working paper
2012-06

Poverty impacts of agricultural policy adjustments in an opening economy:
the case of Colombia

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August 2012

partnership for economic policy
pep

Abstract

We aim to assess the sectoral and poverty impacts of changes in agricultural policy in Colombia on the rural sector. For this we use an agriculture specialized static CGE model, together with a microsimulation model that allows employment to shift between sectors. The results indicate that the sectoral impact of the implemented program tends to be small and varies considerably across crops. Also, while it does reduce poverty, these impacts are small and tend to be concentrated in rural households toward the middle of the household income distribution.

Keywords: Agricultural policy, Rural poverty, Computable General Equilibrium, Microsimulation, Colombia

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Acknowledgements

This work was carried out with financial and technical support from the Partnership for Economic Policy (PEP), which is financed by the Australian Agency for International Development (AusAID) and the Government of Canada through the International Development Research Centre (IDRC) and the Canadian International Development Agency (CIDA). In particular, the authors wish to aknowledge the valuable help and comments provided by Bernard Decaluwé, Veronique Robichaud, Ismaël Fofana, Martin Cicowiez, David Laborde, Antoine Bouet, an anonymous referee, other PEP resource persons and participants at the 8th General PEP Meeting.

1. Introduction

During negotiation of a free trade agreement between Colombia and the United States, the government agreed, with representatives of agricultural producers, to design and operate a program to compensate the losers of the agreement and to enhance sectoral competiveness. A program was launched to these ends in April of 2007 and was given substantial operational resources. This policy package appears to reinforce a policy trend in Colombia toward increased transfers to agricultural producers. In fact, a World Bank study (2008) shows that Colombia has the highest level of transfers per person engaged in agriculture among the eight Latin American economies studied.

Given the level of resources deployed, the policy can be expected to have non-negligible effects on agricultural production and rural poverty reduction. As in other countries, Colombia has high and persistent poverty in the rural sector, and rural poverty has historically been higher than urban poverty.

The goal of this article is to estimate the anticipated short run effects of this program at both the sectoral and micro levels. At the macro level, we want to evaluate the impact of this new agricultural policy on relative prices of goods, quantities produced, employment by sector and real factor returns. At the micro level, we want to assess induced changes in rural households' income and on the incidence of poverty.

We use an integrated top-down macro-micro approach to carry this out. First, we estimate macro changes using an agriculture specialized static computable general equilibrium model. Then, we run outputs from the macro model into a non-standard behavioral microsimulation model that can be used to compute changes in the income of rural households and to measure their poverty status.

The structure of the report is as follows. Section 2 provides the general policy context of the policy changes. Then, in section 3, a general description of the design and implementation of the policy package is provided. Section 4 presents the research objectives and methods, including a technical description of the main characteristics of the CGE model, as well as a general description of the microsimulation model. We present a general description of the relevant characteristics of Colombian agriculture and rural poverty to support our interpretation of the results in section 5. Section 6 presents and discusses the main results and section 7 concludes the paper.

2. Policy background

According to the World Bank (2008), Colombia has made the shift from taxing to supporting agriculture. During the 1960s and up to the end of the 1970s, the nominal rate of assistance to agriculture was negative. It became positive during the 1980s, averaging 5% in the first half of the decade and 0.2% in the second half. The 1990s marked the beginning of a period of rising agricultural assistance: from 8.2% in the first half of the 1990s and 13.2% in the second half, to 25.9% in the first half of the 2000s. Most of this support was provided through border measures such as tariffs, quotas and administrative restrictions, while direct assistance on the domestic market was almost negligible. This stands in contrast with the behavior of the other Latin American countries included in the World Bank study. Although some countries (Brazil, Dominican Republic and Ecuador) have also shifted from overall taxation to protection in the agricultural sector, Colombia stands out in both the precocity and size of its supports. Even countries that have traditionally protected the agricultural sector, like Chile, have been generally decreasing assistance levels.

Within this context, and given the recently negotiated free trade agreement (FTA) with the United States, the Colombian government agreed with farmers' organizations that a policy package would be designed and implemented to smooth out the impact of the FTA implementation period and to boost sectoral competitiveness. As the agricultural sector was deemed to be one of the losers from the agreement, farmers' organizations tend to either oppose its implementation or seek special treatment in terms of longer implementation periods or limited market access provisions. According to official statements to the press at the time of negotiations between the government and sector representatives, the policy package was agreed upon as a way to compensate those who lost out under the agreement. Announced in March 2006, the program, named Agriculture, Secure Income (AIS according to its Spanish language acronym), was put in place in April 2007 with the signing of a law that laid out the general principles and allocated a budget to it.[1] The program was assigned a budget of around US$217 million in 2007, or about 35% of that year's total public sectoral budget (excluding debt service charges). By law, the budget assigned to the project must maintain its real value, so it was indexed to the consumer price index. Although the size of the program is modest in relative terms (around 2.3% of sectoral GDP) it is by far the largest sectoral policy instrument in Colombia.

AIS has a relatively complex structure. The two main components of this program target

[1] Law 1133 (2007).

different objectives. One of them is the direct provision of income support to protect farmers during the implementation period of the FTA with the US (Sectoral Direct Support Component, SDSC). The other aims to make the agricultural sector more competitive through increased productivity and help to launch restructuring processes (Competitiveness Enhancement Component, CEC). Each component addresses a specific objective assigned to the program at its inception. Direct support is unconditionally provided to farmers and is to be selective and temporary. The government is to “objectively” determine the eligible subsectors for this type of support, the amount of support to be given to each subsector, and the conditions that beneficiaries must fulfill. It was also established that all direct support measures should have been phased out after six years of program operation. Measures to enhance competitiveness are also an important part of the program and should thus be allocated no less than 40% of the program's total budget, and the government commits to prioritizing departments (equivalent to a state or province in many other countries) that appear to lag in terms of productivity and competitiveness indices, while ensuring an equitable regional distribution of resources from the program.

Each of these components is set up differently. CEC has three main 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 cofinancing. Subsidized credit is devoted to productive restructuring, land adequation, improved productivity and new investment towards agricultural modernization. The marketing support aspect of this program aims to support the development of traceability systems, domestic absorption mechanisms and other supplementary activities.

This set of instruments is basically channeled through nine subprograms. For our purposes, the most important of these are: the Special Credit Line (SCL), the Incentive for Rural Capitalization (IRC), and the Call for Irrigation and Drainage Projects (CID).[2] The SCL is a subsidized credit scheme that supports productivity improvements and restructuring (shifts between agricultural subsectors) through the financial system. Credit through the SCL has been offered under various conditions over the years, but has tended to be at a significantly lower interest rate than on private markets (generally between 5 to 12 percentage points lower, depending on the type of farmer and the year). Small farmers tend to use this credit to carry out

[2] The other subprograms are the: Incentive for Technical Assistance, Livestock, Sanitation, Coffee Extension Service, Forestry Incentive Certificate, Science and Technology, and a fertilizer program (Fertifuturo).

activities related to planting and maintaining crops, while large-scale farmers use it to acquire machinery to engage in primary transformation of products. Medium size farmers tend to be the main beneficiaries of this scheme (as indicated by their share of total program disbursements) and devote their resources to planting and maintenance of crops and to land adequation.

The IRC is intended to facilitate agricultural investment by offering a line of credit that operates at market interest rates but that includes some financing (credit and interest) forgiveness. The IRC existed before the AIS was established, but the AIS now uses the IRC to distribute some of its resources. It has also expanded the set of activities that are eligible beyond those targeted by the original IRC. The provisions state that small producers are forgiven 40% of credit devoted to activities on an eligibility list. Medium size and large farmers are forgiven 20% subject to some exceptions (depending on the activities carried out). In the case of construction, enlargement or rehabilitation of large irrigation projects, forgiveness is 40% for all farm sizes, and there are no limits to the size of the incentive.[3] The list of eligible activities includes land adequation and water management; productive infrastructure; biotechnology development and application; machinery and equipment for agricultural production; livestock and aquaculture equipment; low technology fishing; primary transformation of agricultural goods; planting, maintenance, and renewal of perennial crops; acquisition of pure breed bovine livestock; implementation of integrated livestock and forestry projects; and investment in generic agricultural inputs.

The CID is a subprogram 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 allocated on a competitive basis. Beneficiaries must have prepared a proposal, including an economic evaluation, and entered a competitive process to determine who gains access to the funds.[4]

Lastly, the SDSC operates through some of the same subprograms used by the CEC, notably the SCL and the IRC. As mentioned above, a difference here is that funds from this component target specific sectors according to a government valuation. The other difference is

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[3] Some of these conditions change from time to time.

[4] This program is the main reason that the AIS has been criticized, since large farmers have been better positioned to present good proposals than small farmers. Furthermore, large farmers fragment their projects, effectively violating the ceilings imposed on subsidy amounts, allowing them to illegally access a major share of resources dedicated to this component of the program.

that the level of the subsidy is higher in this case. Credit forgiveness for medium- and large-scale farmers benefiting from IRC are higher than under the previous arrangement, for instance (30% compared to 20% under the CEC). In 2007, all resources from this component were directed to cereals and rice and were disbursed in similar proportions to the SCL and IRC (44% and 56% on average). In 2009, this component of the program prioritized the cut flowers sector (for social and environmental purposes), planting of corn for feedstock purposes and the planting of beans in coffee growing areas.

Despite the fact that negotiations for the FTA with the US ended in November 2006, and that the treaty was only approved by the US Congress in October 2011 (which means that implementation could only begin in 2012 at earliest), the AIS came into force in 2007 and has been in place since then.[5] To accommodate the fact that the trade pact was not in place and that there was therefore only a weak basis for implementation of the SDSC, the government determined that 72% of the budget should be allocated to the CEC, 26% to the SDSC, and the other 2% went to program administration. This prioritization of the CEC has continued in recent years.[6]

3. Implementation of AIS

Between 2007 and 2009, the program disbursed a total of around US$704 million, 91% of which was devoted to the CEC. As mentioned in the program evaluation that was contracted by the Ministry of Agriculture (Econometria, 2011), the majority of resources were used by four sub-programs: the Special Credit Line (SCL), the Incentive for Rural Capitalization (IRC), the Incentive for Technical Assistance (ITA) and the Call for Irrigation and Drainage Projects (CID). The baseline and the Econometria evaluation itself were limited to these four subprograms.[7]

All subprograms aside from the SCL, the IRC and the CID are expected to yield results that are difficult to accurately evaluate, particularly with a CGE model. For instance, technical assistance (such as through the ITA and the Coffee Extension Service) is expected to raise yields through improved production techniques, promotion of pest and insect control, and better use of inputs. However, the extent to which yields may increase is uncertain and a priori

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[5] In 2009, the program came under fire when a misallocation of resources was made public by the press. With a new government in power, the program was rebranded as Equitable Rural Development (DRE for its acronym in Spanish) in 2011. Large-scale farmers were denied access to the DRE and small operational changes were introduced. Its basic structure, organization and use of policy instruments continue to be the same.

