

AGRICULTURAL POLICY IN THE POST-CONFLICT IN COLOMBIA

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Abstract

This research evaluates the effects of targeting current agricultural policy instruments to zones highly affected by the armed conflict in Colombia, as a way to appraise their power to aid in enhancing agricultural activity and income generation capability in these zones. A static computable general equilibrium model is used for this purpose, running on an agricultural specialized 2014 SAM. The main results indicate that the size of current agricultural subsidies lead to negligible macro effects on the economy, and that even at the sectoral level their impact, when evenly distributed among the main policy instruments and agricultural zones, is quite limited. However, when subsidies are targeted to the zones most affected by the armed conflict, significant increases are obtained in terms of value added for the targeted zones while negative outcomes arise for the rest of zones, as they lose “competitiveness”. This targeting leads to relatively minor changes in the zone-composition of agricultural output and is neutral with respect to the commodity composition of agricultural output. Furthermore, the composition of sectoral factor income changes slightly, favoring capital rents against land rents and wages for skilled and unskilled labor.

JEL: Q18, F52, C68, D58

Keywords: Civil conflict; Rural development; Agricultural policy; CGE modeling; Colombia

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1. Introduction

Around 28% of Colombian municipalities has been affected by the armed conflict. According to data from the 2014 agricultural census, they represent 32% of total agricultural production units in the country, 24.7% of total area under agricultural use, 20% of natural forests, and 22.2% of total rural area. The percentage of land under agricultural use within the set of municipalities directly affected by the conflict is 31.7% (more than four percentage points above the corresponding share among the rest of municipalities) while the share of natural forests is 53.5% (almost 8 percentage points below the corresponding to the rest of municipalities). Land with potential agricultural use (i.e. cleared land with no current use) shows a higher share among municipalities directly affected by the conflict than among the rest of municipalities (11.8% vis a vis 8.8%), suggesting less intensive economic activity in these areas.

This is consistent with Arias et al (2017) finding that rural households accommodate to life in conflict areas at a lower income trajectory. This is not only due to the lower intensity of land use mentioned above, but especially due to changes in the portfolio of activities that these households engage in. In particular, Arias et al show that small farmers substitute activities with short-term yields and lower profitability for high profitability high investment activities. Furthermore, they show that as violence intensifies, farmers concentrate their portfolio of activities in subsistence activities. On the other hand, Fergusson et al (2014) show that deforestation is positively linked to paramilitary violence in Colombia. Using a panel specification, they show that paramilitary action significantly reduces the share of forest cover and that the link between paramilitary action and deforestation disappears once the paramilitary demobilized. The authors discuss evidence suggesting that this relationship operates through population displacement targeted to secure areas for illegal crops development, mineral resources exploitation, and extensive agricultural activities.

Additional evidence pointing in the same direction stems from Niño (2018) and Ospina (2019). Niño studies the effects of the negotiation process underwent by paramilitary groups in the early 2000s that led to quitting armed actions by some of these groups. He finds that, in general, there were no effects on illicit crops cultivation in areas controlled by these groups, but that there was a significant increase in permanent crops cultivation showing up increases in production two to three years after demobilization, while in municipalities with relatively large illicit crops cultivation the share of licit crops was lower, indicating strong substitution effects against legal activities. On the other hand, Ospina studies another negotiating process, this time the one between the Colombian government and the leftist FARC guerrilla that took place toward the end of the 1990s and the beginning of the 2000s and led to the establishment of a large demobilization zone (a safe zone for the guerrilla to stay while the process was developed, that lasted for four years) that was abruptly lifted in 2002 when negotiations were called off. She finds that, comparing land use patterns observed between the negotiating process and after it was shut down, farmers shifted their focus to short term more liquid activities, specially cattle ranching, to the detriment of agricultural activities (both transitory and perennial crops).

Implicit in this set of results is the negative effect of conflict on agricultural investment. This is a relationship that has been internationally studied, for instance in Messer et al (1998), who estimate that during periods of conflict agricultural production drops 12.3% on average each year, and in Ksoll et al (2010) it is shown that post-election violence in Kenya negatively affected cut flower exports. As Kimenyi et al (2014) claim, in the cases of Mali and Nigeria, conflict has four main effects on agricultural actors and investment: (i) reduces human mobility, (ii) reduces access to input markets, (iii) increases theft of various assets, and (iv) increases prices of inputs and products. These effects give rise to coping strategies that include moving production closer to home (so it can be more easily protected), diversification to activities with lower risk of attack, halting agricultural activities altogether and concentrating in businesses outside agriculture, and negotiating protection with armed groups. Also, as documented in Rockmore (2015) rural households in northern Uganda change the composition and size of their livestock portfolio and their crop choice as a response to conflict, decreasing risk at the cost of welfare.

After lengthy negotiations, the Colombian government and the FARC signed a peace agreement in November 2016, and it is therefore expected that much of the obstacles to rural development mentioned above can be removed and that rural households' (and the Colombian population at large) wellbeing could improve. The government issued guidelines for establishing a Framework Plan for the Implementation of the Peace Accord (CONPES, 2018), encompassing a 20-year period during which the national budget planning process should provide for specific investments for peace building. This framework is expected to prioritize investment in areas most affected by violence, rural poverty, the illegal economy, and institutional weakness.

The accord includes provisions beyond disarmament and reintegration of former combatants, and entails a deep transformation of rural areas political and social organization as reflected in the set of policy interventions it calls for, as mentioned ahead. There is widespread recognition that this represents a unique opportunity for sustainable rural development, opening the way for developing new infrastructure projects and increasing investment in rural areas (Morales, 2017). The post-conflict is envisioned as an opportunity to think the rural sector beyond agricultural production and to redefine the relationship between the rural and urban sectors for promoting a holistic vision of the territories, based on a comprehensive (environmental, social, and economic) territorial planning process, supported by the provision of public goods for better security and income generation, with special attention to gender and ethnic issues (CONPES, 2015).

In spite of this bold view of the post-conflict process, the international literature calls the attention to the role of agricultural rehabilitation as a means to linking humanitarian assistance, social protection, and development. In this regard, lessons from the Afghanistan and Sierra Leone experiences, indicate that: (i) the objective of agricultural support should not solely focus on increasing production but also on enhancing consumption, markets, and livelihoods, (ii) local efforts must match to the meso and macro policies necessary to support them, and (iii) there is scope for strengthening the linkages between livelihood protection and development (DFID, 2005). Therefore, agricultural support should facilitate the transition from supply-led programming (as usually implemented by governmental agencies and international donors) to the

establishment of market-driven systems for support delivery, in the context of broader efforts to protect and enhance rural livelihoods -understood as the ways in which households use and combine their assets to achieve desired income outcomes (Longley et al, 2006).

The desirability of these characteristics for policy implementation can only be highlighted if we take into account the main problems associated with areas affected by the armed conflict in Colombia: (i) lagging social and economic progress, (ii) weak land management, land use conflict, and environmental degradation, (iii) lack of security and personal protection, poor access to justice services, and victimization, (iv) weak institutional capabilities and lack of citizens' rights, and (v) challenges for demobilization and reintegration of former combatants (CONPES, 2016).

Within this framework, the aim of this research is to evaluate the potential impact that current agricultural policy instruments may have on agricultural production and income if they were to be targeted to the municipalities more affected by the armed conflict. For this, I use a static computable general equilibrium model (CGE) calibrated to a 2014 Colombian SAM. The model is neoclassical in nature and has distinct production functions for agricultural and non-agricultural activities, allocates land for agricultural uses according to relative prices with different transformation elasticities, and captures the main mechanisms through which agricultural policy instruments generate incentives for farmers.

2. The Colombian Economy and the Agricultural Sector

Structure of the economy

As in other middle-income countries, the services sector accounts for the largest share of total value added in Colombia, as can be appreciated from the first column in table 1. However, the agricultural sector retains a non-negligible share, comparable to those of agroindustry and light industry jointly considered and other industry, contributing 6% to Colombian value added. In terms of labor demand, the agricultural sector represents 9.1% of the wage bill with markedly different shares for unskilled and skilled labor. While it contributes 16.4% of total demand for unskilled labor, its contribution to demand for skilled labor is just 2.4%, clearly reflecting its role in the economy as one of the main holders of unskilled labor.

The largest generators of value added are the services sector with almost 55% of total value added, construction with more than 10% of the total, and mining with more than 9%. Demand for unskilled labor, aside agriculture, concentrates in the services and construction sectors, jointly accounting for more than 62% of this labor segment's wage bill, while demand for skilled labor overwhelmingly concentrates in the services sector, with 77% of the total.

As could be expected, the main forward linkages for the agricultural sector are provided by the agroindustrial sector, the personal services sector (the hospitality and food-service subsectors mainly), and the own sector, as shown in the last column of table 1.

Table 1. Sectoral composition of the Colombian economy

Sector	Sectoral share in:			
	Value added	Unskilled labor demand	Skilled labor demand	Intermediate consumption of ag. goods
Agriculture	6.0%	16.4%	2.4%	9.1%
Mining	9.2%	1.9%	2.7%	0.0%
Agroindustry	2.2%	2.9%	2.3%	74.7%
Light industry	4.0%	4.9%	4.0%	2.9%
Other industry	6.5%	2.7%	3.2%	0.3%
Construction	10.4%	13.6%	4.3%	1.8%
Personal services	6.9%	8.7%	4.0%	10.7%
Other services	54.8%	49.0%	77.1%	0.5%

Source: Colombian 2014 SAM.

