructure, causing greater isolation and obsolescence in production techniques in turn, ultimately reducing the productivity and efficiency of farm households (González & Lopez, 2007). Consequently, poverty in those areas increased. According to the multidimensional poverty index of the Departamento Nacional de Planeación (the National Planning Department; hereafter DNP), for 2014, rural poverty stood at 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, and the implementation of the peace agreement was expected to remove many of the obstacles to rural development and improve the well-being of rural households'. The peace agreement contained six points, including a "Comprehensive Rural Reform" (Point 1) and the "Substitution of Illicit Crops" (Point 4). Both contained a package of policies that sought recovery of the rural areas most affected by conflict, including access to production and labor subsidies and to technical assistance for the implementation of new crops and substitution of illicit crops. In addition, planned investments in road infrastructure were designed to facilitate access to markets and urban centers. This research assessed the overall economic impact of these government policies that, including analyses of sector-based and distributional effects.

II. Literature Review

2.1 Conflict and Agriculture

Colombia's history of has been marked, from its independence in 1819, by internal conflicts of a diverse nature. With regard to more recent history, Pinto, Vergara, and Lahuerta (2005) estimated that the cost of the armed conflict between 1999 and 2003 was equivalent to 7.4% of GPD in 2003. Around 28% of Colombian municipalities and, of those with the highest incidence of armed conflict, 88% were largely rural (Departamento Nacional de Planeación, 2017).

For the Colombian rural sector, Hernández, Ramírez, and Zuur (2014) showed that small-scale agriculture and family farming represented 54% of agricultural value added and 72% of the remuneration of wage-earners in the sector. They also showed that rural non-agricultural activities affected 41.3% of rural employment and 43.2% of rural income, mainly in the services sector. There was also an important income gap between rural and urban areas: rural households received 11.4% of total income, which was much lower than the participation of the rural population in the total population (25%) in 2011. Moreover, 75% of the employed population in rural areas received an income below the legal minimum wage in Colombia. In contrast, this, proportion was 39.4% in urban areas this (Departamento Nacional de Planeación, 2015).

Arias, Ibañez, and Zambrano (2019) found that rural households in conflict areas of Colombia were pushed onto a lower income trajectory as a result not only of lower intensity of land use but especially of changes in the portfolio of activities in which these households engaged. In particular, these authors showed that, as violence intensified, small farmers engaged in activities with short-term yields and lower profitability, specifically in subsistence activities. In general, the international literature has pointed out the negative effect of conflict on agricultural production (Messer, Cohen & D'Acosta, 1998; Ksoll, Macchiavello & Morjaria, 2010), an impact that may be transmitted through 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) pointed 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 promoting rural education that narrowed the gap in school attendance between rural and urban sectors. These actions would require proactive social policies with short- and long-term gains from economic production, considering also the population returning to rural areas and their physical and human capital (Arias, Ibañez & Zambrano, 2019). In addition, Longley, Christoplos, and Slaymaker (2006) suggested that the agricultural policy for rural people affected by conflict should consider the transition from supply-led programming to the establishment of market-driven systems that support the promotion of rural livelihoods.

This vision entailed an explicit rebuke of what had been called the "yeoman farmer fallacy" (Farrington & 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, a significant proportion of the rural poor earn sizeable parts of their income from outside the farm (i.e., they diversify their income sources either for supplementing or substituting agricultural income). It has been estimated that a large share of the income of rural households comes from agriculture, although some evidence points to the increasing importance of non-agricultural activities, which may provide between 35-50% of rural income in developing countries.[1] In general, evidence has shown that poor rural households tended to engage in subsistence-level activities, on- and off-farm, because they are 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 & Poveda, 2016) showed that it had been a persistent characteristic of rural income, positively associated with the income level of the household, and that the share of agricultural income arising from agriculture had declined. Additionally, as income increased, households tended to depend more on non-agricultural salaries and less on agricultural income directly generated on the farm. This dynamic shows the importance of simultaneously considering the interaction between different sources of rural income, in terms not only of the linkages mentioned above but also of the way households take

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

advantage of a range of income sources and markets with which they are involved: products, inputs, and labor.

2.2 CGE Modelling of Agricultural Policy

The CGE modelling approach has been used in the analysis of the impact of economic policies on the agricultural sector. On one hand, the literature has touched upon analyses of such measures as price polices, subsidies, and taxes targeted to the agricultural sector (e.g., de Janvry & Sadoulet, 1987; Hertel & Tsigas, 1988; Parry, 1999; Ding & Rebessi, 2019). A common finding in this literature has been that different policies may affect income across different social groups, "with few instances where net gains are derived by all groups" (de Janvry & Sadoulet, 1987, 244). Besides price polices, this tool has been useful in studying the effects of road improvement on the incidence of poverty (Warr, 2008) and the welfare implications of improvements in irrigation efficiency worldwide (Calzadilla, Rehdanz & Tol, 2011).

On the other hand, another set of literature has estimated the impact of trade policies may on the agricultural sector in various countries (e.g., Blake, Rayner & Reed, 1999; Bach, Frandsen & Jensen, 2000; Holland et al., 2005; Warr, 2005; Ding & Rebessi, 2019). CGE modelling has also been used to estimate the effects of subsidies and trade policy on food production and poverty in developing countries (e.g., Warr & 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 and specifically of the Agro Ingreso Seguro (Agriculture Secure Income Program). This policy was implemented in the 2000s with the aim of triggering competitiveness in the agricultural sector after the free-trade agreement with the United States. In both works, the authors found that the policy had a rather small effect on agricultural production.

We chose to follow a CGE modelling approach to assess the impact of policies proposed in the framework of the 2016 Colombian peace agreement with FARC. These policies were focused on small farms in the zones most affected by armed conflict. Our research adds to the 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.