[6] The 2008 budget allocations were: 93.6% to CEC, 5.2% to SDSC and 1.2% for administrative costs.

[7] The methodology used in this evaluation follows the general procedures of an econometric program evaluation.

estimates may be lacking. Therefore, we only use the CGE model here to estimate the expected impacts of the three subprograms mentioned above.

Despite the institutional complexity of AIS (two components, eleven subprograms, different access rules and subsidy levels for each potential subprogram-component-beneficiary combination), the situation is actually fairly straightforward when looking at the economic incentives it creates for farmers. Table 1 provides a simplified list of the main activities that were financed in 2008 through the three subprograms we consider here and also groups them by the type of incentive that they create.[8]

Table 1. Incentives created by the program

Subprogram	Item	Activity	Effect	Incentive
SCL	Working capital	N.A.	Subsidy on working capital	Lower unit cost
	Investment	Productive infrastructure	Capital subsidy	Lower capital cost
		Primary processing and marketing	Capital subsidy	Lower capital cost
		Machinery and equipment	Capital subsidy	Lower capital cost
		Land adaptation	Capital subsidy	Lower capital cost
		Planting and crop maintenance	Subsidy on working capital	Lower unit cost
		Agricultural production	Subsidy on working capital	Lower unit cost
		Crop maintenance	Subsidy on working capital	Lower unit cost
		Livestock acquisition	Excluded from study	N.A.
		Support services infrastructure	Excluded from study	N.A.
		Livestock maintenance	Excluded from study	N.A.
	Credit refinancing		Excluded from study	N.A.
IRC	N.A.	Agricultural machinery	Capital subsidy	Lower capital cost
		Production infrastructure	Capital subsidy	Lower capital cost
		Planting of late yield perennials	Capital subsidy	Lower capital cost
		Land adaptation	Land subsidy	Lower land cost
		Primary processing	Capital subsidy	Lower capital cost
		Pure breed livestock acquisition	Excluded from the study	N.A.

[8] Items and activities change from year to year, but the way incentives work is similar in spite of this. We illustrate the situation for 2008 since this is the year we use as the basis for the simulation.

CID	N.A.	Irrigation and drainage projects	Land subsidy Productivity enhancement	Lower land cost Higher productivity

Source: authors' schematization

Some comments about the classification in the table are in order. First, 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 are most typically activities that do not include irrigation or water management. Since we wish to establish a clear division between irrigation-related subsidies granted through the SCL or the IRC and those granted through the CID, we treat land adequation subsidies as capital subsidies.[9]

Since the model we use does not distinguish between farmers types, subsidies through the program are only considered at the aggregate level. For the purpose of modeling, the size of the subsidy to small farmers (40%) benefitting from the IRC and the subsidy to large farmers (20%) does not necessarily matter. Rather, it is the total amount granted to each agricultural subsector in the model that matters. The total amounts of subsidies disbursed by the program in 2008 and the implicit subsidy rates are both reported in table 2 for each type of incentive.[10] We can see there that slightly more than half of the resources considered here were granted as subsidies to productive capital (US$74.7 million, or 51.9% of the total), followed by irrigation subsidies (US$64.5 million, or 44.8% of the total) and by working capital subsidies (US$4.7 million, or 3.3% of the total). Therefore, the program actually devoted the majority of resources to uses that may

[9] Admittedly, this distorts the way we evaluate the expected impacts of the program. However, the effect of this assumption is negligible as irrigation financing through the SCL and the IRC is (relatively) small and has an unpredictable effect on productivity, which will be discussed later on as an important consideration when simulating the effects of the CID. In principle, the main effect of this assumption is that it understates the land use subsidy and overstates the capital subsidy, a feature that has a negligible effect given that the model considers that composite land and composite capital-labour are combined in fixed proportions.

[10] Subsidy rates are calculated as the government's share of total project costs. Therefore they do not represent the subsidy level across an entire agricultural subsector, but rather correspond to the average project in the program.

bring some form of technological change, assuming that capital investments reflect a particular technology choice.[11] While working capital subsidies are expected to be neutral in terms of factor proportions, productive capital subsidies clearly support capital intensification and its effect on labour use depends on whether capital and labour are complements or substitutes.

We can also see in the table that the subsector receiving the largest amount of resources is agricultural investment, a subsector that includes newly planted areas of perennial crops. US$55.9 million (38.8% of total subsidies) were allocated to this subsector, followed by fruits and oil palm (respectively 10.4% and 10.2%).[12] In total, 79.4% of resources were assigned to perennial crops. The subsectors with the lowest allocations of resources were plantain, cereals, and other crops (respectively 0.03%, 0.04% and 0.24%). If productive capital subsidies are considered on their own, agricultural investment is by far the largest recipient of this type of subsidy (74.8%), followed by coffee (6.1%), rice (6%) and sugar cane (6%). In terms of irrigation subsidies, the largest beneficiaries are oil palm (22%), fruits (21.9%), sugar cane (10.6%) and cocoa (8.8%). Lastly, with respect to working capital subsidies, the largest subsidy amounts were allocated to rice (25.4%), cotton (22.8%), potatoes (12.5%), vegetables (10.2%) and corn (9.9%). Therefore, the program not only promotes capital intensification, but also tends to offer stronger support for perennial crops.[13]

Table 2. Government expenditures on subsidies and implicit subsidy rates (2008, millions $US)

	Working capital subsidy		Productive capital subsidy		Irrigation subsidy	
Crop	Amount	Actual rate	Amount	Actual rate	Amount	Actual rate
Coffee	0.00	6.4	4.56	22.9	3.69	75.7
Cereals	0.04	2.1	0.02	12.4		
Corn	0.46	1.4	1.35	16.6	2.54	79.1
Rice	1.19	1.8	4.48	12.1	3.25	75.0
Potatoes	0.58	3.9	0.31	12.3	3.95	79.3
Beans	0.21	5.4	0.12	13.2	2.75	79.2
Vegetables	0.48	11.2	0.83	12.9	4.00	78.2
Tubers	0.18	2.8	0.08	2.4	0.34	77.7
Bananas			0.37	11.0	2.59	67.2
Plantain			0.04	17.2		
Fruits	0.00	2.8	0.75	15.9	14.15	77.4
Oil palm			0.52	13.5	14.19	77.5
Oilseeds	0.04	1.4	0.41	19.9		
Other crops	0.00	3.1	0.30	18.1	0.05	40.1

[11] This is clearly not always the case, as capital investment may also be directed to replace old capital.

[12] Fruit and oil palm are perennial crops, as are some other subsectors. The distinction here points to the fact that agricultural investment is an activity that includes the planting of new areas that, by definition, do not yield production yet. This can be compared with subsidies granted to activities producing perennial goods, and which are therefore expected to impact current production levels.

[13] Whether this apparent preference to support perennials is intended or not could be debated, as there is an important demand component at play.

Cocoa	0.00	0.0	0.17	23.6	5.70	74.9
Tobacco	0.44	4.4	0.03	20.4	0.32	72.7
Sugar cane			4.49	14.8	6.82	69.6
Cotton	1.07	1.6	0.01	21.4	0.17	77.0
Ag. investment			55.85	17.0		
Total	4.70		74.69		64.51	

Source: authors' calculations based on Ministry of Agriculture data

4. Research objective and methodology

Our main research objectives are to estimate the likely short run sector-specific impacts of the newly introduced agricultural policy, as well as its likely effects on rural poverty. More specifically, we aim to assess the potential impact of the main components of AIS on the relative prices, quantities produced and real factor returns of agricultural goods as well as the effects these have on income generated by rural households. Given the strong targeting of AIS, we also aim to identify the main winners and losers (in terms of sectors of goods and households) the program will generate within the rural sector.

Despite of the policy package being one of the largest of its kind in the history of Colombian agricultural policy, it is small relative to the size of the sector, with an annual budget of about 2.3% of value added in the sector. Its impact is therefore expected to be primarily felt in the agricultural sector and any induced changes at the aggregate level are likely to be relatively small in the short term. More significant macro effects may be generated by the policy in the longer run, since the rural sector may attract relatively more capital due to the types of incentives the policy creates and the time it takes for newly planted perennial crops to reach their productive age. Our focus here is on the short run (as specified below), so we expect the simulations to indicate relatively small macro impacts; however, it is still important to retain the general equilibrium focus as upstream and downstream linkages affect the final policy outcomes, and also differ from one crop to the next.

We reach our objectives by integrating an agriculture specialized static CGE model and a microsimulation model that allow labour to shift within occupational groups within the agricultural sector. The CGE is used to simulate the impact of sectoral policies on relative prices and macro variables. Changes in macro variables (wages, employment by agricultural subsector, etc.) are fed into the microsimulation model. This process allows for a rich simulation of changes in rural households' income, providing a sound basis for assessment of the poverty effects induced by sectoral policies.

We follow a top-down approach here, so there are no looped interactions between the two models. There are a number of advantages to linking microsimulation models to macro models (Savard, 2003). First, we can accommodate a large number of households without having to face the difficulties inherent to incorporating them directly into the CGE model. Second, discrete choice or integer behavior can be much more easily incorporated into the household model than into the CGE model, and they may be important for modeling the rural sector. While there is no need to ensure that household data from the microsimulation model is consistent with the data from the SAM through every loop in the modeling algorithm, we do need to make sure that they are at least initially consistent.