From the point of view of commodities, the bulk of import value relates to industrial products (both light and other industry), accounting for more than 72% of total imports, followed at a distance by other services that represent 9% of imports. On the export side the highest share belongs to mining, with a share near 55%, as the country has grown dependent on oil and coal exports during the last decades. Other industry accounts for another 20% of export value, while agroindustry and agriculture account for 8.2% and 4.1%, correspondingly. Lastly, final consumption (households) is made up mainly of other services and personal services, jointly representing more than 55% of consumption, light industry products, and agroindustry. Agricultural products represent 5.4% of final consumption.

Table 2. Commodity composition of international trade and final consumption

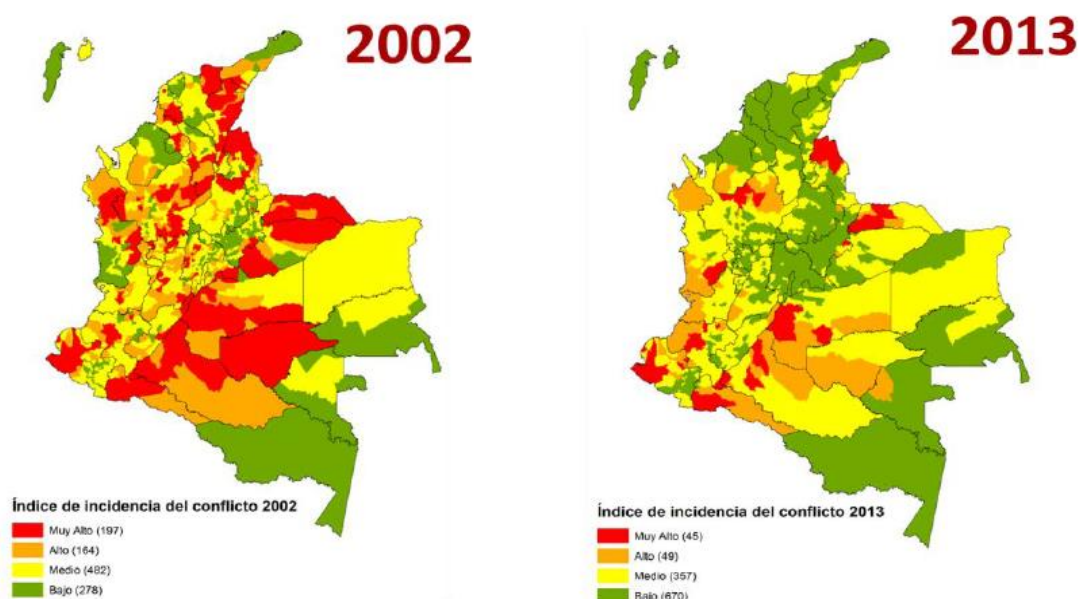
Product	Product share in:		
	Imports	Exports	Final consumption
Agriculture	3.4%	4.1%	5.4%
Mining	0.2%	54.7%	0.0%
Agroindustry	4.7%	8.2%	12.4%
Light industry	47.9%	7.8%	18.5%
Other industry	34.5%	20.0%	8.1%
Construction	0.0%	0.0%	0.0%
Personal services	0.0%	0.2%	14.0%
Other services	9.2%	5.1%	41.6%

Source: Colombian 2014 SAM.

The Colombian economy sustained a trade deficit during the SAM's base year, a feature that has become characteristic of it, that represents roughly 5% of GDP, while foreign savings represents more than 7% of GDP and more than 27% of total savings.

Agricultural sector and the armed conflict

Figure 1 shows a map of Colombian municipalities with a color code indicating the intensity of the conflict. The red color means the intensity of the conflict is very high, while the green color means it is low (orange and yellow mean high and medium incidence, respectively).



Source: CONPES, 2016

Figure 1. Index of the incidence of the armed conflict in Colombia in 2002 and 2013

In order to have a link between the incidence of the armed conflict and agricultural production, I use the average incidence index between 2002 and 2013 to classify the municipalities and data from the 2014 agricultural census, aggregated to the municipality level, to build the structure of agricultural production for each incidence category. As shown in table 3, municipalities with very high and high incidence levels account for almost 20% of agricultural value added¹, while most value added is generated from areas with a medium low incidence level. In proportion to their shares in value added, very high and high conflict incidence areas show lower shares in demand for unskilled labor and higher shares in demand for skilled labor, while their demand for both land and capital are considerably below their value added share in the case of very high intensity areas (indicating relative labor intensity), and below for land demand and above for capital demand in the case of high intensity areas. (indicating relatively low labor intensity).

Table 3. Agricultural value added by incidence of the armed conflict

Conflict Incidence	Value added	Unskilled labor	Skilled labor	Land	Capital
Very high	9.0%	9.0%	9.7%	8.6%	7.9%
High	11.4%	11.3%	11.7%	11.0%	12.4%
Medium	17.5%	17.7%	17.1%	16.7%	18.1%
Medium low	41.5%	41.5%	39.9%	42.1%	43.3%
Low	20.6%	20.5%	21.6%	21.6%	18.3%

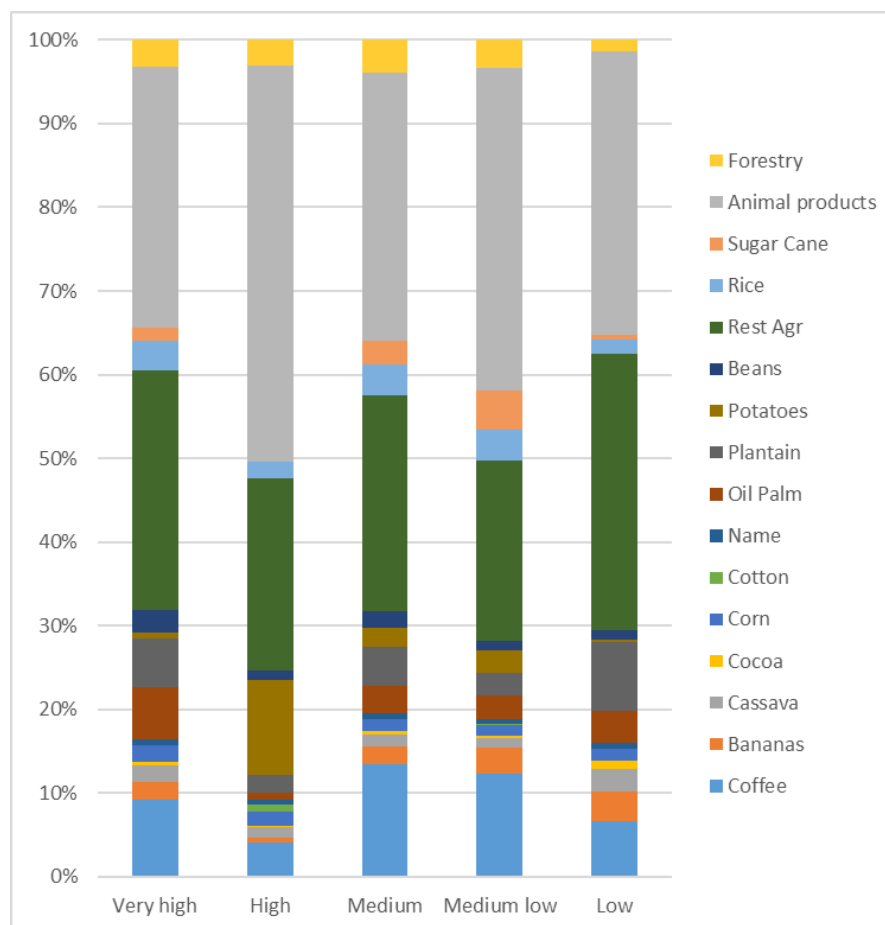
Source: Colombian 2014 SAM.

Medium low incidence areas show the highest value added share and this behavior carries over for both types of labor demand, land rent payments and capital rent payments. Land rent payments are above the corresponding area type's valued added

¹ Agriculture comprises all crops, animal and animal products, and forestry.

share for medium low and low incidence areas, probably reflecting the lower uncertainty associated with agricultural activities performed in there.

As for the composition of crop production, in all areas the majority of production corresponds to the rest of agriculture (a mix of a large variety of commodities), ranging from 23% in high incidence areas to 33% in low incidence areas. None the less, it is animal and animal products production the activity that shows the largest share for all area types. The lowest share of this activity belongs to very high incidence areas, with 31%, and the highest to high incidence areas, with 47%, as can be appreciated in figure 2.