III. Data

An initial SAM was built for the year 2014 with information from the Integrated Economic Accounts (IEA) and the Supply and Use Tables (SUT) (Departamento Administrativo Nacional de Estadística, 2014a, 2014b). Together, the IEA and the SUT provided information on production, value added, intermediate consumption, income, exports, imports, taxes, and government consumption. At a second stage, the resulting SAM was expanded to focus on the rural sector and to consider the impact of armed conflict. This was done by combining data from the 2014 national agricultural census (Departamento Administrativo Nacional de Estadística, 2016) with data on the Incidence Index of the Armed Conflict of the National Planning Department at the municipality level.[2]

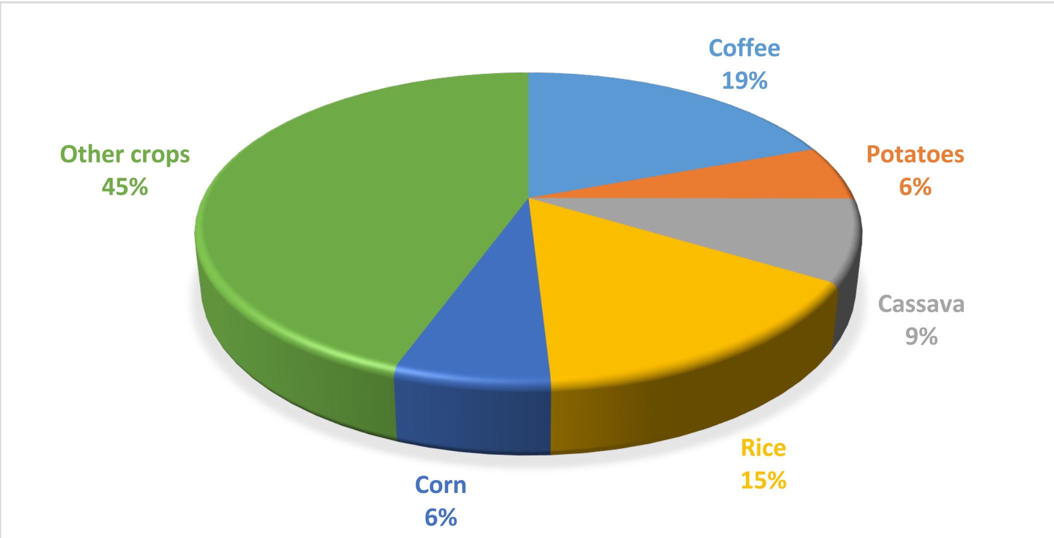
Specifically, we obtained estimates on cost structures for selected national agricultural crops produced by Agricultural Production Units (hereafter, UPAs) for 2014. A national household survey was also used to single out two representative groups of households, rural and urban. We used the RAS technique (Trinh & Viet, 2013) to balance our SAM. Specifically, we used this method to single out cost structures that differed across 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 SUT (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 allowed us to focus on the effects of the policy on five crops—coffee, corn, cassava, rice, and potatoes—based on the share of each crop in total crop output. Coffee, the most planted crop, was used as an input of the coffee-products sector because an important part of coffee production is oriented to exports. Corn, cassava, potatoes, and rice are Colombia's staple foods. As Figure 1 shows,

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

these crops represent around 55% of total crop output. To sum up, our SAM split agricultural production by crop, farm size, and the incidence of armed conflict at the municipality level.

Figure 1: Share of Total Crop Output, by Crop



Source: Authors' calculations.

The production of coffee, corn, cassava, rice, and potatoes was divided into conflict and non-conflict zones based on statistical information available in the national agricultural census. The National Planning Department (Departamento Nacional de Planeación, 2016) constructed an incidence rate for the armed conflict for 2013 (IICA Index) which categorized Colombia's 1,121 municipalities according to the degree of incidence of conflict.[3] The index reported that the conflict incidence was very high in 81 municipalities (7%), high in 106 (9%), moderate in 141 (12%), low in 411 (36%), and very low in the remaining 382 (34%). The division of agricultural activities into small, medium, and large UPAs used information from the Colombian Institute of Agrarian Reform (Resolution No. 041 of 1996) and the Agustín Codazzi Institute. With this information, we employed a comprehensive approach in

[3] The IICA Index was created by the Colombian National Department of Planning and was computed by municipality for the 2002-2013 period. The index considered the standard deviation of the average of six variables: (i) armed actions such as combat and attacks; (ii) homicides; (iii) kidnapping; (iv) land-mine victims; (v) forced displacement; and (vi) coca crops. The rank of this standard deviation produced five categories: very low (s.d. < -0.5); low (s.d. $\in(-0.5, 0)$); moderate (s.d. $\in(0, 0.5)$); high (s.d. $\in(0.5, 1.5)$); and very high (s.d. > 1.5) (Departamento Nacional de Planeación, 2016).

which the size of the UPA varied according to economic activity and region.

This approach allowed us to identify the size of UPAs and the agricultural activities carried out by the UPAs most affected by the conflict, thus establishing the way shocks would be introduced into the model. For this identification, we bore in mind that post-conflict subsidies to agriculture would be directed to the most affected UPAs. Hence, the information on agricultural activities was classified according to the intensity of the conflict: very high (vh), high (h), moderate (m), low (l), or very low (vl), and to UPA size—large (l), medium (m), or 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 these divisions into rural or urban households. According to the 2005 census, 24% of households were rural and 76% were urban. The gross exploitation surplus of the original SAM was divided into capital, land and natural resources used in livestock, fishing, and forestry, using information derived from the GTAP database. For the division of the gross operating surplus into skilled and unskilled labor, capital and land, we turned to the Colombian SAM built by GTAP. This database contained no crop-level information; therefore, the same labor-capital ratio was present in all crops (see Table 1).

Appendix 1 shows the different activities, production factors, and agents included in the SAM. Coffee, corn, cassava, rice, and potatoes were presented according to the five conflict categories and the three sizes of UPA. In addition, we classified other activities as primary, agroindustry, other industries, and services. This disaggregation allowed us to create a sector-based categorization of the effects of post-conflict policies that targeted small and medium sized UPAs and which were located in zones of very high, moderate and high conflict. Finally, we included four institutions: enterprises, government, households, and the rest of the world.[4]

The data showed that the Colombian economy was oriented to the services sector: more than 72% of value added was generated in this sector. In addition, this sector was responsible for more than 70% of payments to skilled and unskilled labor and capital. Another important sector was the primary, which included mining. This sector generated

[4] Appendix 1 shows the SAM 2014 accounts schematically.