The reason that consistency must be verified at the outset is that the results of the models are not guaranteed to converge in the absence of looping. Using a top-down approach without feedback, as we do here, does not strictly lead to convergence. Consistency between the macro and micro data thus ensures that changes in “macro” variables (mainly prices and quantities) have the “right” aggregate impact on households. Since agricultural subsesctors have the same relative size in each model, as are household labour composition and the structure of households’ income from labour factors, changes in macro variables are suitably reflected at the micro level. This is a typical case where the degree of consistency between macro and micro datasets that is required to properly undertake macro-micro modeling should proceed as summarized in Bourguignon, Bussolo, and Cockburn (2010).

The simulation of sectoral policy changes uses the 2008 AIS allocation of resources to the different policy instruments, as illustrated above in table 2.

4.1 The CGE model

The CGE model is based upon a Standard PEP CGE model (in this case the single country, static version: PEP-1-1). 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.[14] Thorough documentation of the model can be found in Decaluwé et al (2009).

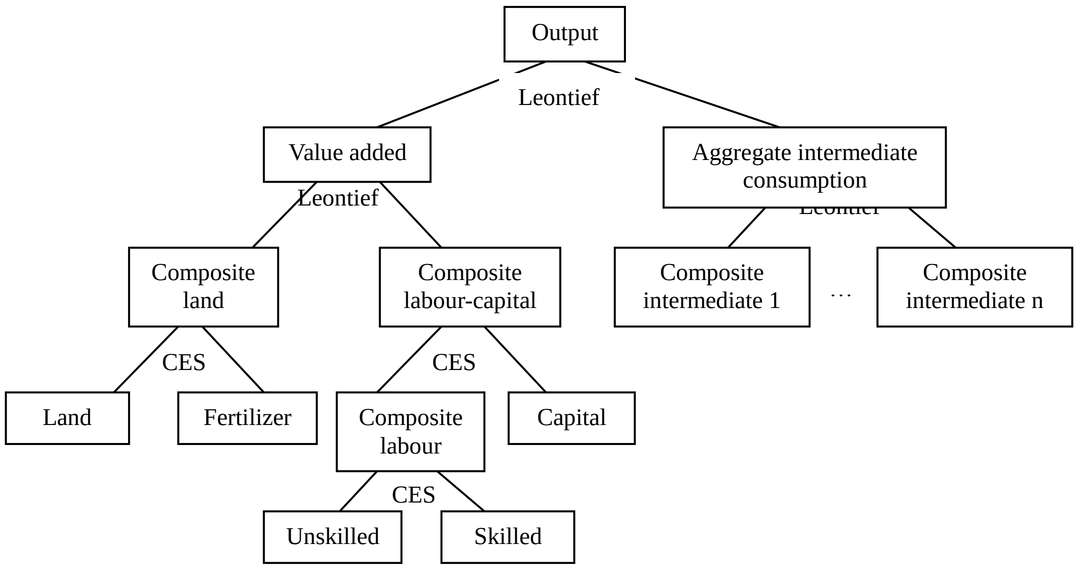
[14] In the sense that local producers can increase their share in international markets as long as they can offer a price that is competitive relative to the world price (in consideration of the price elasticity of export demand).

We make two main changes to the model. First, we modify the structure of production in the agricultural sector, allowing for a convenient representation of agricultural production. Second, we introduce a supply of land services so as to have a more realistic representation of land allocation between agricultural subsectors. However, our definition of agriculture excludes livestock, dairy production, meat production, forestry and fisheries.[15] The reasons for this are that we have no dependable information on land use for these subsectors (especially for livestock) and the dominant mode of livestock production in Colombia, which affects land allocations among rural land-based subsectors.[16]

With respect to the structure of agricultural production, we begin with value added and a composite intermediate good used in fixed proportions (Leontief). We then define value added in a second nest as a Leontief function of composite land and a composite capital-labour factor. Fixed proportions are also used for the composite intermediate good. This specification reflects the large degree of complementarity that commonly appears in agricultural production. As for the value added nest, the capital–labour composite is modeled as a constant elasticity of substitution (CES) combination of composite labour and composite capital (third nest). Composite labour is in turn a CES combination of skilled and unskilled labour (fourth nest). While the model allows for a composite of several types of capital, only one type of capital is currently used. Then again, composite land (third nest) is a CES combination of land and fertilizer, allowing the latter to play a role in determining value added. The structure of agricultural production is represented in figure 1.

[15] However, these sectors are included in the model either independently or as part of other activities.
[16] Livestock activities in Colombia are predominantly extensive (i.e., based on natural and cultivated pastures and itinerant grazing) and are known to be used as a low cost and non labour-intensive way to claim land, in addition to their function as an economic activity.

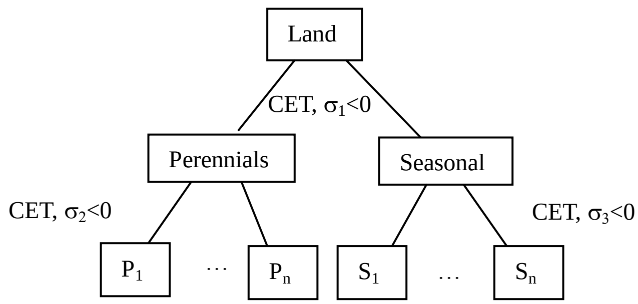
Figure 1: Structure of agricultural production



In terms of land services, agricultural land is assumed to be heterogeneous in the model and only agricultural land is considered (i.e., land services for livestock, forestry and industrial uses are not taken into account). However, crops compete for land services regardless of the agroecological conditions they perform best in and land services are applied to each crop type with certain restrictions. This feature responds to two considerations. First, it approximates the heterogeneity of land: the availability of land is tied to climate and other characteristics that make certain parcels more suitable for some crops than others, which means the land is not freely "mobile" across crops. Second, agricultural 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 crop types, 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 slow in the model and a constant elasticity of transformation (CET) function is used to represent it.

In particular, land is allocated according to the ease of entry into a particular subsector. Subsectors which require sizable investments in land preparation or with a long period until productive maturity are assumed to be less likely to experience changes to other uses. Hence, supply of land services is divided among perennial and seasonal crops (first nest with an elasticity given by σ_1). This decision is usually associated with the need for relatively lumpy investments and cash flow constraints, given that perennials generally take some time to reach a productive age. Then, in the second nest, land is allocated to particular crops (both perennial and seasonal, with elasticities respectively given by σ_2 and σ_3). At this level, land allocation decisions differ by crop type. Land allocation among seasonal crops is the most flexible given that a relatively low level of investment is required to switch from one crop to another. It is more difficult to change land allocation between perennials due to the higher cost of switching crops. The following relationship holds for the three elasticities: $\sigma_1 < \sigma_1 < \sigma_3$. The structure of the supply of land services is shown in figure 2.[17]

Figure 2: Supply of land services



The model uses a 2007 SAM with 31 subsesctors and 31 commodities. Of these subsectors and commodities, 23 belong to or are directly related to the agricultural sector: nine are seasonal crops, nine are perennial crops, and the remaining five are perennials that are not yet productive (reflecting agricultural investment), livestock and poultry, forestry, agricultural services and agroindustry. The non-agricultural sectors include two services sectors (general services and financial services) and two sectors that produce agricultural inputs (fertilizers and other agrochemicals). There are three production factors: land, labour and capital. Land is only used by crops, so livestock and poultry, forestry and agricultural services only use labour and capital. Labour is split into four categories: rural unskilled, rural skilled, urban unskilled and urban skilled, and there is only one type of capital. Households are disaggregated into rural and urban households, each of which is further divided by income quintile, for a total of 10 household types. We do not consider self-consumption of agricultural goods produced by rural households.[18]

A key feature of the SAM used with the model is that it explicitly specifies rural non-agricultural subsectors and income for rural households. This means that all relevant subsectors

[17] A detailed description of the implementation of agricultural production and supply of land services is given in appendices A and B.

[18] Consumption shares consistent with the LES system for each household type were estimated from household survey data, following Bibi et al (2009). A list of model parameter and elasticities is provided in Appendix H.

in the model discern between urban and rural sources of labour. Regarding the labour market, the model allows for either full factor mobility or factor specificity. In the simulations, we assume that labour 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 labour mobility within the agricultural sector. As land allocation between agricultural subesctors is slow, labour mobility in the agricultural sector is lower. Also, as production in the agricultural sector uses a capital-labour composite factor with sector–specific capital, labour mobility tends to be limited. For these reasons, and for the purposes of our present objectives, we believe that it is suitable to achieve closure in the model's labour market through wages, with perfectly inelastic supply of labour, even though it is generally assumed that labour mobility between agriculture and other subsectors should be modelled as less than perfect. Also, specifying capital as sector–specific is convenient because we aim to evaluate the short run effects of the policy package under consideration.

4.2 Modelling strategy

In light of our discussion in section 3, we basically need to model three types of incentives created by the policy: subsidies which lower unit costs, subsidies which lower productive capital costs and subsidies which lower land use costs (including a productivity effect).