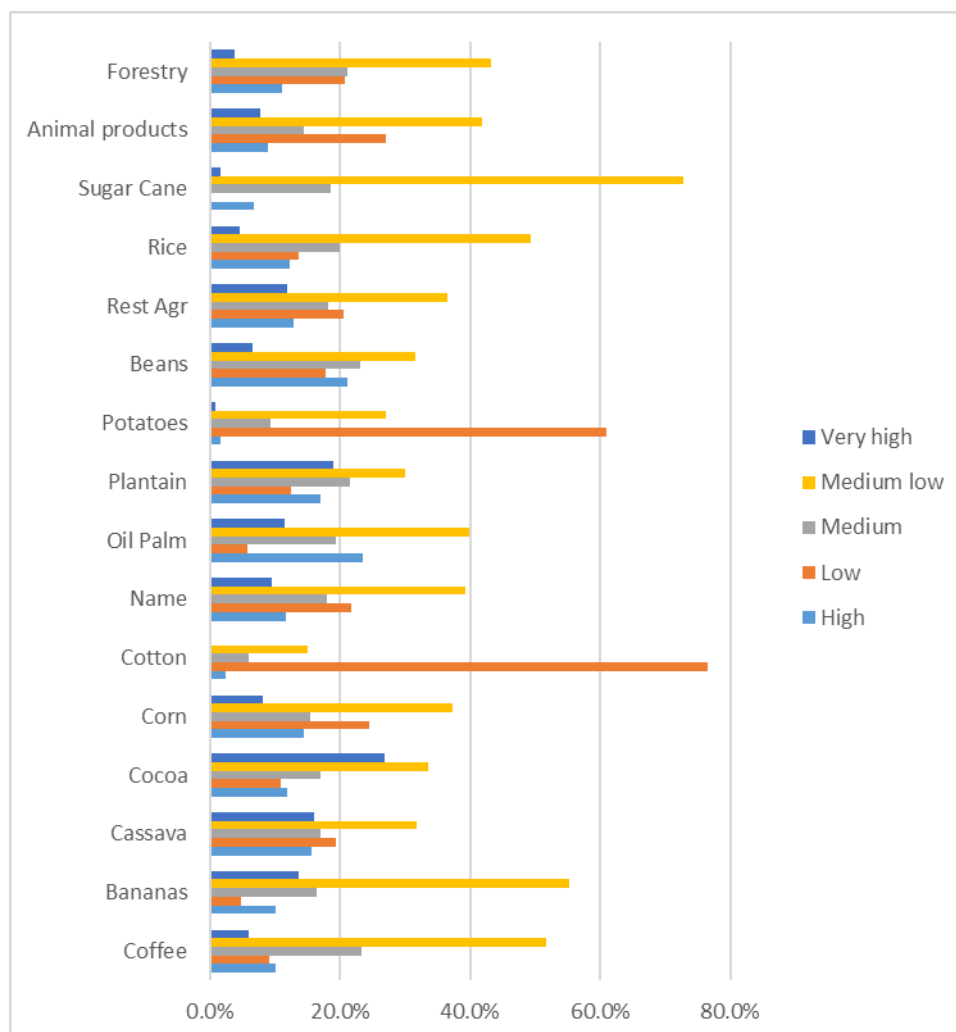
Source: Colombian 2014 SAM.

Figure 2. Product composition of agricultural production by incidence of the armed conflict

From figure 2, it can also be seen that the main crops in very high incidence areas are coffee, oil palm, and plantain, while for high incidence areas are potatoes, coffee, and forestry. In the case of medium incidence areas the main products are coffee, plantain, and rice, and for medium low incidence areas the main products are coffee, rice, and forestry. Lastly, in the case of low incidence areas the main products are plantain, coffee, and oil palm.

From the standpoint of products, figure 3 illustrates the composition of their production according to the incidence of the armed conflict. The set of products that show the largest shares of cropping in very high incidence areas are cocoa, plantain, cassava, and

bananas, while those that show the largest shares in high incidence areas are oil palm, beans, cassava, and corn. On the other side, the crops with the largest shares in low incidence areas are cotton, animal products, corn, forestry, and cassava.



Source: Colombian 2014 SAM.

Figure 3. Area composition of agricultural production by product

Main agricultural policy instruments

Irrespective of the myriad programs through which agricultural policy is implemented in Colombia, the government basically deploys three main sets of policy instruments: productivity incentives, subsidized credit, and marketing support. Productivity incentives aim to improve technical assistance, the development and transfer of agricultural technologies, implementation of good agricultural practices, fostering associativeness, and land adequation, irrigation and drainage co-financing. Subsidized credit is devoted to productive restructuring, land adequation, improved productivity, and new investment towards agricultural modernization. The marketing support component aims to support the development of traceability systems, domestic absorption mechanisms, storage, and other supplementary activities.

The policy instruments that are of our interest operate within three broad programs: the Special Credit Line (SCL), the Incentive for Rural Capitalization (IRC), and Irrigation and Drainage Projects (IDP).

The SCL is a subsidized credit scheme that supports agricultural activities that are of importance for basic nutritional needs, are considered sensitive because of social or economic reasons, or are valuable for export. This credit program is open to all types of farmers (small, medium, and big farmers) with interest rates that are between 4 and 7 percentage points below market rates. Between 2010 and 2018, small farmers got 57.4% of total subsidies granted by the government, medium size farmers got 33.9% of subsidies, and large farms got the remaining 8.7% (out of a total of 110 million USD). According to the government, for each dollar in subsidies, farmers invested 9.2 dollars in agricultural projects (MADR, 2018).

The IRC is intended to facilitate agricultural investment by offering a credit line that operates at market interest rates but that includes some financing (credit and interest) forgiveness (40% for small producers, 20% for medium size and large farmers). This credit line promotes cultivation of perennial crops, acquisition of machinery and equipment, and improvements in productive infrastructure. Recently (from 2017), subsidized credit for the same purposes was channeled through the LEC, under slightly different conditions. Between 2010 and 2018, the government allocated more than 660 million USD to the IRC program.

Lastly, the IDP is a program which co-finances irrigation and drainage projects for existing or prospective production. The size of the subsidy granted by the government varies by project type (individual, cooperative or regional) and may reach up to 80% of direct costs. The remainder of the costs must either be covered by regional institutions, directly by the farmers or by both. Funds for this program are currently allocated on the basis of the National Plan for Irrigation and Drainage (for family and peasant agriculture) or through the IRC.

In general, the effects of this set of policy instruments can be represented as providing the following incentives for farmers: lower unit costs, lower capital costs, lower land costs, and higher productivity. Since a broad range of items are eligible for a working capital subsidy in numerous productive activities (ranging from input purchases to outsourcing of different activities), it is convenient to represent the effects of this subsidy as being across the production process in a manner that effectively lowers unit costs. Second, investments financed through either the SCL or through the IRC are almost entirely intended to raise the amount of capital in use, and its effects are better represented as a capital subsidy. There are some exceptions to this, however. Investment subsidies allocated to planting and crop maintenance or to agricultural production tend to be less specific in terms of which items are eligible and thus behave much like working capital subsidies, and are thus also viewed as lowering unit costs. However, while subsidies for land adequation may sometimes include irrigation-related activities, these most typically are activities that do not include irrigation or water management. Since I want to establish a clear division between irrigation-related subsidies and land adequation subsidies, I consider land adequation subsidies as capital subsidies.

3. Research Questions and Methodology

Research Questions

As mentioned, the aim of this research is to evaluate the potential impact that current agricultural policy instruments may have on agricultural production and income if they were to be targeted to the municipalities more affected by the armed conflict. The set of policies I model here are not the whole set of policies that have been envisioned as part of the rural reform process agreed upon in the peace agreement. In this sense, they provide a lower bound for the capability of the government for enhancing agricultural activities with the current budget allocation, provided the targeting referred to above takes place (which is an improbable outcome as it is likely that the political economy process behind resource allocation would push for a more distributed policy intervention).

Within this framework, the policy questions I aim to shed light on are:

- What will happen to the supply of agricultural products if current policy intervention concentrates in very high and high incidence areas?
- How will this policy shift affect the composition of agricultural production among areas with different incidence of the armed conflict?
- How will this policy shift affect rural labor demand?
- How will the pattern of income sources change as a consequence of policy implementation?

The Model

The model is based upon the static, single country, Standard PEP CGE model.² It has a neoclassical structure with equations that describe producers' production and input decisions, households' behavior, government demands, import demands, market clearing conditions for commodities and factor markets, and numerous macroeconomic variables and price indices. Supply and demand equations for private-sector agents are derived from optimization problems, in which agents are assumed to be price-takers in a competitive market. The model treats the external sector as a single region and adopts a "mild" version of the small country assumption.³

I introduce two main changes to the model. First, I modify the production function for the agricultural sector, allowing for a convenient representation of agricultural production. Second, I introduce a supply function for land services so as to have a more realistic representation of land allocation between agricultural subsectors. Land allocation is done at the national level, which means that all incidence level areas are responsive to changes in land allocation taking place at any one of them (i.e. land allocation changes do not limit themselves to the limits of the area where they are taking place).

² The model, the Standard PEP-1-1 model, is thoroughly documented in Decaluwé et al (2009).

³ In the sense that local producers can increase their share in international markets as long as they can offer a price that is competitive relative to the world price (in consideration of the price elasticity of export demand).

The structure of agricultural production reflects the large degree of complementarity that commonly appears in agricultural production. It uses composite land, as a CES combination of land and fertilizer, allowing the latter to play a role in determining value added. This structure is represented in figure A.1 in the appendix. In terms of land services, agricultural land is assumed to be heterogeneous in the model. However, agricultural activities compete for land services regardless of the agroecological conditions under which they best perform and land services are applied to each activity with certain restrictions.