13.45% of value added and provided 4.47%, 12.62%, and 12.53% of total payments to skilled and unskilled labor and capital, respectively. Finally, coffee, corn, cassava, rice, and potatoes contributed only 1.6% to total added value. Coffee was relatively intensive in unskilled labor, with a labor-capital ratio of 27.21, followed by corn, cassava, rice, and potatoes with 9.024% (see Table 1).

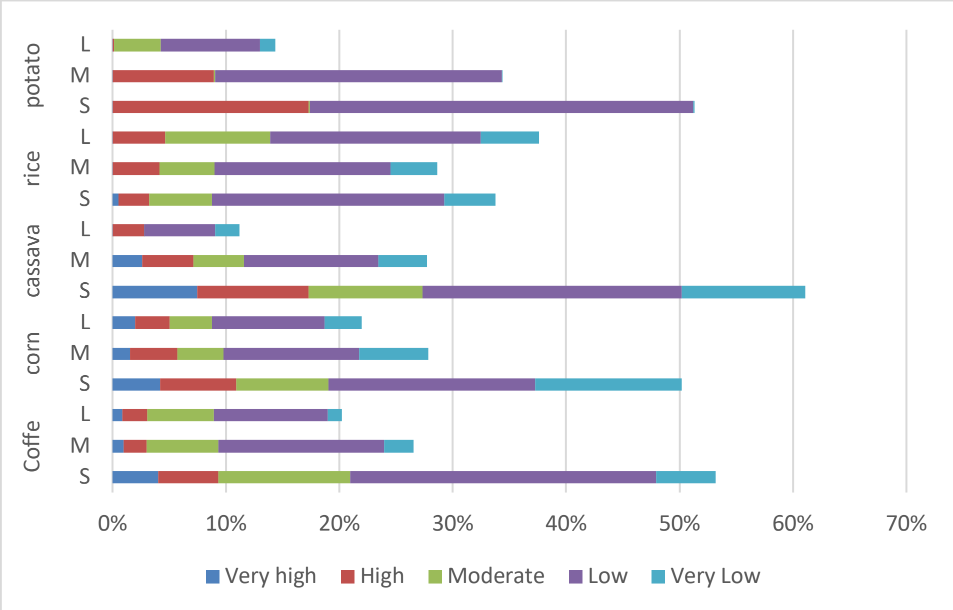
Table 1: Composition of the Colombian Economy by Sector (2014)

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
Potatoes	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: Authors' calculations.

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

Figure 2: Share of Value Added for Crops by Conflict and Size



Source: Authors' calculations.

Table 2 shows that the basket of goods exported by Colombia had low diversification, with significant dependence on the primary sector. In fact, primary products made up more than 59% of Colombian exports. Within this sector, mining activities were the main export. Export intensity—i.e., the relationship between exports and domestic production—showed that the primary sector was most oriented to exports (fourth column in Table 2), indicating the sector's dependence on exports.

Table 2: Colombian International Trade by Sector (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
Potatoes	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		

Source: Authors' calculations.

Table 2 also shows that agroindustry products represented 7.99% of total exports and an export intensity of 1.24. The participation of corn, potatoes, cassava, and rice was jointly low in exports (1.55%) because most of their production was for domestic consumption. In turn, coffee beans were not exported but used as an input into the agroindustry sector (i.e., coffee products). Petroleum products and chemicals, included in other industries, were also important exports.

On the imports side, 57% of imports corresponded to the primary sector and 27.2% to other industries. Moreover, the domestic industry presented a high dependence on the import of capital goods. Import intensity, measured as the ratio of imports to domestic absorption (both valued at purchase prices), was highest in the primary second and second highest in other industries (Column 5, Table 2).

In sum, the SAM partially accounted for regional differences by considering the degree of incidence of armed conflict at the municipality level. This regional aspect of the SAM was complemented by the split in agricultural production and by considering solely the production of five of Colombia's most important crops by municipality and farm size.

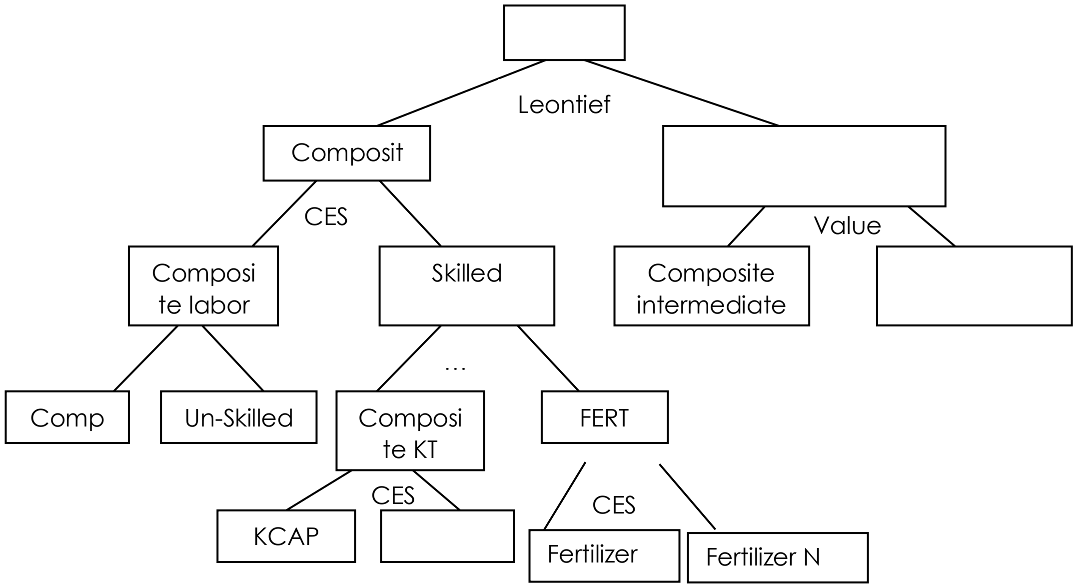
IV. Methodology

We used the single-country static CGE model known as PEP 1-1 as the starting point for developing our model. We introduced the following extensions related to the modeling of the agricultural sector: an 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 wages that differed across activities. In addition, we introduced other modifications related to the model closure rule.