We model all subsidies that effectively lower unit costs as creating a (negative) wedge between an subsector’s unit cost and its basic price:

$$PT_j = (1 + ttip_j - SWK_j)PP_j$$

where:

$PP_j = unit\ cost\ of\ activity\ j$
$PT_j = basic\ price\ of\ industry\ j's\ output$
$SWK_j = subsidy\ rate\ of\ working\ capital\ for\ activity\ j\ (endogenous)$
$ttip_j = tax\ rate\ on\ the\ production\ of\ activity\ j$

On the other hand, productive capital subsidies lower the cost of capital for beneficiary subsectors so the price of this factor decreases according to the implicit subsidy rate (across the entire subsector):

$$RTI_j = R_j\left(1 + ttik_j - SKD_j\right)$$

where:

$R_j = rental\ rate\ of\ capital\ in\ activiy\ j$
$SKD_j = rate\ of\ subsidy\ for\ capital\ used\ in\ activity\ j\ (endogenous)$
$ttik_j = tax\ rate\ on\ capital\ used\ in\ industry\ j$

Irrigation subsidies have two effects. One is that they lower the cost of using land and therefore act as a subsidy for productive capital. The second is that they are expected to improve productivity since enhanced water availability and management is expected to increase yields. These effects are modeled as follows:

$$RTT_j = RTS_j(1 + ttit_j - STI_j)$$

$$CT_j = CTPF_j * B_j^{CT}\left[\beta_j^{CT} TD_j^{-\rho_j^{CT}} + (1-\beta_j^{CT})FD_j^{-\rho_j^{CT}}\right]^{\frac{-1}{\rho_j^{CT}}}$$

where:

$RTT_j = Land\ rental\ rate\ payed\ by\ activity\ j$
$RTS_j = Land\ rental\ rate\ supplied\ to\ activity\ j$
$STI_j = Land\ rent\ subsidy\ rate\ for\ activity\ j\ (endogenous)$
$CT_k = Composite\ land\ used\ in\ activity\ j$
$CTPF_j = Productivity\ parameter, land\ irrigated\ for\ activity\ j\ (endogenous)$
$TD_j = Land\ used\ for\ activity\ j$
$FD_j = Fertilizer\ used\ for\ activity\ j$
$ttit_j = Tax\ rate\ on\ land\ used\ for\ activity\ j$
$B_j^{CT} = Scale\ parameter\ for\ activity\ j\ (CES\ composite\ land)$
$\beta_j^{CT} = Share\ parameter\ for\ activity\ j\ (CES\ composite\ land)$
$\rho_j^{ct} = Elasticity\ parameter\ for\ activity\ j\ (CES\ composite\ land)$

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 we 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.[19]

Lastly, it is worth mentioning some general characteristics of the simulation.[20] We should start here by considering the financing of the program. This is done by assuming that public expenditures to subsidize agricultural activities are financed 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 labour is fixed, fully utilized and freely mobile between all sectors, government spending is fixed, investment is savings-driven, the current account balance is fixed and total land demand is fixed.[21] We define our time horizon as short term, so capital is assumed to be sector-specific. This feature is not only consistent with the idea that most capital

[19] Given the nature of this information, a sensitivity analysis is conducted to evaluate the effect of changes in this parameter (see subsection 3.5).
[20] A detailed description of how the simulation is implemented is provided in appendices C through F.
[21] Since we have land demand specified by a CES aggregate (of composite land) and land supply by a CET aggregate, the supply of land services must be endogenous.

used in agricultural activities is more related to trees and plants than to machinery and equipment,[22] 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 the subsectors.

Given the above depiction of the type of policy instruments that are modeled and the timeframe some of them require to become fully operational, we should clarify what we mean by the short term for the purpose of this simulation. Here, we consider short term as up to two years, allowing enough time for new capital investments to be built and put into operation (particularly productive capital, land improvements and irrigation); the time is assumed to be too short for areas that are planted with perennials to enter their productive stage. This allows us to reconcile the static nature of the model with the main features of the policy package, making the simulation meaningful. In particular, we do not address the fact that some of the policy instruments aim to promote the planting of new perennial crops or the entrance of previously planted areas into production, both of which would require use of a dynamic model (or a long run simulation).

4.3 The microsimulation model

We use a non-standard behavioral approach for the microsimulation model. It is non-standard in that we do not seek to mimic household members' labour participation or labour choice behaviour. Instead, we combine parametric and nonparametric approaches in an ad hoc fashion that is well suited to the structure of the data we use to construct the microsimulation model, as explained below.

Based on the 2008 Colombian Living Standard Measurement Survey (LSMS), we construct a household database that is consistent with macro data (the SAM the CGE runs on) in terms of the aggregate wage bill, capital income, land income and transfers. Consistency is achieved as follows: macro data relating to aggregate payments from subsectors to factors (capital, land and labour) are used to adjust the corresponding (aggregate) survey data. Then, household (total) income quintiles are constructed for both urban and rural households and incomes shares from factors[23] are calculated for each household bracket. These income shares by quintile are used to split the macro account in the SAM among household types. We then use the micro data to calculate the share of each type of labour in each subsector and use these shares to split payments to labour across subsectors in the SAM. Lastly, we calculate income shares from

[22] At least for the Colombian case.
[23] For each factor: labour, land and capital.

each type of labour to divide among household types.[24] In this way we have consistency at the macro level (SAM and aggregates in the microdata) and the same household and functional income structures in both datasets.

The micro database keeps all relevant household and individual-level information such as the adult equivalent number of members, occupational status, gender, relationship to household head, employment status, age, subsector, land holdings, various sources of income and sample weights.

Wage equations are estimated using a two-stage Heckman procedure for economically active (and employed) people belonging to the four labour types considered in the macro model. Estimated parameters are retained, as are residuals for each individual's estimate. These parameters and residuals are then used to update wages for each individual, using percentage changes in macro variables from the CGE model simulation. The estimated increase in the individuals' mean income, as estimated through the wage equation, is higher due to the CGE results, and residuals are added so as to (approximately) preserve unexplained income and income variation among individuals.

The specification of the labour market in the CGE model uses wages as the market clearing mechanism, so there is no unemployment. In spite of this, and considering that our main interest is income changes among rural households due to changes in agricultural subsectors, we exploit a feature of agricultural production to mimic changes in employment. Since Colombia is a mountainous tropical country, crops can be classified according to regions (by altitude) where they can be cultivated: hot weather, mild weather and cold weather areas. Changes in employment for each agricultural sector can then be assigned to each of these regions. For crops that grow well in more than one region, employment changes are divided between regions according to the share of the crop in each region.

It is often assumed that the move from one region to another involves migration of the worker. We assume that workers (and households) do not move in response to changes in employment, but rather that employment moves between regions, and this is reflected by changes in the demand for specific types of labour that result from changes in cultivation of crops. It is these segmented labour markets for each labour type in each region that allow us to mimic overall changes in employment.

We use data from the household survey to assign households to the three regions in the

[24] That is, income from rural unskilled labour, rural skilled labour, urban unskilled labour and urban skilled labour.

database. Given the above, we can draw unemployed workers from the labour market when demand for their labour type increases in a (weather) region, or expel workers when there is a decrease. For this, we build a queue based on the probability that an employed or unemployed individual respectively gets fired or gets a job. We use a probit model to estimate these probabilities.

To get around the problem that arises when changes in employment yield non-integer values, we look to Ferreira-Filho and Horridge (2004). They use a procedure they call the "quantum weights method." The basic idea is simple. They create a variable named jobscore for each person in the database and set its value to 1 if he/she is employed. Then, when there are changes in overall employment, this variable weights the effects. The procedure entails splitting the household into two households so as to replicate the change in the simulated jobscore. This is done by dividing the sample household weight to obtain the simulated individuals' values for jobscore. The two households share the same characteristics, with the exception that one contains one working adult with a given sample weight (resulting from the division above) and the other contains an unemployed adult with another complementary sample weight). In general, a new record is created for each worker with jobScore<1 and for each of the unemployed within a labour type and region, for which demand increases. The procedure is only followed for the (infra) marginal worker.[25]

Individuals moving from unemployment into employment obtain a wage determined by the parameters of the wage equation, accounting for the wage change coming from the CGE model. To this income we add an unexplained income calculated from a random draw based on the residuals from the wage equation (applied to employed workers). As employment only changes in agriculture,[26] it is assumed that changes in individuals' employment across the rest of the economy are based on their probability of being fired, regardless of whether any members of their household work in agricultural subsectors and regardless of the region they live in.

Other household income, in particular income from land holdings and capital, is updated in the model according to changes in rent for these two factors. For poverty calculations, the poverty line is also updated according to changes in the consumer price index (we prefer this to other alternatives because there are sizable changes in consumption shares across household types).

[25] An example of the way the procedure works is provided in Appendix G.

[26] Recall that there is no change in the level of employment in the macro model and that we are merely mimicking changes in employment on the basis of reallocations of labour demand by agricultural subsectors.

4.3 Linking the two models

Consistency between the macro (SAM) and micro (LSMS) data is ensured from the very beginning by adjusting individuals' and households' income, accounting for sample weights, according to the macro aggregates.

The main aspects of linking the two models have been presented above. The micro model is fed with percentage changes in employment by labour type and (weather) region, driving job reallocation processes. Also, as changing labour demand in the agricultural sector is linked to employment in the rest of the economy, employment in non-agricultural sectors are also transmitted from the macro model.

Price changes (in percent) are also fed into the microsimulation model. These prices include wages for each labour type, capital rents, land rents and the consumer price index, to be used as explained above.

5. Stylized facts about Colombian agriculture and rural poverty, and size of shocks

Before discussing the simulation results, it is useful to have an overview of the Colombian agricultural sector and rural poverty. We should also consider the relative size of the policy shocks, by looking at the size of subsidies to each subsector as a share of total resources disbursed by the government.

Table 3 shows some of the main macro statistics at the sector level. It indicates that the services sector is by far the largest contributor to total value added (first column), followed by machinery and construction then beverages and manufactures. The agricultural sector, including livestock and forestry, accounts for slightly more than nine percent of total value added and for 5.7% if only crops are considered. The share of value added in total sectoral value (second column) is higher for the agricultural sector than for other sectors in the economy. Value added accounts for an average of around 80% of total sectoral value in the agricultural sector, compared to just 49% in the rest of the economy. The share of value added is highest in the oil palm, fruits, coffee and beans sectors.