This feature responds to two considerations: it approximates the heterogeneity of land, and, in practice, land uses are conditioned upon certain economic constraints. In particular, land use may depend on the ease with which land can be allocated to different activities, according to characteristics such as the way cash flows produced or required in the subsector behave, or by the size of initial investments. Therefore, land allocation is sluggish in the model and a constant elasticity of transformation (CET) function is used to represent it as illustrated in figure A.2 in the appendix.

The model runs on a 2014 SAM with 101 activities and 38 commodities, of which 79 are agricultural activities that produce 16 commodities. There are three production factors: land, labor and capital. Land is only used by agricultural activities, while labor is split into unskilled and skilled categories and there is only one type of capital. There is only one representative household and there is no consideration of self-consumption of agricultural goods produced by rural households.

Regarding the labor market, the model allows for either full factor mobility or factor specificity. In the simulations, I assume that labor is perfectly mobile between sectors while capital is sector-specific. However, it must be kept in mind that there are two features in the model that result in limited labor mobility within the agricultural sector. As land allocation between agricultural subsectors is slow, labor mobility in the agricultural sector is lower. Also, as production in the agricultural sector uses a capital-labor composite factor with sector-specific capital, labor mobility tends to be limited. For these reasons, and for the purposes of my current objectives, it is suitable to achieve closure in the model's labor market through wages, with perfectly inelastic supply of labor, even though it is generally assumed that labor mobility between agriculture and other subsectors should be modeled as less than perfect. Also, specifying capital as sector-specific is convenient because I aim to evaluate the short to medium run effects of agricultural policy.

Simulation characteristics

In light of the discussion in section 2, I basically need to model three types of incentives created by agricultural policy: subsidies which lower unit costs, subsidies which lower productive capital costs, and subsidies which lower land use costs (including a productivity effect). I model all subsidies that effectively lower unit costs as creating a (negative) wedge between a subsector's unit cost and its basic price. On the other hand, productive capital subsidies are modeled as lowering the cost of capital for beneficiary subsectors so the price of this factor decreases according to the implicit subsidy rate. Lastly, irrigation subsidies are modeled as having two effects: one, they lower the cost of using land and therefore act as a wedge between supply and demand land rents;

second, they are expected to improve productivity since enhanced water availability and management is expected to increase yields. The productivity effect through irrigation should ideally be calibrated on a crop by crop basis. Unfortunately, the information to do this is neither abundant nor reliable enough, so I assume that the productivity effect is the same across all crops. Furthermore, the parameter is estimated on the basis of the (average) assumed yield gap between irrigated and non-irrigated land for several crops. Data on yield gaps come from information available for some crops and from experts' judgment.⁴

Lastly, it is worth mentioning some general characteristics of the simulation. First, the financing of the program is modeled by assuming that public expenditures to subsidize agricultural activities are funded through direct taxes designed to raise the exact amount needed (i.e., tax rates for households and firms adjust endogenously). Second, the simulation uses the following closure rules: the nominal exchange rate is the numeraire, the supply of labor is fixed, fully utilized, and freely mobile between all sectors, government expending is fixed, investment is savings-driven, the current account balance is fixed, and total land demand is fixed. I define the time horizon as short to medium term, so capital is assumed to be sector-specific. This feature is not only consistent with the idea that most capital used in agricultural activities is more related to trees and plants than to machinery and equipment (in the Colombian case), but also with the fact that, even in the case of capital that is not strictly specific to an activity (like machinery), the timeframe considered in the simulation makes it unlikely that there could be any significant capital reallocation between subsectors.

4. Results and discussion

In recent years, the Colombian government has spent around 130 million USD a year in subsidies for the agricultural sector (i.e. only in the set of subsidies mentioned above), which represent about 0.7% of gross sectoral value (or 1% of sectoral GDP). As I am not interested in the actual breakdown of the subsidy amount across activities or regions, the starting point of the simulations is to build a benchmark distribution of subsidies that illustrates the way they are expected to work and against which it is possible to compare other results. This benchmark simulation, named “all subsidies” assumes that the whole subsidy amount is evenly split between the three subsidy types (on working capital, on productive capital, and on land improvements) and allocated to each activity in proportion to its share in gross sectoral value, so it is “neutral” in terms of commodities and producing areas. Agricultural activities are defined on the basis of the main commodity they produce and the type of area where they locate; eg. there are five coffee activities, according to the level of incidence of the conflict: coffee in very high incidence areas, coffee in high incidence areas, coffee in medium incidence areas, coffee in medium low incidence areas, and coffee in low incidence areas, for instance.

Then, three additional scenarios are defined, in which the total subsidy amount is allocated to just one type of subsidy. These scenarios are named only working capital,

⁴ Equations used to implement the structure of agricultural production, the supply of land services, and the policy shocks, are listed in table A.1 in the appendix.

only capital, and only land. Their purpose is to shed light on the way each subsidy type works and, therefore, impinges upon the combined subsidies scenario. As the purpose is to analyze what would happen if the set of subsidies were directed exclusively to areas highly affected by the conflict (very high incidence and high incidence areas), another set of four scenarios, similarly defined, but with subsidies restricted to these type of areas is run. In the following, the results from these simulations are presented and discussed, with an emphasis on their outcomes rather than on the mechanisms determining them.

Macroeconomic results with subsidies even distributed

Given the size of the subsidies it is expected that their impact on the macro variables be small. In fact, as table 4 shows, the change in real GDP when all subsidies operate is negligible (a drop of 0.008%). Under this scenario, the nominal value of consumption increases 0.034%, export value increases 0.012%, and import value increases 0.005%. If subsidies were only targeted to working capital, the real negative impact on GDP would be higher (0.06%), the increase in the nominal value of consumption would be lower and the impacts on exports and imports value would be higher than under the all subsidies scenario. Results from the only capital subsidy scenario yield the lowest relative changes in real GDP, exports value and imports value, decreasing real GDP and import value, while increasing exports value. In contrast to the rest of scenarios, the impact on nominal consumption is negative (in the order of 0.04%). Lastly, the scenario only land subsidy is the only one that yields a marginal increase in real GDP (0.04%), along with the largest increase in the nominal value of consumption and increases in exports and imports value.

Table 4. Macro results from the simulations (subsidies even distributed geographically)

Scenario	Percentage change in:			
	Real GDP	Consumption	Exports	Imports
All subsidies	-0.008	0.034	0.012	0.005
Only working capital	-0.061	0.025	0.016	0.014
Only capital	-0.001	-0.038	0.002	-0.005
Only land	0.035	0.112	0.016	0.005

Source: model simulation.

The reason why the only land scenario yields a positive effect on GDP is because it entails a productivity effect associated with higher crop yields due to irrigation and better water management. Wages for skilled workers increase 0.14% and for unskilled workers increase 0.35%, while capital rents increase for all agricultural activities and most non-agricultural activities (at the expense of the more capital intensive activities in the economy), and land rents increase for most agricultural activities.

In contrast, the only working capital subsidy yields the most negative effect on GDP, since there are no productivity effects and the subsidy favors value added generation in the agricultural sector (and industrial sectors heavily linked to it) in detriment of value added generation in the rest of the economy. Wages for skilled and unskilled workers increase (0.05% and 0.13%, respectively), while capital rents increase for most activities in the economy, and land rents increase for most agricultural activities, leading to a

higher price of value added that is insufficient to compensate for the fall in the quantity of value added in key (non-agricultural) activities of the economy.

The only capital subsidy scenario leads to the least negative effect on GDP. This outcome is mainly the consequence of the capital specificity assumption in the model, which implies that most effects of the subsidy get “capitalized” in capital rents in the agricultural sector with scant spillovers to the rest of the economy. In effect, there are very small changes in value added across activities (ranging from -0.04% to 0.04%), while capital rents in the agricultural sector rise in average 17.2% (with a maximum of 41.3% and a minimum of 2.5%), and fall in average in the non-agricultural sector by 0.01% (with a max of 0.06% and a min of 0.04%). Wages for skilled workers fall 0.01% and for unskilled workers fall by 0.001%, while land rents fall in average 0.01%.

From the above it can be inferred that the result arising from the all subsidies scenario must be the outcome of the interplay of these forces, so the negative effect on GDP from the working capital subsidy overtakes the positive effect arising from the subsidy on land management.

However, it must be noted that the price of value added falls for all agricultural activities under the only land scenario, a fact due to the fall in the price of composite land driven by the subsidy and by the tendency to demand less land as it becomes more productive.⁵ This price effect dominates the increase in the quantum of value added leading to a decline in the value of value added for the agricultural sector. In contrast, under the only working capital scenario, the value of value increases even though the rise in value added quantum is lower, the difference stemming from the fact that the price of value added increases as the subsidy pushes agricultural basic prices up. Lastly, under the only capital scenario, the response from agricultural value added is tamed for the reasons discussed above. The corresponding figures are presented in table 5, from where it can be appreciated that non-agricultural value added increases under the only land and the only working capital scenarios, and negligibly decreases under the only capital scenario. The all subsidies scenario leads to a decrease in agricultural value added and an increase in non-agricultural value added.

Table 5. Changes in value added

Scenario	Percentage change in:	
	Agr. Value added (\$)	Non-agr. value added (\$)
All subsidies	-0.055	0.062
Only working capital	0.647	0.046
Only capital	-0.024	-0.004
Only land	-0.729	0.137

Source: model simulation.