The form of the production structure for agriculture is shown in Figure 3. Note that fertilizer had an explicit role in generating value added because it affected soil fertility.

[5] In the original model, we assumed that all activities produced the same variety of a given commodity. Thus, coffee from Municipality A was the same as coffee from Municipality B.

Figure 3: Nested Structure of Agricultural Production



We changed the behavioral equations that determined the production function of the crop sectors. Specifically, we allowed for the substitution between the use of fertilizers and agricultural land. The production function was organized in various nests (Figure 3). We started with the top nest, which determined the composition of value added VA_j. On the other hand, the combination of value added with intermediate inputs was modeled as we had done for non-agricultural activities.

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

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

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

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

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

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

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

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

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

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

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

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

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. Our SAM identifies a single good classified as a fertilizer (i.e., "chemical products").

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

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

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

(I) The "pure" form of the small-country hypothesis was introduced. Under this form, we assumed that producers could always sell as much as they wanted in the world market at the current price. It takes into account the fact that Colombia is a price taker in the

[6] Appendix 2 shows our extensions to the PEP 1-1 model.

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

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

In case $\sigma_i^{XD} = \infty$, Equation 62 in Decaluwé et al. (2013) can be simplified to:

13. $$ePWX_i = PE_i^{FOB}$$

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.

(II) Remuneration depends upon the type of labor for which each activity pays, allowing us to see income gaps between rural and urban households. In the 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 with data on the number of workers by sector. To do so, the remuneration to labor type i paid by the activity j, is computed as

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

where $wdist_{l,j}$ is a "distortion" factor applied to labor type l in industry j that allows the modeling of cases in which 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 were modified by this distortion term are presented in Appendix 2.

(III) The wage curve was obtained by endogenizing the unemployment rate (UERAT), which presents a negative relationship between unemployment and wages. In Colombia in 2014, the unemployment rate for skilled and unskilled labor corresponded to 11% and 8%, respectively (Departamento Administrativo Nacional de Estadística, 2014).

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

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

The wage-curve equation is:

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

The parameters of the model were calibrated using the SAM built for the benchmark year, 2014, described in Section 3. Elasticities were calibrated on the basis of information from a variety of sources: Sadoulet and de Janvry (1995), Annabi et al. (2006), Muhammad et al. (2011), and Flórez and Ramírez (2016). In addition, capital and land were assumed to be fixed and specific for each sector. We further assumed that capital and land were fixed and specific by farm-size, region, and crop. At the farm level, we assumed that production technology varied across farm-sizes and crops. Additionally, we considered that the production of each crop required certain natural conditions that were specific to each site and distributed across the region. This feature was represented in our model by the spatial division of the country into municipalities classified according to the armed conflict. This meant, for instance, that large farms in low-conflict areas could not change land allocation to alternative crops.

Labor was assumed to be perfectly mobile between sectors. These assumptions on the mobility of capital and labor meant that the analysis referred to a short-run to intermediate-run period of adjustment. In the very short-run, labor was 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 made it possible to measure the impact of post-conflict policies on the income and consumption of rural and urban households, bearing in mind the need to prevent inter-temporal or welfare leakages (Warr, 2008). Thus, the increase in real government spending and subsidies was financed with direct taxes either on households or on specific firms to keep the budget deficit and real investment demand at base levels. The nominal exchange rate was the numeraire; therefore, the current account was exogenous. Finally, the balance of savings and investment was achieved through household savings.

In this sense, we adapted the PEP 1-1 model by focusing on the agricultural sector; considering large, medium and small industries; and classifying industries according to the way in which they were affected by armed conflict in Colombia: very high (vh), high (h), moderate (m), low (l), and very low (vl). In addition, two types of households (rural and urban) and two labor classifications(skilled and unskilled) were introduced. These modifications made it possible to develop appropriate scenarios for simulations of post-conflict policies and their impact on the distribution of income.

V. Application and Results

According to the Colombian Peace Agreement, implementation was intended to target the crops of medium and small agricultural production units located in areas of moderate, high, and very high conflict. These areas were located in 158 out of Colombia's 1,122 municipalities.

In the simulations, we considered the work of Junguito, Perfetti, and Delgado (2017) who estimated that the implementation of the peace agreement's rural reforms would cost an average of 0.49% of GDP from 2017 to 2031, including the cost of policies such as transfers to rural farmers older than 65, construction of tertiary roads, technical assistance, and the construction of physical infrastructure for irrigation, drainage, or flood protection. Each of these policies had a different cost, and they were included in our simulations.

Our simulations were meant to capture two main aspects of the peace agreement. On the one hand, Point 1 of the peace agreement, "Comprehensive Rural Reform", was aimed at increasing the productivity of the factors employed in growing crops. It included programs such as technical assistance from the government for the adoption of good agricultural practices by small and medium farmers. It also included greater investment in the construction of infrastructure such as irrigation systems, intended to increase the productivity of land (Lozano & Restrepo, 2016), and tertiary rural roads. Considering the figures presented in Junguito, Perfetti, and Delgado (2017), we estimated that the implementation of this point would represent an increase of public final consumption by 1.4%—that is, 0.24% of GDP.

Naturally, the impact of this policy on productivity may well depend upon the type of program and the type of crop. For instance, for the case of Colombia, Lozano and Ramírez-Villegas (2016) found that irrigation and drainage systems could positively affect the productivity of rice over 20%, whereas the effect on coffee crops was much lower at 11%. In general, Argüello and Valderrama-Gonzalez (2015) estimated that an increase in irrigated land and drainage systems could result in yield gains that ranged 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 rural roads were about 2.9 percentage points higher than in municipalities with fewer tertiary roads.