Machinery and construction unsurprisingly comprises the bulk of investment, with beverages and manufactures, and services following far behind. With respect to international trade, exports are largely concentrated in three sectors: oil and minerals, beverages and manufacturing, and agroindustry (mainly green coffee), together accounting for nearly 70% of exports. This figure rises to 85% when exports in the chemicals and nonmetals, and machinery and construction sectors are added. On the import side, beverages and manufactures, machinery and construction, and chemicals and nonmetals together account for around 80% of total imports. The data below shows that the agricultural sector does not figure prominently in international trade: it accounts for 6.2% of total exports and 4.1% of total imports. The highest outcome of an agricultural subsector is found for exports of other crops (3.2%), primarily a result of fresh cut flower exports.[27]

Table 3. Sectoral composition of value added, investment and trade in Colombia, 2007

Sector	Share in value added	Value added share	Investment share	Exports share	Imports share
Coffee	0.9	92.2	0.4	0.0	0.0
Cereals	0.0	79.3	0.0	0.0	1.0
Corn	0.1	66.6	0.0	0.0	1.6
Rice	0.2	60.7	0.0	0.0	0.0
Potatoes	0.2	65.0	0.0	0.1	0.0
Beans	0.1	90.6	0.0	0.2	0.1
Vegetables	0.3	88.7	0.0	0.1	0.1
Tubers	0.5	83.6	0.0	0.1	0.1
Banana	0.2	70.2	0.0	1.5	0.0
Plantain	0.4	89.3	0.0	0.2	0.1
Fruits	0.8	92.2	0.0	0.3	0.5
Oil palm	0.3	94.4	0.0	0.5	0.0
Oilseeds	0.0	73.1	0.0	0.0	0.3
Other crops	0.4	67.1	0.0	3.2	0.2
Cocoa	0.0	88.3	0.0	0.0	0.1
Tobacco	0.0	88.5	0.0	0.0	0.0
Sugar cane	0.7	89.9	0.0	0.0	0.0
Cotton	0.0	76.2	0.0	0.0	0.1
Ag. Services	0.1	79.4	0.0	0.0	0.0
Ag. Investment	0.2	66.9	1.5	0.0	0.0
Animal production	3.4	74.8	0.5	0.9	0.1
Forestry	0.2	76.0	0.0	0.0	0.1
Agroindustry	3.5	27.7	0.0	11.1	4.8
Oil and minerals	7.1	74.4	0.0	30.8	0.9
Beverages and manufacts.	9.1	43.9	9.3	26.4	35.4
Fertilizer	0.2	42.4	0.0	0.9	1.2
Agrochemicals	0.1	46.3	0.0	0.0	1.1
Chemicals and nonmetals	2.6	37.3	0.0	8.2	14.7
Machinery and construct.	9.7	46.4	84.9	8.0	30.0
Services	54.2	62.5	3.3	6.8	4.4
Financial services	4.2	58.9	0.0	0.6	3.1

Source: 2007 Colombian SAM

In terms of factor proportions, the agricultural sector generally appears to have a lower capital:labour ratio than the rest of the economy. However, this variable is highly variable across sectors. The average capital:labour ratio is 2.37 for agriculture and is 3.87 for non-agricultural sectors. The highest ratios for non-agricultural activities are found in the oil and minerals sector (16.13, the highest for the economy) and the livestock sector (11.04, the third largest). There is

[27] This results from the fact that, since coffee processing belongs to agroindustry, coffee exports (a traditionally important Colombian export) are made by a non-agricultural sector.

considerable variation among agricultural subsectors: the highest ratio belongs to the sugar cane sector (14.64, the second largest in the economy) and the lowest is found in the corn sector (0.12, the lowest in the economy); the standard deviation of this variable within agriculture is 3.13. Table 4 shows the relevant figures for these and other factor-related variables in the agricultural sector.

Table 4. Relative factor intensity use in agricultural subsectors in Colombia, 2007

Sector	K/L ratio	T/L ratio	K/T ratio
Coffee	0.74	0.09	7.93
Cereals	1.90	0.44	4.36
Corn	0.12	0.36	0.33
Rice	3.16	1.12	2.82
Potatoes	0.99	0.18	5.54
Beans	4.07	0.19	21.98
Vegetables	3.36	0.21	16.03
Tubers	2.78	0.32	8.64
Banana	1.37	0.09	16.03
Plantain	1.19	0.34	3.45
Fruits	2.76	0.15	19.00
Oil palm	2.88	0.30	9.73
Oilseeds	3.06	2.03	1.51
Other crops	0.20	0.04	5.50
Cocoa	0.58	0.28	2.11
Tobacco	1.26	0.11	11.39
Sugar cane	14.64	4.63	3.16
Cotton	0.46	0.18	2.62
Ag. Investment	0.29	0.03	9.44

Source: 2007 Colombian SAM

Land:labour ratios (second column in table 4) tend to be low in Colombian agriculture. The highest ratio is found in the sugar cane sector, while the lowest is in the agricultural investment sector. The average land:labour ratio is 0.58 and its standard deviation is 1.09. Lastly, capital:land ratios (third column) also appear to be highly variable within agriculture. The largest ratio is found in the beans sector, followed by the fruits and banana sectors. The lowest ratio belongs to the corn sector, followed by the oilseeds sector and the cocoa sector. The average ratio for agriculture is 8 and its standard deviation is 6.34.[28]

The agricultural sector's share in total factor use is relatively low, as can be inferred from its share of value added. Agriculture accounts for 5.3% of total labour use and 4.5% of total capital use. Coffee has the highest share of labour demand, while the shares of several sectors is less than 0.1%. The highest shares in capital use belong to the fruits, sugar cane, tubers and coffee sectors, while, as in the case of labour, the shares are under 0.1% in several sectors. With respect to land use, the sugar cane sector accounts for almost 34% of the total, while the coffee,

[28] It must be recalled that ratios are for values, not quantities.

rice, tubers and plantain sectors have shares ranging between 8 and 10 percent, for a total of 36%.

With respect to sectoral labour demands, the agricultural sector employs almost 50% of rural unskilled workers, nearly 18% of rural skilled workers, 2.6% of urban unskilled workers and 0.8% of urban skilled workers. The largest agricultural user of rural unskilled workers is the coffee sector (15.8%) followed by the fruits (5.3%) plantain (4%) and agricultural investment (3.9%) sectors. In turn, the largest employer of rural skilled workers is the fruits sector (10.2%), followed by the coffee (1.7%) and other crops (1.6%) sectors. As can be expected from the above figures, agricultural subsectors do not play a significant role in demand for urban labour.

Table 5 shows the share of labour demand by labour type and sector. We can see that although the agricultural sector does not occupy a significant share of urban employment, several subsectors are exceptions in this respect. This is the case for tobacco, agricultural services, other crops, banana and oil palm. Also, most sectors are highly dependent on rural unskilled labour. This is notably the case for potatoes, oilseeds, beans, cocoa and coffee. Skilled labour, whether rural or urban, is relatively important in sectors such as banana, sugar cane, cotton, fruits, rice and other crops. In most of these cases, it is the urban rather than rural pool of labour that provides most of the skilled workers.

Table 5. Composition of labour demand by sector in the Colombian economy, 2007

Sector	Rural labour		Urban labour	
	Unskilled	Skilled	Unskilled	Skilled
Coffee	92.1	1.2	6.2	0.4
Cereals	84.4		15.6	
Corn	84.9		14.7	0.4
Rice	67.6		14.8	17.6
Potatoes	100.0			
Beans	95.2		4.8	
Vegetables	82.4	3.2	14.4	
Tubers	73.3		26.7	
Banana	31.2		33.5	35.2
Plantain	77.2		9.3	13.5
Fruits	69.1	16.7	13.3	0.9
Oil palm	45.8	6.2	33.4	14.6
Oilseeds	100.0			
Other crops	30.7	1.9	52.1	15.3
Cocoa	93.3		6.7	
Tobacco	21.0		79.0	
Sugar cane	54.7	0.8	22.3	22.2
Cotton	62.7	22.9	14.4	
Ag. investment	70.8	3.0	19.7	6.6
Ag. services	37.3		62.7	
Rest of the economy	4.1	0.8	45.3	49.8

Source: 2007 Colombian SAM

Based on the national poverty line, poverty is high in Colombia. It has also been persistent, especially in the rural sector (CRECE, 2005). According to our own measures, based on the 2008 Colombian LSMS, the national incidence of poverty was 42.3% and extreme poverty touched 15.7% of the population.[29] In terms of households, poverty affected 36.4% of them and 15.5% were in extreme poverty. In table 6, we can see that poverty and extreme poverty are the highest in rural areas: measured at the individual level, the first reached almost 59% and the second 27%, while the corresponding figures for urban areas are 37% and 12%. When measured at the household level, poverty is more than 20 percentage points higher in rural than in urban areas, and is almost 13 percentage points higher for extreme poverty.

The poverty gap (row FGT1 in table 6) is also highest in the rural sector, whether measured at the individual or household level, meaning that the poor in the rural sector are further below the poverty line and more effort is thus needed to bring them out of poverty. Lastly, the severity of poverty index (row FGT2) is also highest in the rural sector.

Table 6. Measures of poverty in Colombia, 2008

Measure		Individuals			Households		
		Urban	Rural	Total	Urban	Rural	Total
Poverty	FGT0	37.1	58.7	42.3	32.0	52.2	36.4
	FGT1	16.4	28.6	19.3	15.7	26.7	18.1
	FGT2	10.1	18.1	12.0	10.8	17.9	12.4
Extreme poverty	FGT0	12.2	26.9	15.7	12.7	25.4	15.5
	FGT1	5.9	11.9	7.4	7.7	12.7	8.8
	FGT2	4.1	7.5	4.9	6.0	8.9	6.7

Source: authors' calculations based on 2008 LSMS

This glimpse at the structure of poverty provides a useful indication on how the simulated policy will (or will not) impact rural poverty. Table 7 shows the relevant information. Figures are presented on the incidence of poverty and extreme poverty for different categories of individuals. We can see that, among the working age population, individuals that are employed have just over a 31% incidence of poverty and a 9.4% incidence of extreme poverty. As could be expected, poverty and extreme poverty are higher among unemployed and inactive individuals, and are particularly high among the unemployed (54.3% in poverty and 24.4% in extreme poverty). If employed individuals are classified by economic sector, we see an incidence of poverty and extreme poverty that is considerably higher in the agricultural sector than in the mining, industry and services sectors. As a matter of fact, poverty is about 1.5 times higher among agricultural sector employees than among mining and industry employees, and more

[29] Our figures are slightly lower than the official ones due to the use of different methodologies in order to make survey data compatible with national accounts data (in particular, we use income from land, which is not usually well measured). The official incidence of poverty at the national level for 2008 is 46% and is 17.8% for extreme poverty. The same applies to the urban-rural disaggregations of poverty.

than double that of services sector employees.

Further disaggregating employed individuals by their labour type shows that poverty and extreme poverty are the highest among rural unskilled workers. The incidence of poverty for this type of worker is 1.6 times higher than for urban unskilled workers, 7.1 times that of urban skilled workers, and 4 times that of rural skilled workers. Differences for extreme poverty are even higher.

Rural and urban households are further divided by income quintile in the SAM. The lower part of table 7 provides figures on the incidences of poverty and extreme poverty for each of these household types. From there it follows that poverty spreads along the whole spectrum of households, including some extreme cases in urban households belonging to the highest quintile.[30] The incidence of poverty is very high in the lower quintiles in both urban and rural areas and declines with household income, although this decline with income is more pronounced among urban households. As a consequence, poverty seems to be more widespread in rural than in urban areas.