Zone level results with subsidies even distributed

In what follows, the results for some key variables at the zone level are presented (in table 6) and discussed. Due to limitations in data availability, it was not possible to

⁵ In the model, land rents are valued at producer prices (i.e. including the downward effect from the subsidy), while from the point of view of households income they are valued at prices comprising the value of the subsidy.

differentiate production technologies across zones, so the structure of intermediate demand and value added is the same across zones for the same commodity. This implies that variation in results for the five zones mainly stems from their relative heterogeneity in the portfolio of commodities that they produce.

Table 6. Zone level results (percentage changes)

Scenario	Incidence	Value added (\$)	Value added (Q)	Unskilled labor demand	Skilled labor demand	Land demand	Prod. (Q)
All subsidies	Very high	-0.012	0.388	0.412	0.484	0.036	0.404
	High	-0.017	0.399	0.407	0.478	0.030	0.392
	Medium	-0.025	0.382	0.402	0.474	0.043	0.385
	Med. low	-0.059	0.377	0.397	0.472	-0.016	0.380
	Low	-0.110	0.362	0.377	0.457	-0.031	0.361
Only working capital	Very high	0.678	0.367	0.382	0.419	-0.030	0.367
	High	0.655	0.357	0.378	0.407	0.008	0.358
	Medium	0.647	0.351	0.373	0.401	-0.011	0.348
	Med. low	0.644	0.331	0.352	0.384	-0.019	0.331
	Low	0.634	0.319	0.330	0.374	0.052	0.314
Only capital	Very high	-0.026	-0.012	-0.014	-0.008	0.002	-0.013
	High	-0.024	-0.013	-0.013	-0.007	-0.0001	-0.013
	Medium	-0.022	-0.010	-0.011	-0.006	0.001	-0.011
	Med. low	-0.023	-0.010	-0.011	-0.006	0.001	-0.011
	Low	-0.026	-0.013	-0.015	-0.007	-0.003	-0.013
Only land	Very high	-0.635	0.794	0.815	0.977	0.117	0.807
	High	-0.631	0.772	0.807	0.971	0.079	0.783
	Medium	-0.649	0.758	0.792	0.963	0.135	0.768
	Med. low	-0.740	0.758	0.794	0.971	-0.036	0.769
	Low	-0.868	0.736	0.767	0.943	-0.121	0.737

Source: model simulation.

From the first two columns in table 6 follows that no zone is specialized enough so as to show a value added outcome that differs from those in other areas. The value of value added increases for all zones under the only working capital scenario as so does the quantum of value added, both with low variability. The largest changes in the value of value added and value added quantum belong to the only land scenario, the first with moderate variability and the second with a low one. Changes in quantum are positive while changes in value are negative, as a result of the effects discussed above. The only capital scenario yields small changes in both value and quantum of value added, both negative. As a result, the all subsidies scenario shows negative but moderate decreases in the value of value added for all zones (although with a relatively high variability across them –the coefficient of variation is 0.83) and relatively large and positive changes in value added quantum (with low variability –the coefficient of variation is 0.03). Under this scenario the zones with the largest variations in valued added quantum are those with high and very high incidence of the armed conflict.

Labor demand moves in unison with value added quantum and this is true for both unskilled and skilled labor. The largest changes are found under the only land and all subsidies scenarios. In all cases, changes in labor demand for skilled labor are larger

than for the unskilled labor (when they are negative they are less so), so the set of policies tends to have a slight bias against unskilled labor.

Differently from the above, demand for land does not necessarily follows the direction of changes in value added quantum, showing increases and decreases across zones within the same scenario (even in the only land scenario, in which zones with medium low and low incidence of the armed conflict show decreases in land demand –which carry over to the all subsidies scenario).

Production quantum follows the same behavior as the quantum of value added, being slightly larger in the cases of the all subsidies and only land scenarios, smaller in the case of the only working capital scenario, and the same in the case of the only capital scenario.

Lastly, with the only exception of the only capital scenario, results from the simulations tend to slightly favor very high, high, and medium incidence zones, as follows from the figures in table 6.

Macroeconomic and sectoral results with subsidies targeted

When subsidies are targeted to very high and high incidence zones, there is scant variation in macro results. As expected, all figures show the same signs and orders of magnitude with outcomes from the targeted scenarios marginally lower than those from the evenly distributed subsidies scenarios (the differences being in the order of 0.0023 to 0.0002 percentage points). In contrast, changes in the value of value added for the agricultural sector are higher under this set of scenarios. Under the all subsidies scenario the value of value added decreases 0.013% (0.042 percentage points less than under the all subsidies even distributed scenario) while the corresponding to non-agricultural activities increases 0.058% (0.004% less than under the evenly distributed scenario).

Zone level results with subsidies targeted

Table 7 presents the results for value added, factor demand, and production volume for each zone and scenario when subsidies are targeted exclusively to very high and high incidence zones. From there it is clear that even though subsidies are low at the agricultural sector level, they can have sizeable effects at the zone level when targeted. Under the all subsidies scenario, the value of value added increases more than 21% in very high and high incidence zones, and the same happens with value added quantum (although at a lower level, indicating a positive contribution of value added prices). Demand for labor increases in a commensurate way for the two zones targeted, the increases for unskilled labor being larger than those for skilled labor. Demand for land also increases, slightly more in very high incidence zones than in high incidence zones. The same behavior shows up for production quantum.

The down side of these results is that the rest of zones show negative figures. The value of value added decreases 5.6% in average for medium, medium low, and low incidence zones, while value added quantum decreases 5%, so the price of value added decreases too. Given that wages equalize across sectors in the economy, the differing behavior between value added prices for targeted and non-targeted zones arises from capital and land rents. In effect, land rents tend to rise for very high and high incidence zones and

to decrease for the rest of zones and the same is true with respect to capital rents, the latter showing the largest increases. Labor demand decreases slightly more for unskilled workers than for skilled workers and production quantum decreases proportional to value added although slightly less.

Table 7. Zone level results under the targeted scenarios (percentage changes)

Scenario	Incidence	Value added (\$)	Value added (Q)	Unskilled labor demand	Skilled labor demand	Land demand	Prod. (Q)
All subsidies	Very high	21.6	20.9	23.3	22.3	12.2	21.3
	High	22.3	21.6	23.0	21.3	11.8	20.7
	Medium	-6.1	-5.5	-6.0	-6.0	-3.1	-5.2
	Med. low	-5.6	-4.9	-5.4	-5.3	-2.8	-4.7
	Low	-5.1	-4.5	-4.9	-4.8	-2.9	-4.3
Only working capital	Very high	26.6	22.7	24.5	22.1	13.5	22.1
	High	25.8	21.9	24.2	23.3	13.2	21.5
	Medium	-6.5	-5.9	-6.4	-6.5	-3.5	-5.6
	Med. low	-5.8	-5.3	-5.8	-5.6	-3.2	-5.0
	Low	-5.2	-4.7	-5.1	-5.0	-3.2	-4.4
Only capital	Very high	-0.026	-0.012	-0.014	-0.008	0.002	-0.013
	High	-0.024	-0.013	-0.013	-0.007	0.000	-0.013
	Medium	-0.022	-0.010	-0.011	-0.006	0.001	-0.011
	Med. low	-0.023	-0.010	-0.011	-0.006	0.001	-0.011
	Low	-0.026	-0.013	-0.015	-0.007	-0.003	-0.013
Only land	Very high	13.6	14.2	15.3	14.7	7.9	14.1
	High	13.2	13.8	15.1	14.1	7.7	13.7
	Medium	-4.0	-3.5	-3.9	-3.9	-2.0	-3.4
	Med. low	-3.7	-3.2	-3.5	-3.4	-1.8	-3.1
	Low	-3.4	-3.0	-3.2	-3.2	-1.9	-2.8

Source: model simulation.

Results for the rest of scenarios follow a similar pattern. However, a couple of remarks are in order. Increases and decreases in the variables presented are larger under the only working capital scenario but these results must be taken with caution, as the only land scenario could not be implemented as intended since the model could not accommodate the required shock.⁶ There are no changes between the only capital scenario under the even distribution of subsidies and the targeted distribution. In both cases, the capital subsidy is “capitalized” into capital rents, only that, in the last case, capitalization accrues only to the targeted zones (with increases in a range between 12.5% and 208.6% for individual activities). This implies that no targeting is effective in terms of generating changes in value added or labor market behavior under this scenario.

Under the all subsidies (targeted) scenario, the distribution of the quantum of agricultural production among zones shifts in favor of the targeted zones, but the

⁶ Under this scenario, the total subsidy amount is only a third of what it is under the only working capital and only capital scenarios, since the model becomes infeasible for the equations modeling land behavior for very high and high incidence zones. It is important to note that under the all subsidies scenario, the subsidy amount is the same as for the even distribution of subsidies scenario, so they are fully comparable.

changes arising from it are relatively small as shown in table 8. The share of very high incidence zones increases almost two percentage points, while that of high incidence zones increases slightly more than two percentage points. The shares of the rest of zones decrease 1.4 percentage points in average, with the largest decrease affecting the medium low zone (2.1 percentage points). Total agricultural output increases 0.37%.

Table 8. Zones' shares in agricultural production quantum

Zone	Scenario:	
	Base	All subsidies (targeted)
Very high	8.8%	10.6%
High	11.0%	13.2%
Medium	17.1%	16.1%
Medium low	41.3%	39.2%
Low	21.8%	20.8%

Source: model simulation.