Depending upon the source of the credit, impacts on yields ranged from 6% to 24% (Echavarría et al., 2018). Considering that public information did not include the specific features of the programs involved in implementation of the peace agreement and that such programs could affect several crops simultaneously, we assumed a conservative increase in total factor productivity of 4% in our simulations. In the last part of this section, we describe the results of a sensitivity analysis designed to reveal the range of possible effects of the policy on the economy, given a set of feasible effects of the policy on factor productivity.

The other main aspect of the peace agreement lay in Point 4, which corresponded to an illicit-crop-substitution program. According to Junguito, Perfetti, and Delgado (2017), the program would require an investment of COP $375,667 million pesos annually, of which direct subsidies to rural farmers amounted to COP $145,667 million, and transfers to rural households came to COP$ 230,000 million. Taking into account these Junguito group's estimates, we considered a subsidy of 5.8% to rural farmers, a 12.5% increase in government transfers to rural households in the form of a labor subsidy, and a 0.3% increase in government consumption (0.05% of GDP) to implement the program of subsidies under Point 4.

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

- Scale parameter φ_j^{VA} in the CES value added equation. (See Equation 1.) This shock corresponded to greater technical assistance and the construction of irrigation systems and tertiary roads. Therefore, we believed that it directly affected added value.
- Tax rate on type l worker compensation in industry j, $ttiw$ in the equation that determined government's revenue from payroll taxes on type l labor in industry j (TIW):

[7] See Appendix 3: Definition of Variables and Parameters.

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

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

A reduction of the tax rate on the production of industry j, $ttip$ in the areas most affected by the conflict caused a reduction in production costs and, therefore, an increase in production:

18. $TIP_j = ttip_j PP_j XST_j$

Needless to say, the results from the simulation (partly) depended upon how the government financed higher expenditures necessary to implement the peace agreement. On the one hand, the government could charge direct taxes to either rural or urban households, to both types of households, or to specific economic sectors. On the other hand, the government has the option of indirect taxation levied on commodities. Therefore, we first analyzed the general effects of implementation of Points 1 and 4 of the peace agreement, considering the following options for the financing of this policy:

(I) An increase in the direct tax rate on urban and rural households (Direct).

(II) An increase in the direct tax rate on urban households only (Direct-urban).

(III) Indirect tax on commodities (Indirect).

(IV) An increase in the tax rate on the financial sector (Tax-financ). In 2018, the Colombian congress passed tax reforms that included a higher income tax rate for the financial sector. This change was justified by growth in the financial sector in previous years. In 2017, in particular, the growth rate in the financial sector was four times higher than the growth of the Colombian GDP (Guevara, 2018). Moreover, Villabona and Quimbay (2017) pointed out that this economic sector had benefited the most from tax exemptions. Bearing in mind this policy change and the ongoing implementation of the peace accord, we simulated a scenario in which the implementation of Points 1 and 4 of the peace accord were financed with taxes directly charged to the financial sector.

(V) An increase in the tax rate on the mining sector (Tax-min). Villabona and

Quimbay (2017) estimated that, during 2000-2015, the Colombian mining sector benefited from tax exemptions of up to USD $14.8 billion, receiving the second greatest benefit of tax exemptions after the financial sector. In practice, our proposed increase in the tax rate could also be seen as a reduction in these tax benefits.

Table 3 shows the effects of different financing options on macroeconomic indicators. Tax-financ and Tax-min positively affected consumption by rural households, while the opposite was observed for consumption by urban households because the policy caused a drop in income from capital (the main source of income for urban households) while income from labor (the main source of income for rural households) increased. Tax-financ and Tax-min, therefore, generated a drop in urban households' disposable income while the disposable income of rural households increased.

Under the various scenarios, the effect on the GDP tended to be null, with a small negative effect of Indirect and Tax-financ (-0.1%). With direct taxes on households and Tax-min, conversely, the effect was positive and around 0.1%. The impact of the Tax-financ option on GDP was a consequence of the reduction in capital income that families received, which negatively affected urban households' disposable income and, therefore, their consumption, negatively affecting the GDP.

With Indirect, commodity prices and taxes paid by both urban and rural households increased. However, because the policy also significantly increased the income of rural households, the final effect on consumption and disposable income was positive. On the other hand, despite the increase in the disposable income of urban households, the increase in prices outweighed this effect, leading to a fall in consumption.

Finally, with Direct, the tax burden to finance the policy was two times higher for urban households than for rural households. However, the increase in total income of urban households was greater than the increase in taxes. Despite this increase in disposable income, the higher effect of the rise in prices decreased urban households' consumption. The total income of rural households increased but less than the cost of additional taxes.

All the financing options but Direct not only increased the disposable income of rural households but also reduced the income disparity between urban and rural areas. The latter effect was stronger for Direct-urban and Tax-financ (see Table 4). Considering this result and the effect on household consumption (Table 3), we concluded that the financial sector would be the most suitable option for financing the implementation of Points 1 and 4 of the peace agreement. Below, we explain in detail the potential effects of the peace accord's agricultural policy on the economy, assuming that higher government spending were to be financed with direct taxes on the financial sector.

Table 3: Macroeconomic Indicators of Different Government' 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: Authors' calculations.

Table 4: Percent Changes in Disposable Income of Type H Households Under Different Government' Financing Options

	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: Authors' calculations.

As can be seen in table 5, at the sector level we found that coffee production increased in all municipalities, including those that did not benefit from the policy, generating a fall in their basic prices, which stimulated the intermediate consumption of coffee in the local market. In municipalities that directly benefited from the policy, the average increase was 28%; in those that did not, the average increase was 0.9%. This subsector produces coffee beans, which are not exported but are the main production input of the coffee-products subsector. With an increase of 9.8% in domestic production and 11% in exports, the coffee-products subsector benefited the most from the policy among non-agricultural sectors (see Table 5). The growth in the production and export of coffee products stimulated the intermediate consumption of coffee beans in such a way that it exceeded the increase in production in the municipalities that received the shock. Consequently, coffee output also increased in the municipalities that did not received the shock.