Table 7. Incidence of poverty and extreme poverty across varied categorizations

Criteria	Category	Poverty incidence	Extreme poverty incidence
Working age	Employed	31.1	9.4
	Unemployed	54.3	24.4
	Inactive	45.8	18.4
Sector	Agriculture	53.9	21.2
	Mining	28.1	13
	Industry	28.0	6.2
	Services	25.9	7.0
Labour type	Urban unskilled	31.3	13.5
	Urban skilled	7.2	2.7
	Rural unskilled	50.1	27.2
	Rural skilled	12.6	5.0
Household income quintile	Rural quintile 1	95.5	92.1
	Rural quintile 2	79.0	53.8
	Rural quintile 3	59.4	15.3
	Rural quintile 4	26.4	2.4
	Rural quintile 5	5.2	0.0
	Urban quintile 1	83.7	67.6
	Urban quintile 2	56.5	11.8
	Urban quintile 3	22.4	0.1
	Urban quintile 4	2.8	0.0
	Urban quintile 5	0.2	0.0

Source: authors' calculations based on 2008 LSMS

[30] This may initially appear odd, until considering the way that household quintiles and poverty are calculated: quintiles are calculated on the basis of total household income regardless of the number of members, while poverty is calculated on a per capita basis.

Figure 3 shows the sectoral composition of household incomes.[31] It illustrates the rural dependence on agriculture, particularly among low income rural households (even though the richest rural households still derive more than 50% of their income from agriculture). The most noticeable feature of rural household incomes is that agricultural income declines and services-based income increases, with an overall increase in households' income. This situation is compatible with (and reflects) the fact that poverty decreases among individuals employed in the services sector.

As expected, urban households generally rely on income from services, which remains around 80% of total income across all household types. The share of income from agriculture declines with household income, declining systematically from 10% in quintile 1 households to 2.6% for quintile 5 households. Income from industrial activities is higher among households toward the middle of the income distribution, and is highest for households in quintiles 2 and 4, respectively at 16.4% and 16.5%.

As the bulk of rural poverty is concentrated in the lowest quintiles of rural households, and their income is mostly derived from agricultural activities, the policy is expected to be effective at reducing rural poverty as a whole.

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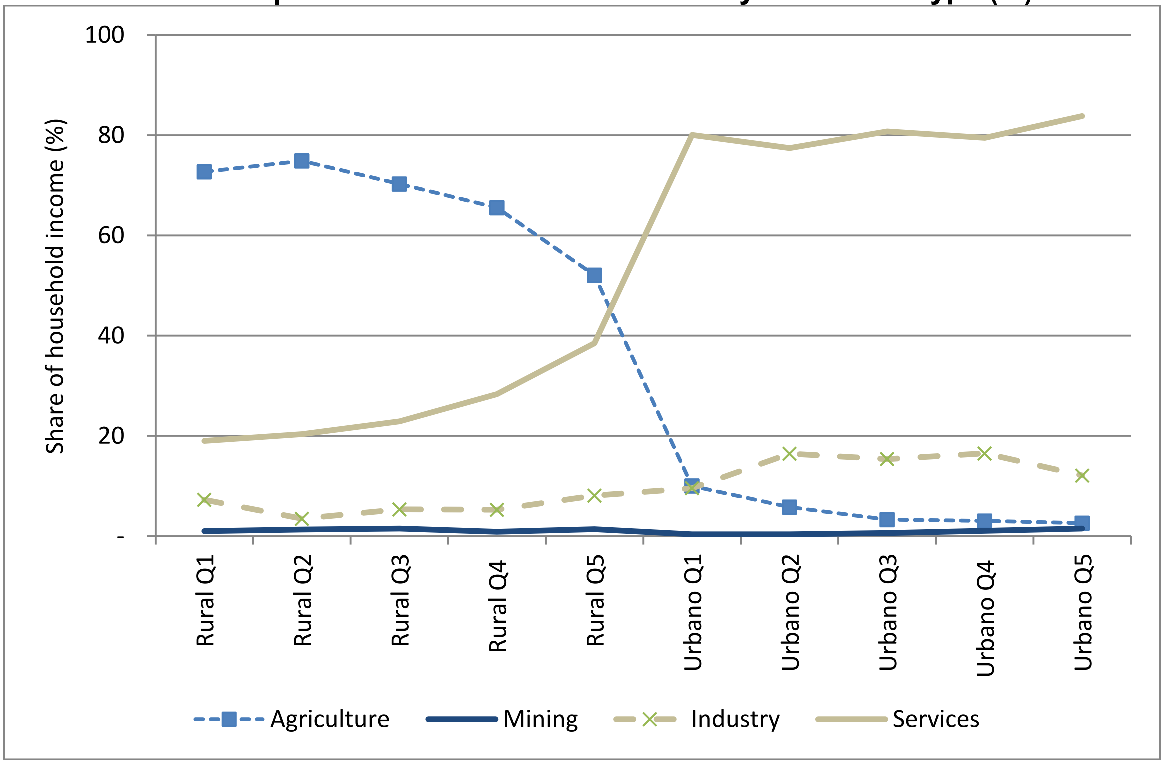
[31] Based on factor income from labour and capital, excluding land income.

Figure 3. Sectoral composition of households' income by household type (%)



Source: authors' calculations based on 2008 LSMS

The government subsidies presented in table 2 generally reflect relatively small subsidy rates at the subsector level. Since these subsidy rates are the rates that matter for the simulation, they are shown in table 8. Three features stand out from the numbers shown in this table. First, given the size of the program relative to sectoral GDP, there is a large gap between the subsidy rate given to the program beneficiary (presented in table 2) and the subsidy rate for the subsector as a whole. For instance, the subsidy rate averages 22.9% among coffee producers who actually received subsidies, but this rate is just 0.72% across the subsector as a whole. The size of this gap depends upon the total amount of subsidies allocated to a subsector as a share of total production in the subsector. The relevant point here, however, is that beneficiaries from the program gain a significant advantage over non-beneficiaries and this effect is not captured in our evaluation, since we do not differentiate among different producers within a subsector or between beneficiaries and non-beneficiaries.

The second feature is that the most significant subsidies are those that reduce the cost of productive capital or of irrigated land use (as opposed to subsidies that do not tend to affect factor proportions), the latter being the most important in relative terms. Lastly, the largest subsidy for agricultural investment is for productive capital (i.e., new plantings of perennials), followed by corn and rice, while irrigation subsidies cover a larger variety of subsectors (eight subsectors receive land subsidies above 12%).

Table 8. Subsidy rates at the subsector level granted through the AIS program (%)

Subsector	Working capital	Productive capital	Land use	Productivity
Coffee	0.00	0.72	4.52	0.88
Cereals	0.09	0.09		
Corn	0.18	11.80	8.28	2.49
Rice	0.15	1.92	4.08	1.15
Potatoes	0.07	0.18	12.53	2.04
Beans	0.07	0.06	31.32	10.29
Vegetables	0.07	0.19	15.91	6.33
Tubers	0.01	0.01	0.42	0.20
Bananas		0.17	18.08	3.64
Plantain		0.01		
Fruits	0.00	0.07	23.97	6.06
Oil palm		0.15	36.61	10.54
Oilseeds	0.03	0.92		
Other crops	0.00	0.26	0.22	0.02
Cocoa		0.87	51.91	16.98
Tobacco	1.10	0.18	20.77	4.71
Sugar cane		0.45	2.13	0.98
Cotton	1.51	0.12	3.61	0.92
Ag. investment		41.09		

Source: CGE simulation

6. Results

The results of the two models are presented separately, starting with the CGE model then moving to the results from the micro model.

6.1 Results from the CGE model

We begin with results relating to quantities. Table 9 shows changes in value added, demand for composite labour, demand for land, and demand for fertilizer for each agricultural subsector. It must be recalled that value added is a fixed proportions combination of composite capital-labour and composite land; the percentage changes for these three variables are thus the same. As all subsectors receive subsidies, value added may be expected to increase in all cases. However, the table shows that this is not true: value added decreases for plantain, other crops and agricultural investment, although only by 0.08 to 0.14%. From the supply side, the increase in production is limited by the fixed nature of capital, which largely determines the outcome presented in the table. Given the structure of agricultural production, any change in value added must be accounted for in the composite capital-labour nest as a change in demand for composite labour (LDC). As table 9 shows, changes in labour demand exceed the change in value added, the difference being driven by the share of labour in composite capital-labour (these changes are more similar when the share of labour is higher) and by the elasticity of substitution between composite labour and capital.[32]

Prices adjust to ensure optimality at all stages of production and to maintain the fixed proportions assumption between composite capital-labour and composite land. For this reason, changes in demand for land and fertilizer (composite land) need to move in the same direction as changes in composite capital-labour. However, as irrigation subsidies positively affect productivity, changes in demand for land and fertilizer do not necessarily always have the same sign as changes in demand for composite labour (as higher productivity has the same effect as an increase in composite land). In fact, when looking at the expected effects of irrigation subsidies on productivity, together with changes in land and fertilizer use, we can see that the increase (decrease) in demand for composite land lowers (raises) the increase in demand for composite land when the expected productivity effect is higher. This is particularly evident when observing lower fertilizer use.

Table 9. Value added and input usage in agriculture (percentage changes in quantities)

Subsector	Value added	Composite labour	Land	Fertilizer
Coffee	0.06	0.10	-0.4	-1.0
Cereals	0.18	0.51	0.7	-0.5
Corn	2.42	2.70	2.6	-2.4
Rice	0.16	0.66	0.8	-2.4
Potatoes	0.28	0.55	3.8	-3.3
Beans	0.37	1.79	0.3	-17.9
Vegetables	0.22	0.94	-2.7	-12.6
Tubers	0.01	0.05	0.0	-1.5
Bananas	0.41	0.95	1.4	-4.8
Plantain	-0.12	-0.25	-0.6	1.0
Fruits	0.24	0.88	1.1	-8.8
Oil palm	0.89	3.43	2.3	-14.9
Oilseeds	0.24	0.95	0.4	-0.9
Other crops	-0.14	-0.17	-1.1	0.0
Cocoa	3.13	4.88	5.2	-21.5
Tobacco	1.09	2.51	4.7	-7.1
Sugar cane	0.01	0.22	-1.0	-0.8
Cotton	1.80	2.58	2.5	-0.2
Ag. investment	-0.08	-0.11	-1.1	0.0

Source: CGE simulation

These changes in demand for land and fertilizer can be explained by two main factors. First, we can consider the degree of complementarity or substitutability between them. In this particular case, we assume that land and fertilizer are weak substitutes,[33] so these changes

[32] As the same elasticity value is assumed for all subsectors, there are no differences across sectoral behavior in this regard. We use an elasticity value of 1.5.