With respect to the commodity composition of agricultural production (under the same scenario), the results basically show no change (as the commodity portfolio of all zones does not show very large variation, as illustrated in section 2). Most changes situate at the second decimal figure level.

As for the composition of factor income generated in the sector, the share of wages as a whole decreases slightly, as presented in table 9, affecting both wages for unskilled and skilled labor. The share of capital rents increases 0.3 percentage points (an outcome arising from the share of subsidies allocated to capital use) and the share of land rents decreases 0.1 percentage points. Therefore, although there is some movement in this regard, the structure of income generation for the sector as a whole remains largely untouched.

Table 9. Composition of factor income in the agricultural sector under the all subsidies targeted scenario

Factor income	Shares in scenario:		Real percentage change
	Base	All subsidies	
Wages unskilled	71.78%	71.62%	0.564
Wages skilled	11.68%	11.66%	0.560
Capital rents	6.08%	6.38%	5.907
Land rents	10.46%	10.34%	-0.394

Source: model simulation.

Lastly, in real terms income arising from unskilled and skilled wages increase 0.56%, income arising from capital rents increases 5.9%, and income arising from land rents decreases 0.4%, so even though the structure of income generation is preserved, there are potentially important distributive consequences depending on the income generation structure at the household level.

5. Conclusions

This research evaluates the effects of targeting current agricultural policy instruments to zones highly affected by the armed conflict in Colombia, as a way to appraise their power to aid in enhancing agricultural activity and income generation capability in these zones. A static computable general equilibrium model is used for this purpose, running on an agricultural specialized 2014 SAM. The main results indicate that the size of current agricultural subsidies lead to negligible macro effects on the economy, and that even at the sectoral level their impact, when evenly distributed among the main policy instruments, is quite limited.

When subsidies are concentrated on working capital and evenly distributed among zones, they increase both value added quantum and value for all agricultural zones, slightly favoring the ones most affected by the armed conflict. When they concentrate on productive capital, given in the model it is assumed that capital is sector specific, there are zone-wise decreases in value added value and quantum, as the subsidy mostly gets capitalized in capital rents; therefore, the impact of this instrument is highly dependent on the actual behavior of investment (if no additional capital is used in the sector, as assumed in the simulation, the subsidy is basically useless). When subsidies concentrate on land management (irrigation and drainage, mainly), the largest effects are attained on value added quantum, but value added value decreases essentially due to a fall in land rents. As subsidies are distributed among policy instruments a particular combination of the results just discussed ensues.

In the case of interest for this research, when subsidies are targeted to the zones most affected by the armed conflict and are evenly distributed among policy instruments, significant increases are obtained in terms of value added (both in the value and quantum dimensions -in the order of 21%) for the targeted zones, and negative outcomes arise for the rest of zones (in the order of 5.4%), as they lose “competitiveness”. This targeting leads to relatively minor changes in the zone-composition of agricultural output (the targeted zones increasing their share in the order of 2% and the rest decreasing in the order of 1.4%), and is neutral with respect to the commodity composition of agricultural output. Furthermore, the composition of sectoral factor income changes slightly, favoring capital rents against land rents and wages for skilled and unskilled labor (even though, both labor types moderately gain in the absolute level of factor income generated).

There are several policy implications arising from these results. First, there is indeed the potential for current policy instruments and the financial resources allocated to them, to have a significant positive impact on the agricultural zones most affected by the armed conflict, if they are specifically targeted by these policies. However, complete targeting on them would imply imposing negative effects on the rest of agricultural zones and, therefore, policy design should be careful in devising the right targeting level so as to avoid harming other (also in need) producing zones. Second, priority should be given to the policies with the best potential to deliver positive outcomes, such as land subsidies that entail a productivity enhancing effect. Third, attention should be given to the behavior of agricultural investment in these zones, as the lack of it in the face of policies that subsidize its use may result in a transfer to capital rents with possible

negative distributive effects and almost no productive effect. Fourth, there potentially are significant effects from the policy on factor income generation that may be important at the rural households level, given their composition of factor income (in particular, households most dependent on wage income could benefit the less from the policies). Hence, policy implementation should judiciously consider regionally or locally monitoring the evolution of factor markets and the implementation of complementary policy interventions aimed at ameliorating undesirable distributive outcomes.

References

- Arias, M.A., A.M. Ibañez, and A. Zambrano. 2017. Agricultural Production Amid Conflict: Separating the Effects of Conflict into Shocks and Uncertainty. Households in Conflict Network, Working Paper 245, March.
- CONPES. 2014. Documento CONPES 3810. Política Para el Suministro de agua potable y saneamiento básico en la zona rural, Republic of Colombia, August.
- CONPES. 2016. Documento CONPES 3867. Estrategia de preparación institucional para la paz y el posconflicto, Republic of Colombia, September.
- CONPES. 2018. Documento CONPES 3932. Lineamientos para la articulación del Plan Marco de Implementación del Acuerdo Final con los instrumentos de planeación, programación y seguimiento a políticas públicas del orden nacional y territorial, Republic of Colombia, June.
- DFID. 2005. Post-Conflict Agricultural Rehabilitation: Linking Social Protection, Livelihood Promotion and Humanitarianism, DFID-European Commission, London.
- Kimenyi, M., J. Adibe, M. Djire, A. Jirqi, A. Kergna, T. Deressa, J. Pugliese, and A. Westbury. 2014. The Impact of Conflict and Political Instability on Agricultural Investments in Mali and Nigeria, Africa Growth Initiative Working Paper 17, Brookings Institution.
- Ksoll, C., R. Macchiavello, and A. Morjaria. 2010. The Effect of Ethnic Violence on an Export-Oriented Industry. CEPR Discussion Paper 8074. Washington.
- Longley, C. I. Christoplos, and T. Slaymaker. 2006. Agricultural Rehabilitation. Mapping the Linkages Between Humanitarian Relief, Social Protection, and Development, Humanitarian Policy Group Report 22, April.
- MADR. 2018. Memorias al Congreso de la República 2014-2018. Por un campo productivo y moderno, que siembra, se transforma y vende. Gobierno de Colombia.
- Messer, E., M. Cohen, and J. D'Acosta. 1998. Food from Peace: Breaking the Links Between Conflict and Hunger. Food, Agriculture, and the Environment Discussion Paper 24, IFPRI, Washington.
- Morales, I. 2017. Peace and Environmental Protection in Colombia. Proposals for Sustainable Rural Development, The Inter-American Dialogue, January.
- Niño, G. 2018. Agricultura en el posconflicto: evaluación del efecto del acuerdo de Santa Fé de Ralito (2003-2006) en la agricultura lícita e ilícita. Master Thesis Universidad de los Andes.
- Ospina, V. 2019. Efectos del conflicto armado en las decisiones de producción en el área rural: evidencia para Colombia.
- Rockmore, M. 2015. Conflict and Agricultural Portfolios: Evidence from Northern Uganda. Mimeo. Cornell University.

Appendix

A. Implementation of agricultural production

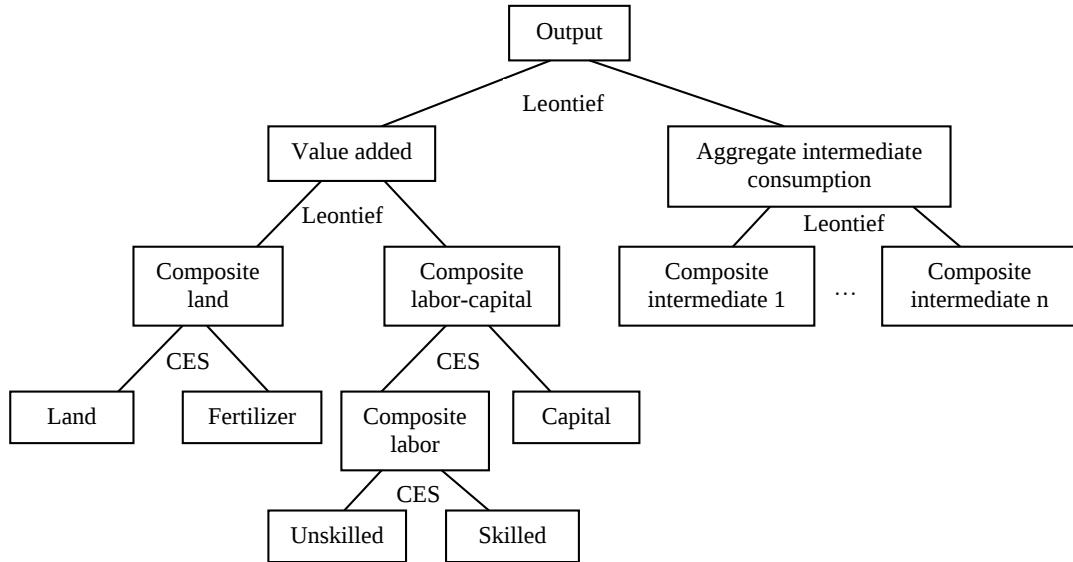


Figure A.1. Structure of Agricultural Activities

B. Implementation of Supply of Land Services

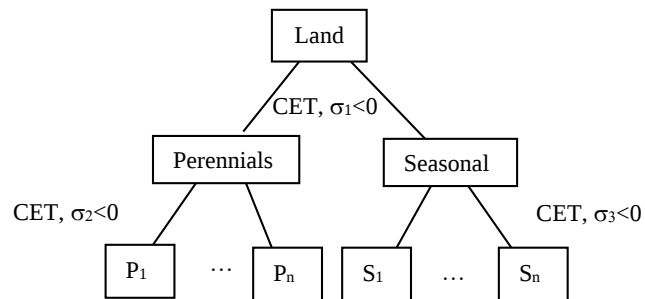


Figure A.2. Structure of Supply of Land Services

Table A.1 Implementation of agricultural production, supply of land services, and policy shocks