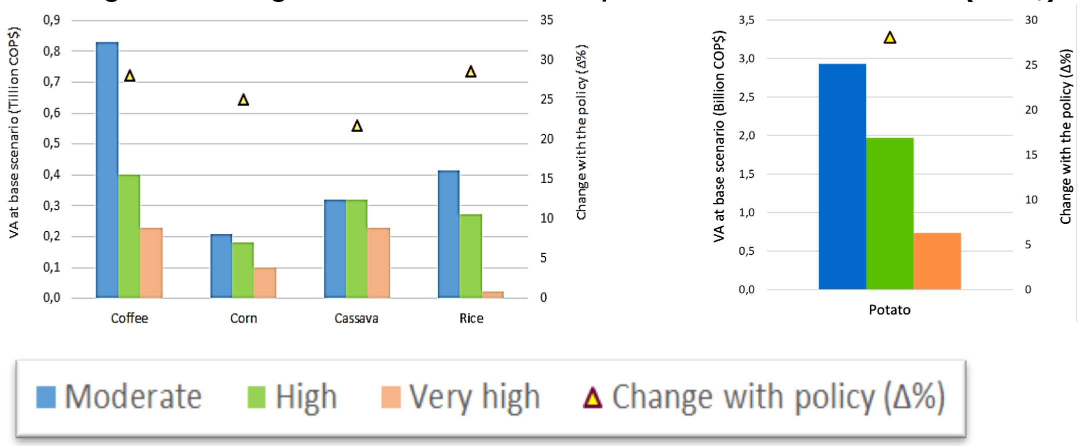
The increase in productivity brought a higher value added to all agricultural products (see Figure 3), which caused an increase of the same proportions in intermediate consumption and in the production of the crops in the industries that were beneficiaries of the policy (see Table 5). On average, the policy especially affected output and value added of coffee, rice, potatoes, and corn, with growth above 25% (see Figure 3).

Table 5: Aggregate Output of Crops and Municipalities That Receive the Shock, under Base and Policy Scenarios (Trillion COP$)

Size	Product	Municipalities that received the shock			
		Base			Policy - Average change (%)
		M	H	VH	
Small & Medium	Coffee	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
	Potatoes	0.076	0.017	0.007	15.185
Large	Coffee	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
	Potatoes	0.068	0.022	0.004	-0.660

Source: Authors' calculations.

Figure 4: Change in Value Added of Crops That Received the Shock (COP$)



Source: Authors' calculations.

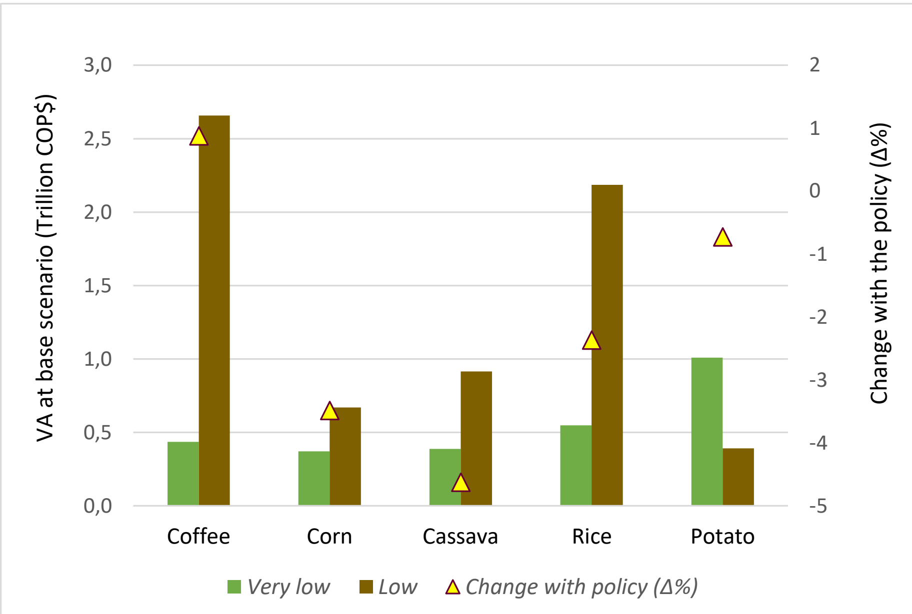
The positive impact occurred only in the municipalities that received the shock for potatoes, corn, rice, and cassava. In municipalities that did not received the shock, aggregate output of crops fell between 0.4-4.7% (see Table 6 and Figure 4). As explained above, the production of corn, cassava, potatoes, and rice is largely oriented to the domestic market. As production increased in the municipalities that received the shock, the internal price dropped, and the demand for these crops from municipalities that did not received the shock fell.

Table 6: Aggregate Output of Crops in Municipalities That Did Not Receive the Shock, under Base and Policy Scenarios (Trillion COP$)

Sizeu	Product	Municipalities that did not received 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
	Potatoes	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
	Potatoes	0.090	0.150	-0.451

* Average change for both types of municipalities, in percent.
Source: Authors' calculations.

Figure 5: Benchmark and Change In Value Added of Industries in Municipalities with Low Incidence of Conflict



Source: Authors' calculations.

Coffee, corn, cassava, and potato crops are unskilled-labor- intensive. Therefore, as a result of the increase in aggregate output of these crops, an increase in the demand for labor was expected. As can be seen in Table 7, the demand for unskilled labor in rural and urban areas of the municipalities that received the shock showed a significant increase. In rural and urban areas, demand grew by 27% and 15%, respectively. Likewise, an increase in the demand for skilled labor was seen in municipalities that received the shock. In the municipalities that did not receive the shock, the fall in output led to a decrease in the demand for labor (except in the coffee sector where the impact, although small, was still positive).

Table 7: Changes in the Demand for Labor (percent)

Products	*Municipalities that received the shock*				*Other municipalities*			
	Skilled		Unskilled		Skilled		Unskilled	
	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
Potatoes	5.7	5.4	5.7	16.3	-0.4	-0.8	-0.4	-1.1

Source: Authors' calculations.