[33] We assume the same elasticity of substitution for all subsectors: 0.5. This is in line with the view that fertilizer and land infrastructure can be regarded as complements while fertilizer and land can be viewed as substitutes (Ruttan, 2001). As we do not have the means to distinguish between land and land infrastructure, we adopt a midway substitutability/complementarity relationship.

tend to move in the same general direction. However, as subsidies for land use are fairly large (as illustrated in table 8), prices vary a fair bit within composite land, and land and fertilizer substitutability is enhanced, resulting in several cases where demand for land and fertilizer move in opposite directions. The average change in relative prices between land and fertilizer due to the shock is 11.3%, and ranges from a high of over 30% to a low of 0.3%, mostly depending on the size of the land use subsidy.

The second factor affecting substitutability between land and fertilizers comes from the supply of land services. Since reallocation of land services is slower between perennials and seasonal crops, and is slower within perennials than within seasonal crops, competition for land services becomes more intense among perennials. While it is easy to see that land is not easily reallocated from seasonal to perennial crops, it is also possible for a perennial crop that benefits from a fairly high subsidy to see its effective demand for land decrease if other perennial crops receive even higher subsidies, because the latter may outcompete the first crop type in its demand for land. This is the case of coffee, a crop with a 4.52% subsidy for land use that nevertheless sees its demand for land decrease by 0.4%.

Agricultural investment itself warrants brief attention, as it secures the highest subsidy rate for productive capital, but its output nevertheless shrinks. This result is driven by several factors. First, as capital is sector-specific, the capital subsidy does not impact demand for this factor. Instead, the change in demand for composite capital-labour depends on the change in the price difference between capital and composite labour. In this particular case (as is also true for plantain and other crops), this lower price difference leads to reduced demand for composite labour use and a decline in output. On the demand side, agricultural investment enters the economy's investment account in fixed proportions, so the increase in agricultural investment is also limited on that side because the model is savings-driven.

The overall increase in each agricultural subsector (value added) is determined by the amount of the subsidy allocated to that subsector and the combined effect of competition for resources and the specific resource allocations required by each of these subsectors. The average increase in output is low (0.6%) and it is also low at the aggregate level of the agricultural sector (0.2%).

We will now describe some of the results in values as opposed to quantities. First, it is useful to observe the changes in unit costs for all agricultural subsectors. Table 10 shows both unit costs and base prices of each subsector. As mentioned before, the working capital subsidy creates a wedge between these two prices, lowering the base price, making agricultural output cheaper for other agents in the economy. As can be verified from the figures in the table, the difference between these two prices is the working capital subsidy level granted to each subsector. It can also be observed that (unweighted) average unit costs decline 0.7% as a result of the other two types of subsidies granted through the program. The sizes of the unit cost declines depend on: the level of the subsidy to each subsector, the shares of the contribution of capital and land to production, and factor price changes. Subsectors receiving the highest subsidies have the highest declines in unit costs. For instance, unit costs for cocoa production decline by 7.2%, largely due to high land subsidies (almost 52% as shown in table 8); subsidies for productive capital in this sector are above average, but do not approach the highest subsidy levels. Changes in price wedges (i.e., the differences between the capital rental rate and the rental rate paid by each subsector, and between the rental rate of land and the rental rate paid by each subsector) can be calculated from table 10; subsidy levels (as presented in table 8) result from price changes due to changes in competition for these two factors in the various subsectors of the economy.

The changes in the price of value added are determined by factor price changes and factor shares. For composite capital-labour, the capital rental rate paid by the subsectors increases despite the subsidy because capital is sector specific. On the other hand, wages increase marginally for all types of labour, the highest increases being those of rural unskilled labour (0.5%) and rural skilled labour (0.2%). This causes upward pressures on the price of value added. On the composite land side, the rental rate of land paid by the subsectors decreases due to the subsidy and the price of fertilizer also drops under declining demand. Hence, on this side we have downward pressures on the price of value added. The result is, as shown in table 10, that the second effect is generally larger and that the price of value added tends to fall, in most cases marginally.

Table 10. Percentage changes in prices and the value of value added

Subsector	Unit cost	Basic price	Capital rent	Paid capital rent	Land rent	Paid land rent	Value added price
Coffee	0.16	0.16	1.26	0.53	3.25	-1.42	0.17
Cereals	0.02	-0.07	0.87	0.77	-2.70	-2.70	0.16
Corn	-1.67	-1.85	15.90	2.23	-1.79	-9.92	-2.51
Rice	-0.82	-0.96	2.76	0.79	-2.65	-6.62	-1.20
Potatoes	-0.67	-0.74	1.05	0.87	-1.20	-13.58	-1.00
Beans	-0.32	-0.39	1.73	1.67	-2.89	-33.31	-0.35
Vegetables	-0.32	-0.39	1.25	1.05	-4.36	-19.58	-0.38
Tubers	0.08	0.06	0.42	0.41	-3.03	-3.44	0.07
Bananas	-0.19	-0.19	0.98	0.81	7.19	-12.20	-0.35
Plantain	0.51	0.51	0.23	0.22	2.88	2.88	0.59
Fruits	-0.44	-0.44	1.04	0.97	6.54	-19.00	-0.49

Oil palm	-1.71	-1.71	2.69	2.53	8.93	-30.95	-1.84
Oilseeds	-0.18	-0.21	2.07	1.13	-2.87	-2.87	-0.31
Other crops	0.10	0.10	0.33	0.07	1.97	1.75	0.12
Cocoa	-7.19	-7.19	4.63	3.71	15.32	-44.54	-8.04
Tobacco	-0.33	-1.40	1.99	1.81	-0.82	-21.42	-0.59
Sugar cane	0.01	0.01	0.88	0.43	2.10	-0.08	-0.01
Cotton	-0.12	-1.62	2.20	2.09	-1.86	-5.40	-0.06
Ag. investment	0.19	0.19	70.24	0.30	1.88	1.88	0.24

Source: CGE simulation

As domestic prices tend to fall, the ratio of FOB prices to international prices (exogenous) also falls and exports tend to increase in quantity. This is true for all subsectors aside from plantain and other crops. Nonetheless, exports only increase by a small amount with the exceptions of cocoa, corn, cotton and oil palm, as shown in table 11. Furthermore, the price paid for export crops relative to local prices determines the size of changes in the destination market. If local prices increase by more than export prices, the proportional change in the supply to the domestic market is higher than in the export market and vice versa. For the most part, the increase in exports tends to be higher than the increase in the supply to the domestic market. Lastly, the relationship between domestic and import prices determines the change in imports. This ratio decreases in most cases, leading to a limited decline of imports in most cases (table 11).

Percentage changes in employment and wages, as transmitted from the CGE simulation to the microsimulation model are presented in table 12. Employment changes for agricultural subsectors are reported on a regional basis and are derived from sectoral changes. Demand for agricultural labour increases for rural unskilled workers (+0.4%), rural skilled workers (+1.03%), urban unskilled workers (+0.6%) and urban skilled workers (+0.6%). These increases imply reduced labour demand in the rest of the economy among rural unskilled workers (0.4%), rural skilled workers (0.2%), urban unskilled workers (0.02%) and urban skilled workers (0.005%). The largest relative increase in labour demand by the agricultural sector is for rural skilled workers; when considered in absolute terms, however, the largest increase is for rural unskilled workers. As shown in the table, labour demand in agriculture increases the most for hot weather crops (the region with relatively high cultivation of perennials). It is also important to mention that land rents paid to land owners increases by 1.7%, while capital rents received by capital owners does so by 0.13%.

Table 11. Changes in quantities traded (percentages)

Subsector	Exports	Domestic demand	Imports
Coffee		0.06	
Cereals	0.14	0.18	0.06

Corn	2.75	2.41	-0.58
Rice	1.05	0.10	-1.79
Potatoes	0.66	0.22	-0.91
Beans	0.54	0.30	-0.45
Vegetables	0.39	0.22	-0.31
Tubers	0.02	0.02	0.11
Bananas	0.39	0.35	-0.09
Plantain	-0.48	-0.10	0.63
Fruits	0.43	0.24	-0.33
Oil palm	2.19	0.08	-4.09
Oilseeds	0.30	0.23	-0.16
Other crops	-0.16	-0.06	0.19
Cocoa	9.12	2.96	-9.03
Tobacco	1.82	0.77	-1.93
Sugar cane	0.00	0.07	
Cotton	2.47	1.79	-1.30

Source: CGE simulation

Finally, it should be mentioned that, as expected, the program has almost no aggregate impact. Nominal GDP increases by 0.021% while the GDP deflator increases by 0.019%. The size of the direct tax needed to finance the program is negligible.

Table 12. Percentage changes in labour demand by labour type and region, and percentage changes in nominal wages

			Labour type			
			Rural unskilled	Rural skilled	Urban unskilled	Urban skilled
Employment	Agriculture	Hot weather	0.58	1.59	1.29	1.22
		Mild weather	0.29	0.90	0.76	0.70
		Cold weather	0.45	0.46	0.10	-0.02
	Rest of the economy		-0.37	-0.22	-0.01	-0.01
Wages			0.49	0.20	0.04	0.01

Source: CGE simulation

One of the appealing features of the AIS program is that it is designed to enhance productivity. The AIS is expected to impact productivity through several mechanisms, the two most important of which are the CID and the ITA. As mentioned above, the simulation only accounts for the first of these and its impact is parameterized in the model on the basis of an average yield gap between irrigated and non-irrigated land that is assumed to be 20% across all agricultural subsectors. The productivity impacts already shown in table 8 result from this assumed yield gap. Given the importance of this parameter in determining the results, we now present estimates when alternative assumptions that use extreme values for the yield gap are used (a 10% and a 30% value, equivalent to halving the base estimate and increasing it by half). The main results are presented in table 13, which presents the difference between the resulting changes under the alternative assumptions and the 20% yield gap. A negative number indicates an estimate that is lower than for the 20% gap, and vice versa.