Implementation of agricultural production	
$VA_{jag} = v_{jag} * XST_{jag}$	(1)
$CI_{jag} = io_{jag} * XST_{jag}$	(2)
$CT_{jag} = ioct_{jag} * VA_{jag}$	(3)
$CK_{jag} = iock_{jag} * VA_{jag}$	(4)
$CT_{jag} = B_{jag}^{CT} \left[\beta_{jag}^{CT} TD_{jag}^{-\rho_{jag}^{CT}} + (1 - \beta_{jag}^{CT}) FD_{jag}^{-\rho_{jag}^{CT}} \right] \rho_{jag}^{\frac{-1}{CT}}$	(5)
$TD_{jag} = \left[\frac{\beta_{jag}^{CT} RTC_{jag}}{RTT_{jag}} \right]^{\sigma_{jag}^{CT}} (B_{jag}^{CT})^{\sigma_{jag}^{CT}-1} CT_{jag}$	(6)
$FD_{jag} = \left[\frac{(1 - \beta_{jag}^{CT}) RTC_{jag}}{PC_{fert}} \right]^{\sigma_{jag}^{CT}} (B_{jag}^{CT})^{\sigma_{jag}^{CT}-1} CT_{jag}$	(7)
$\rho_{jag}^{CT} = \frac{1 - \sigma_{jag}^{CT}}{\sigma_{jag}^{CT}}$	(8)
$CK_{jag} = B_{jag}^{CK} \left[\beta_{jag}^{CK} LDC_{jag}^{-\rho_{jag}^{CK}} + (1 - \beta_{jag}^{CK}) KDC_{jag}^{-\rho_{jag}^{CK}} \right] \rho_{jag}^{\frac{-1}{CK}}$	(9)
$LDC_{jag} = \left[\frac{\beta_{jag}^{CK} RC_{jag}}{1 - \beta_{jag}^{CK} WC_{jag}} \right]^{\sigma_{jag}^{CK}} KDC_{jag}$	(10)
$KDC_{jag} = B_{jag}^{KD} \left[\sum_k \beta_{k,jag}^{KD} KD_{k,jag}^{-\rho_{jag}^{KD}} \right] \rho_{jag}^{\frac{-1}{KD}}$	(11)
$KD_{k,jag} = \left[\frac{\beta_{k,jag}^{KD} RC_{jag}}{RTI_{k,jag}} \right]^{\sigma_{jag}^{KD}} (B_{jag}^{KD})^{\sigma_{jag}^{KD}-1} KDC_{jag}$	(12)
$LDC_{jag} = B_{jag}^{LD} \left[\sum_l \beta_{l,jag}^{LD} LD_{l,jag}^{-\rho_{jag}^{LD}} \right] \rho_{jag}^{\frac{-1}{LD}}$	(13)
$LD_{l,jag} = \left[\frac{\beta_{l,jag}^{LD} WC_{jag}}{WTI_{l,jag}} \right]^{\sigma_{jag}^{LD}} (B_{jag}^{LD})^{\sigma_{jag}^{LD}-1} LDC_{jag}$	(14)
$\rho_{jag}^{CK} = \frac{1 - \sigma_{jag}^{CK}}{\sigma_{jag}^{CK}}$	(15)
$\rho_{jag}^{KD} = \frac{1 - \sigma_{jag}^{KD}}{\sigma_{jag}^{KD}}$	(16)
$\rho_{jag}^{LD} = \frac{1 - \sigma_{jag}^{LD}}{\sigma_{jag}^{LD}}$	(17)
$DI_{i,jag} = aija_{i,jag} * CI_{jag}$	(18)

$RTC_{jag} = \frac{RTT_{jag} * TD_{jag} + PC_{fert,jag} * FD_{jag}}{CT_j}$	(19)
$RCK_{jag} = \frac{WC_{jag} * LDC_{jag} + RC_{jag} * KDC_{jag}}{CK_{jag}}$	(20)
$PVA_{jag} = \frac{RTC_{jag} * TC_{jag} + RCK_{jag} * CK_{jag}}{VA_{jag}}$	(21)
$WC_{jag} = \frac{\sum_l (WTl_{l,jag} * LD_{l,jag})}{LDC_{jag}}$	(22)
Implementation of Supply of Land Services	
$TS = B^{LS} [\beta^{LS} TSP \rho^{LS} + (1 - \beta^{LS}) TSS \rho^{LS}]^{\frac{1}{\rho^{LS}}}$	(23)
$TSS = \left[\frac{\beta^{LS}}{1 - \beta^{LS}} \frac{RTTP}{RTTS} \right]^{\sigma^{LS}} TSP$	(24)
$\rho^{LS} = \frac{1 + \sigma^{LS}}{\sigma^{LS}}$	(25)
$TSP = B^{TSP} \left[\sum_{j=perennial} \beta_j^{TSP} TSP J_j^{\rho^{TSP}} \right]^{\frac{1}{\rho^{TSP}}}$	(26)
$TSP J_j = \frac{TSP}{(B^{TSP})^{(1+\sigma^{TSP})}} \left[\frac{RTT_j}{\beta_j^{TSP} RTTP} \right]^{\sigma^{TSP}}$	(27)
$TSP J_j = TD_j$	(28)
$\rho^{TSP} = \frac{1 + \sigma^{TSP}}{\sigma^{TSP}}$	(29)
$TSS = B^{TSS} \left[\sum_{j=seasonal} \beta_j^{TSS} TSS J_j^{\rho^{TSS}} \right]^{\frac{1}{\rho^{TSS}}}$	(30)
$TSS J_j = \frac{TSS}{(B^{TSS})^{(1+\sigma^{TSS})}} \left[\frac{RTT_j}{\beta_j^{TSS} RTTS} \right]^{\sigma^{TSS}}$	(31)
$TSS J_j = TD_j$	(32)
$\rho^{TSS} = \frac{1 + \sigma^{TSS}}{\sigma^{TSS}}$	(33)
$RTTP = \frac{\sum_{j=perennial} RTT_j TSP_j}{TSP}$	(34)
$RTTS = \frac{\sum_{j=seasonal} RTT_j TSS_j}{TSS}$	(35)
Implementation of Subsidized Credit for Working Capital	
$SWK_j = \frac{gswk_j}{(PP_j * XST_j)}$	(36)
$PT_j = (1 + ttip_j) * (1 - SWK_j) * PP_j$	(37)
$TIP_j = ttip_j * (1 - SWK_j) * PP_j * XST_j$	(38)

$SG = YG - \sum_{agng} TR_{agng,gvt} - G - \sum_j (SWK_j * PP_j * XST_j)$	(39)
Implementation of Subsidized Credit for Productive Capital	
$SKD_{k,j} = \frac{gskd_{k,j}}{KD_{k,j}}$	(40)
$TIK_{k,j} = ttik_{k,j} * R_{k,j} * KD_{k,j} * SKD_{k,j}$	(41)
$SG = YG - \sum_{agng} TR_{agng,gvt} - G - \sum_k \sum_j (R_{k,j} * SKD_{k,j} * KD_{k,j})$	(42)
$RTI_{k,j} = R_{k,j} * (1 + ttik_{k,j}) * (1 - SKD_{k,j})$	(43)
Implementation of Subsidized Credit for Land Improvements and Irrigation	
$tdi_j = \frac{gsti_j}{iuc}$	(44)
$tdie_j = tdi_j * ygap$	(45)
$STI_j = (tdi_j / TD_j) * tsub_j$	(46)
$CTPF_j = \left(\frac{tdie_j}{TD_j} \right) + 1$	(47)
$CT_j = CTPF_j * B_j^{CT} \left[\beta_j^{CT} TD_j^{-\rho_j^{CT}} + (1 - \beta_j^{CT}) FD_j^{-\rho_j^{CT}} \right]^{\frac{-1}{\rho_j^{CT}}}$	(48)
$SG = YG - \sum_{agng} TR_{agng,gvt} - G - \sum_j (RTT_{jag} * STI_{jag} * TD_{jag})$	(49)
$TD_j = \left\{ \left[\frac{\beta_j^{CT}}{1 - \beta_j^{CT}} \right] * \left[\frac{PC_{fert}}{(RTT_j * (1 - STI_j))} \right] \right\}^{\sigma_j^{CT}} * FD_j$	(50)
$RTC_j = \frac{[RTT_j * (1 - STI_j)] * TD_j + PC_{fert} * FD_j}{CT_j}$	(51)
Implementation of Mechanism for Raising AIS' Funding	
$DTAIS = \frac{AISEXP}{[\sum_f YFK_f + \sum_h YH_h]}$	(52)
$TDH_h = PIXCON^n * ttdh0_h + [ttdh1_h + DTAIS] * YH_h$	(53)
$TDF_f = PIXCON^n * ttdf0_f + [ttdf1_f + DTAIS] * YFK_f$	(54)