Given the significant increase in the demand for labor in the municipalities that received the shock, a significant increase in wages was also expected. However, the impact on wages was rather modest, and the most significant increase occurred in rural unskilled labor (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 the assumption that labor was a perfect mobile factor, labor moved toward areas where there was an increase in the demand for labor.

Table 8: Changes in Wages (percent)

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: Authors' calculations.

We also found an increase in the remuneration of land, especially in municipalities that received the shock (vh, h, m), which may be explained by the fact that this type of capital is essential in the production processes of the crops under consideration. The most significant increases were 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 was a drop in the rental rate of land, except in coffee crops where the impact was positive (see Table 9). The increase in coffee production throughout the country, both in the municipalities that received the shock and those that did not, caused an increase in demand for and the rental rate of land.

Table 9: Changes in the Rental Rate of Land (percent)

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
Cassava	2.01	3.08	4.10	-3.10	-3.09
Rice	1.99	5.58	5.22	-1.28	-1.23
Potatoes	1.02	0.31	-0.63	0.10	0.08

Source: Authors' calculations.

Table 10 shows some of the main changes for the economy, by sector. From this table, note that the value added of coffee and the other selected crops was triggered by the policy's effects in municipalities where some conflict had occurred. Moreover, the strong linkage of the agroindustry (coffee products) with the production of coffee increased both production and exports (0.53% in the case of exports). The contrary effect was observed in value added of primary goods and other industries. The policy led to a slightly decrease in value added of primary goods and other industries of 0.37% and 0.35%, respectively. Exports of cassava, corn, and potatoes increased by an average of 13.5%. Recall, however, that the share of these crops in total exports was only 1.55%, on average (see Table 2).

Table 10: Aggregate Changes in Economic Sectors Under the Policy, w.r.t. Benchmark (percent)

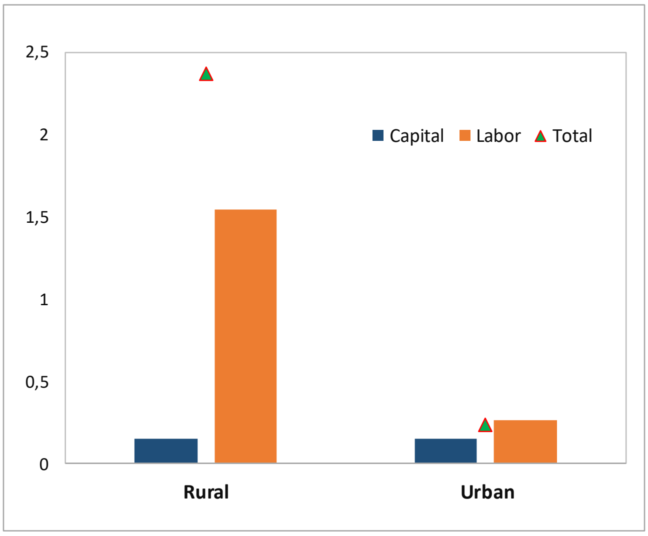
	Value Added	Exports	R Capital	LD			
				Skilled-Urban	Skilled-Rural	Unskilled-Urban	Unskilled-Rural
Coffee	11.86	—	5.52	9.42	9.06	9.41	13.87
Corn	7.83	15.36	1.43	4.24	3.90	4.23	8.51
Cassava	6.34	17.53	0.38	2.62	2.29	2.62	6.82
Rice	8.83	12.98	2.06	5.20	4.86	5.20	9.48
Potatoes	5.63	4.92	0.18	2.04	1.70	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: Authors' calculations.

On the other hand, the capital factor in the coffee sector benefited most, with an increase in remuneration of 5.52%. This was a consequence of the positive effects of the policy both in the municipalities that received the shock and in those that did not. The capital income of the agroindustry also increased significantly (by 2.62%), which was explained by the performance of coffee products due to their connection to the production of coffee. The total effect on the demand for labor for the different crops was positive—that is, the positive effect in the sectors that received the shock prevailed. On the other hand, the primary sector, services, and other industries showed a reduction in the demand for labor.

Finally, the policy had a positive effect on the different sources of income of rural and urban households. Figure 5 shows that the most important change was in the labor income of rural households as a result of the increase in demand for labor, particularly unskilled labor (see Table 8). Moreover, the total increase in rural income was higher than the increase in the income of urban households, which may be explained by the fact that direct taxes were increased on firms in the financial services sector, which are skilled-labor-intensive, to finance this policy. Thus, the demand for skilled labor decreased in the services sector, demands 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 was quite similar in urban and rural areas (close to 0.1%). The impact on the remuneration to capital was not highly significant because the sectors that received the shock were not capital-intensive.

Figure 6: Changes in Income of Type h Households (percent)



Source: Authors' calculations.

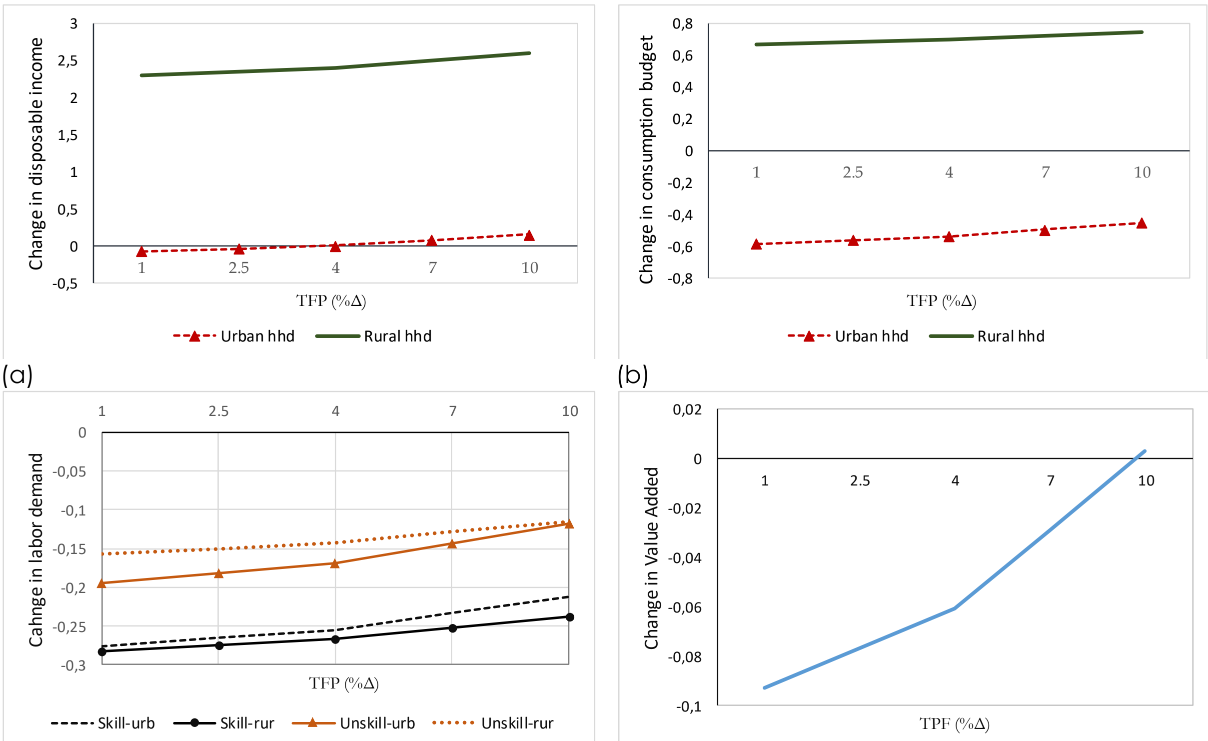
VI. Sensitivity Analysis

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

- In general, the impact on the demand for labor at an aggregate level was negative, independent of the level of productivity and especially for skilled labor. Increments in the level of productivity did not generate significant changes in demand for labor, essentially because the policy had only a positive impact on the demand for unskilled labor in crops that received the shock; in the other sectors the impact was negative. However, because the share of these crops in aggregate production was only 2.12%, the impact on aggregate demand for both skilled and unskilled labor was expected to be negative. Nonetheless, the higher the change in TFP, the lower the effect TFP(see Figure 6a).

- Similarly, a higher effect on TFP had a negative impact on total added value. As a consequence of the fact that these crops had a very small share of GDP, total added value only exhibited positive behavior for TFP changes over 10% (see Figure 6b).
- The disposable income of urban and rural households was directly related to changes in productivity levels. In the case of urban households, the impact was always positive as a consequence of the increase in the demand for rural labor. However, the disposable income of urban households only showed a positive effect for TFP changes above 4% (see Figure 6c).
- The consumption budget of urban and rural households also had a direct relationship to changes in productivity levels. For urban households, the impact was always positive and very similar to that of disposable income, although the growth rate was lower. The consumption budget of urban households, on the other hand, behaved negatively for all levels of TFP changes (see Figure 6d).

Figure 7: Sensitivity Analysis for TFP Changes



(c) (d)

Source: Authors' calculations.

VII. Concluding Remarks

Colombia is was experiencing a social and economic transition. After several decades of armed conflict, which particularly affected rural areas, the peace agreement between FARC and the Colombian government was expected to overcome many obstacles to rural development and to improve the well-being of these communities and of the nation in general. As part of this transition, the peace agreement assigned an important role to agriculture. We used a computable general equilibrium approach to analyze the impact of the main programs proposed for implementation of the peace agreement, specifically Point 1 ("Comprehensive Rural Reform") and Point 4 ("Substitution of Illicit Crops").

Our analysis showed that the policy was effective in achieving its goals. The package of proposed activities had a positive impact on agricultural production in the target zones (that is, the municipalities that had been mostly intensely affected by armed conflict). The increments ranged from 15-28% in the agricultural production of the most representative crops.

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

An important message from this research is that, in order to reduce the opportunity costs of the implementation of the peace agreement's agricultural policies, the financing options for this policy are critical and require careful thought because of their potential effect on disposable income. Furthermore, the opportunity cost of the policy can be mitigated if the effect on the productivity of factors introduced by this policy is stronger. This could be done, for instance, through providing public goods that effectively increase productivity in the zones that are the target of the policy—specifically in the construction of infrastructure such as tertiary roads and irrigation systems. The quality of technical assistance and sources of credit may be also be key in these efforts.

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Appendices

Appendix 1: Accounts of SAM 2014

Accounts of SAM 2014

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 tobacco	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

Appendix 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 appendix corresponds to the numbering 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 is simplified 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 government behavior assuming that real government spending could be exogenous (i.e., all the CG_i variables) while G was endogenous. Specifically, we dropped Equation 55 from the model and added the following equations:

$$CG_i = cgbar_i \cdot CGADJ \qquad \text{(A4)}$$

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

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 (Equation 43) and the GDP deflator.

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

Tax Rates

Equations A7 and A8 define 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 were scaled by the variable $TTDADJ$ and/or $TTICADJ$. In practice, this set of equations allowed us to expand the available policy instruments to finance the government budget.[8]

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

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

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

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 faced an endogenous income tax rate.

Household Savings

Equation A10 defines the marginal propensity to save of households. Its structure is

8 Note, however, that in the simulations shown in Section 3 we assumed that tax rates were constant; i.e., that $TTDADJ$ and $TTICADJ$ did not change.

the same as that of Equations A7 and A8 for tax rates and A4 for government consumption. In fact, whether $MPSADJ$ is flexible depends upon the closure rule for the savings-investment balance.

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

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

PEP-1-1 assumes that all sectors pay the same wage. In contrast, our model allowed us to complement 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 was computed as

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

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.

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

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

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

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

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

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 added

Equation A12 to the model 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.

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

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

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

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

$$P_{j,i} \cdot XS_{j,i} = PEJI_{j,i} \cdot EX_{j,i} + PLJI_{j,i} \cdot DS_{j,i} \quad \text{(A15)}$$

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

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

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

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

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

Appendix 3. Definition of Variables and Parameter

Value added

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

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

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

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

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

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