List of variables, parameters, and coefficients

B^{LS} = scale parameter (CET – total supply of land)
 B^{TSP} = scale parameter (CET – supply of land for perennial crops)
 B^{TSS} = scale parameter (CET – supply of land for seasonal crops)
 B_{jag}^{CK} = scale parameter (CES – composite labor – capital)
 B_{jag}^{CT} = scale parameter (CES – composite land)
 B_{jag}^{KD} = scale parameter (CES – composite capital)
 B_{jag}^{LD} = scale parameter (CES – composite labor)
 $AISEXP$ = total expending on subsidies
 CI_{jag} = total intermediate consumption of agricultural activity j

CK_{jag} = composite labor – capital used in agricultural activity j
 $CTPF_j$ = composite irrigated land productivity factor in activity j
 CT_{jag} = composite land used in agricultural activity j
 DD_m = domestic demand for domestically produced good m
 DD_{nm} = domestic demand for domestically produced good nm
 $DI_{i,jag}$ = demand for composite intermediate i by ag. activity j
 $DTAIS$ = direct tax rate for financing policy instruments
 $EX_{j,x}$ = quantity exported of good x by activity j
 FD_{jag} = demand for fertilizer by agricultural activity j
 G = current government expenditure on goods and services
 IM_m = quantity imported of good m
 KDC_{jag} = demand for composite capital by agricultural activity j
 $KD_{k,jag}$ = demand for type k capital in ag activity j
 LDC_{jag} = demand for composite labor by agricultural activity j
 $LD_{l,jag}$ = demand for type l labor in ag activity j
 PC_{fert} = price of composite fertilizer
 PC_i = purchaser price of good i
 PD_m = price of local product m sold on the domestic market
 PD_{nm} = price of local product nm sold on the domestic market
 PE_{FOB_x} = fob price of exported good x
 PE_x = price received for exported good x
 $PIXCON$ = consumer price index
 PL_m = price of local good m
 PL_{nm} = price of local good nm
 PM_m = price of imported product m
 PP_j = activity j unit cost
 PT_j = basic price of industry j 's output
 PWM_m = world price of imported good m
 RCK_j = rental rate of composite labor – capital in ag. activity j
 RC_{jag} = rental rate of composite capital in ag. activity j
 RTC_{jag} = rental rate of composite land in ag. activity j
 RTI_{jag} = rental rate of type k capital in ag. activity j
 RTT_j = rental rate of land paid by perennial crop j
 $RTTP$ = composite rental rate of land paid by perennial crops
 $RTTS$ = composite rental rate of land paid by seasonal crops
 RTT_j = rental rate of land paid by seasonal crop j
 RTT_{jag} = rental rate of land in ag. activity j
 $R_{k,j}$ = rental rate of capital k in activity j
 SG = government savings
 $SKD_{k,j}$ = rate of subsidy for capital k used in activity j
 $SSMM_{i,m}$ = rate of subsidy for good m on good i 's margin
 $SSNM_{i,nm}$ = rate of subsidy for good nm on good i 's margin
 $SSMX_{i,x}$ = rate of subsidy for good x on good i 's margin
 STI_j = subsidy rate on land rent due to irrigation subsidies in activity j
 SWK_j = rate of subsidy for working capital for activity j
 TDF_f = income taxes of type f firms
 TDH_h = income taxes of type h households

TD_{jag} = demand for land by agricultural activity j
 TIC_m = government revenue from indirect taxes on good m
 TIC_{nm} = government revenue from indirect taxes on good nm
 $TIK_{k,j}$ = government revenue from taxes on capital k used in activity j
 TIP_j = government revenue from taxes on industry j 's production
 TIx_x = government revenue from indirect taxes on good x
 $TR_{agng,govt}$ = governmental transfers to non governmental agents
 TS = total supply of agricultural land
 TSP = aggregate supply of land for perennial crops
 TSS = aggregate supply of land for seasonal crops
 TSP_j = supply of land for perennial crop j
 TSS_j = supply of land for seasonal crop j
 VA_{jag} = value added of agricultural activity j
 WC_{jag} = wage rate of composite labor in ag. activity j
 $WTl_{l,jag}$ = wage rate paid to type l labor in ag activity j
 XD_x = total quantity exported of good x
 XST_j = total aggregate output of activity j
 XST_{jag} = total aggregate output of agricultural activity j
 YFK_f = capital income of type f firms
 YH_h = total income of type h households
 YG = total government income
 $aij_{i,jag}$ = input – output coefficient
 $gscm_{i,m}$ = total expending on subsidy for good m on good i 's margin
 $gscm_{i,nm}$ = total expending on subsidy for good nm on good i 's margin
 $gscmx_{i,x}$ = total expending on subsidy for good x on good i 's margin
 $gskd_{k,j}$ = total amount of subsidy on capital k for activity j
 $gsti_j$ = total amount of subsidy for land improvements in activity j
 $gswk_j$ = total amount of subsidy for working capital for activity j
 $iock_{jag}$ = coefficient (Leontief – composite labor – capital)
 $ioct_{jag}$ = coefficient (Leontief – composite land)
 io_{jag} = coefficient (Leontief – intermediate consumption)
 $qgscm_{i,m}$ = quantity equivalent of subsidy for good m on good i 's margin
 $qgscm_{i,nm}$ = quantity equivalent of subsidy for good nm on good i 's margin
 $qgscm_{i,x}$ = quantity equivalent of subsidy for good x on good i 's margin
 $tdie_j$ = irrigated land in non – irrigated equivalent land in activity j
 tdi_j = newly irrigated land in activity j
 $tmr_{i,m}$ = rate of margin i applied to good m
 $tmr_{i,nm}$ = rate of margin i applied to good nm
 $tmr_{i,x}$ = rate of margin i applied to good x
 $tsub_{jag}$ = subsidy rate on the value of irrigation projects i activity j
 $ttdh0_h$ = intercept (income taxes of type h households)
 $ttdh1_h$ = marginal income tax rate of type h households
 $ttdf0_f$ = intercept (income taxes of type f firms)
 $ttdf1_f$ = marginal income tax rate of type f firms
 $ttic_m$ = tax rate on good m
 $ttic_{nm}$ = tax rate on good nm

$ttik_{k,j}$ = tax rate on capital k used in industry j
 $ttim_m$ = tax and duties rate on imports of good m
 $ttip_j$ = tax rate on the production of activity j
 $ttix_x$ = export tax rate on good x
 v_{jag} = coefficient (Leontief – value added)
 $ygap_j$ = average yield gap between irrigated and non
 – irrigated land in activity j
 iuc = cost to government of a hectare of irrigated land
 m = imported good, $m \in I$
 n = price elasticity of indexed transfers and parameters
 nm = non imported good, $nm \in I$
 x = non imported good, $x \in I$
 β^{LS} = share parameter (CET – total supply of land)
 β_j^{TSP} = share parameter (CET – supply of land for perennial crops)
 β_j^{TSS} = share parameter (CET – supply of land for seasonal crops)
 β_{jag}^{CK} = share parameter (CES – composite labor – capital)
 β_{jag}^{CT} = share parameter (CES – composite land)
 $\beta_{l,jag}^{KD}$ = share parameter (CES – composite capital)
 $\beta_{l,jag}^{LD}$ = share parameter (CES – composite labor)
 ρ^{LS} = elasticity parameter (CET – total supply of land); $1 < \rho^{LS} < \infty$
 ρ^{TSP} = elasticity parameter (CET – supply of land for perennial crops); 1
 $< \rho^{TSP} < \infty$
 ρ^{TSS} = elasticity parameter (CET – supply of land for seasonal crops); 1
 $< \rho^{TSS} < \infty$
 ρ_{jag}^{CK} = elasticity parameter (CES – composite labor – capital); $-1 < \rho_j^{CT} < \infty$
 ρ_{jag}^{CT} = elasticity parameter (CES – composite land); $-1 < \rho_{jag}^{CT} < \infty$
 ρ_{jag}^{KD} = elasticity parameter (CES – composite capital); $-1 < \rho_{jag}^{KD} < \infty$
 ρ_{jag}^{LD} = elasticity parameter (CES – composite labor); $-1 < \rho_j^{CLD} < \infty$
 σ^{LS} = elasticity of substitution (CET – total supply of land); $0 < \sigma^{LS} < \infty$
 σ^{TSP} = elasticity of substitution (CET
 – supply of land for perennial crops); $0 < \sigma^{TSP} < \infty$
 σ^{TSS} = elasticity of substitution (CET – supply of land for seasonal crops); 0
 $< \sigma^{TSS} < \infty$
 σ_{jag}^{CK} = elasticity of substitution (CES – composite labor – capital); $0 < \sigma_{jag}^{CK}$
 $< \infty$
 σ_{jag}^{CT} = elasticity of substitution (CES – composite land); $0 < \sigma_{jag}^{CT} < 1$
 σ_{jag}^{KD} = elasticity of substitution (CES – composite capital); $0 < \sigma_{jag}^{KD} < \infty$
 σ_{jag}^{LD} = elasticity of substitution (CES – composite labor – capital); $0 < \sigma_{jag}^{LD}$
 $< \infty$