Table 13. Results from alternative values of the yield gap between irrigated and non-irrigated land

Subsector	Difference in value added		Difference in demand for composite labour		Difference in demand for land	
	10%-20%	30%-20%	10%-20%	30%-20%	10%-20%	30%-20%
Coffee	-0.01	0.01	-0.01	0.01	-0.36	0.35
Cereals	0.09	-0.09	0.25	-0.25	0.38	-0.37
Corn	0.11	-0.10	0.12	-0.11	0.64	-0.63
Rice	0.01	-0.01	0.04	-0.04	0.46	-0.45
Potatoes	0.01	-0.01	0.02	-0.01	0.67	-0.65
Beans	0.00	0.00	0.01	0.00	1.02	-1.00
Vegetables	0.01	-0.01	0.03	-0.03	0.67	-0.66
Tubers	0.02	-0.02	0.08	-0.07	0.14	-0.14
Bananas	-0.04	0.04	-0.10	0.10	-0.30	0.29
Plantain	-0.03	0.03	-0.07	0.07	-0.24	0.24
Fruits	-0.02	0.02	-0.08	0.08	-0.18	0.18
Oil palm	-0.06	0.06	-0.22	0.22	-0.10	0.09
Oilseeds	0.17	-0.17	0.65	-0.64	0.23	-0.23
Other crops	-0.02	0.02	-0.02	0.02	-0.43	0.42
Cocoa	-0.16	0.16	-0.26	0.25	-0.08	0.08
Tobacco	0.00	0.00	0.00	0.00	0.81	-0.79
Sugar cane	-0.05	0.05	-0.73	0.71	-0.15	0.15
Cotton	0.07	-0.07	0.10	-0.09	0.53	-0.51
Ag. investment	-0.01	0.01	-0.02	0.02	-0.44	0.44

Source: CGE simulation

As the new values for yield gaps are the same distance from the 20% value (10 percentage points below or above), the changes in productivity in each subsector also differ from the values reported in table 8 by the same amount in either direction. This also holds for changes in value added, demand for composite labour and demand for land. The main result of interest here, however, is that none of our estimates differ substantially from those when using the 20% benchmark. The absolute value of the largest differences are less than 0.2% for value added, are around 0.7% for composite labour demand, and are just over 1% for demand for land. Thus, even though these values may vary substantially at the individual level and in relative terms, they do not have a strong impact on the aggregate results of primary interest in this study. In summary, the different assumptions with respect to the values for the yield gap, although not innocuous, do not affect the direction of our estimates and have a nearly negligible impact on the final outcomes.

6.2 Microsimulation model results

The above results point to a number of likely outcomes from the microsimulation model. First, since the wage rate for rural unskilled workers increases and the incidence of poverty is highest among this type of workers, one can expect improvements with respect to poverty. However, considering the size of the poverty gap, it is unlikely that the resulting increase in wages will lower the incidence of poverty. Instead, it is more likely that the effect will be a lower gap and, perhaps, severity of poverty.

Changes in employment seem to move in the same direction. Employment in agriculture essentially increases in all regions and the incidence of poverty tends to be lower among employed individuals. The high dependence of rural households on agricultural income means that the income of rural households generally rises with employment in this sector. One factor acts against this benefit, however. Since jobs in agriculture are often paid less and are thus linked to a higher poverty rate than other jobs, mixed results can be expected in terms of the employment status of different household members. If new workers become employed in the agricultural sector and no other household member loses a job, then the household's poverty may decline. If the opposite is true and other household members lose their (non-agricultural) jobs, then the household is likely to become worse off (since the incidence of poverty among non-agricultural workers is lower).

The two extreme outcomes for rural households can thus be summarized as follows. The best outcome arises when no household members lose their job and when a household member gets hired in the agricultural sector (recall that non-agricultural jobs decrease). The worst outcome arises when non-agricultural workers get fired and no worker in the household gets hired in agriculture. Since the hiring/firing process depends on individual probabilities of being hired or fired, there is no way to ascertain an expected outcome beforehand. Given the size of estimated changes in employment and wages, however, it seems reasonable to assume that expected changes in the incidence of poverty will be small and that changes in the poverty gap may be higher.

Table 14 shows the incidences of poverty and extreme poverty resulting from the microsimulation. The results indicate very limited impacts on poverty. When measured at the individual level, the incidence of poverty decreases by 0.03 percent points in urban areas, by 0.06 in rural areas and by 0.04 percent at the national level. When measured at the household level, the incidence of poverty remains nearly unchanged, while it decreases by 0.01 percentage points in rural areas. When measured at the individual level, the poverty gap increases by 0.04 and 0.05 percentage points, respectively in urban areas and nation-wide, compared to an increase of 0.06 percentage points in rural areas. The same trends are obtained when the household is taken as the unit of measure. The severity of poverty increases marginally in all cases, whether measured on the basis of individuals or households. Extreme poverty increases regardless of the statistic used (incidence, gap or severity of poverty) when measured at the individual level, while the gap and severity of poverty in rural areas are both exceptions in this regard when the household is taken as the unit of measure.

These results deserve some comment. The fact that the incidence of rural poverty decreases when measured at the individual level and does not do so when measured at the household level (except for among rural households) is a feature linked to household composition. While wages increase across all labour types, they increase by the most for rural labour categories. However, household income, including in the rural sector, depends on income originating from agricultural and non-agricultural subsectors. While employment in the former increases, it decreases in the rest of the economy, meaning that households face a possibility of reduced employment if their income comes from non-agricultural subsectors, a situation that is less likely in the case of rural households given the composition of their employment.

Table 14. Poverty and extreme poverty results from the microsimulation

Measure		Individuals			Households		
		Urban	Rural	Total	Urban	Rural	Total
Poverty	FGT0	37.08	58.64	42.22	31.96	52.19	36.36
	Difference	-0.03	-0.06	-0.04	0.00	-0.01	0.00
	FGT1	16.41	28.65	19.33	15.72	26.68	18.10
	Difference	0.04	0.06	0.05	0.02	0.02	0.01
	FGT2	10.14	18.18	12.06	10.84	17.86	12.36
	Difference	0.05	0.07	0.05	0.02	0.01	0.01
Extreme poverty	FGT0	12.26	26.97	15.76	12.71	25.44	15.48
	Difference	0.07	0.06	0.06	0.02	0.07	0.03
	FGT1	5.99	11.98	7.42	7.68	12.72	8.78
	Difference	0.05	0.07	0.06	0.02	-0.01	0.02
	FGT2	4.14	7.61	4.97	6.05	8.85	6.66
	Difference	0.05	0.09	0.06	0.02	-0.01	0.01

Source: microsimulation model

This last point may become clear when recalling that low income rural households derive most of their income from agricultural subsectors (see figure 3), either in the form of wages or other factor income. Given this, we may expect households' income to rise due to the general increase in agricultural subsector. This is not necessarily the case, however, as indicated by the results found in table 15. There, households have been ordered from the highest to lowest incidence of poverty in the base data, and we can see that the incidence of poverty either does not vary or slightly increases among the poorest households. Only households toward the middle of the income distribution actually see a decrease in poverty, particularly for rural quintile 3 and urban quintile 4.

Since wages do not change much, the ability of these changes to lift households out of poverty is limited. The biggest factor here is entry and exit from employment. It turns out that members of households with the lowest income levels also have the lowest probabilities of being hired and the highest probabilities of being fired; this makes it difficult for them to take advantage of the changes arising from the shock. As shown in the table, the incidence of poverty only decreases for rural households in quintiles 3, 4 and 5 and for urban households in quintiles 3 and 4.

Another way to consider the results is to look at how the incidence of poverty changes depending on individuals' sector and labour type. Table 16 presents the relevant data. The agricultural and services sectors are the only ones to see this measure of poverty affected: it decreases in the first case and increases in the second, an outcome that is consistent with employment reallocations from the rest of the economy towards agriculture. This also leads to a decrease in poverty among rural unskilled workers and increases for all other labour types. In these cases, the incidence of poverty is calculated on a per capita basis for individuals employed in a particular sector or belonging to a particular labour type, and are calculated in terms of total income of their household. That is, the individual's poverty status is also affected by income coming from other household members.

Table 15. Poverty incidence by household type: pre- and post-simulation

Household type	Base	Simulation	Change
Rural quintile 1	95.54	95.54	0.0
Urban quintile 1	83.69	83.69	0.0
Rural quintile 2	78.95	79.07	0.12
Rural quintile 3	59.4	59.26	-0.14
Urban quintile 2	56.54	56.54	0.0
Rural quintile 4	26.41	26.21	-0.2
Urban quintile 3	22.36	22.34	-0.02
Rural quintile 5	5.23	5.16	-0.07
Urban quintile 4	2.81	2.67	-0.14
Urban quintile 5	0.22	0.22	0.0

Source: microsimulation model

Therefore, for example, when the incidence of poverty decreases for individuals employed in agriculture, there are two sources behind this decline: changes in wages and net changes in employment within the household. Table 16 illustrates how these components interact to yield the results found in table 15.

Table 16. Poverty incidence according to individuals' sector and labour type: pre- and post-simulation

Sector	Base	Simulation	Labour type	Base	Simulation
Agriculture	53.94	53.87	Urban unskilled	31.29	31.31
Mining	28.06	28.06	Urban skilled	7.15	7.18
Industry	27.96	27.96	Rural unskilled	50.14	50.09
Services	25.87	25.90	Rural skilled	12.59	13.08

Source: microsimulation model

As mentioned, the CGE simulation assumed that the yield gap between irrigated and non-irrigated land was 20%, and that this was uniform across agricultural subsectors. A sensitivity analysis was performed for this parameter, leading to the conclusion that changes in the parameter result in very small changes from the baseline scenario, as reported in table 13. Runs of the microsimulation model (not reported here, for brevity) show negligible differences compared to the results reported above.

7. Conclusions

We attempt to provide an estimate of the sectoral and rural poverty impacts of newly implemented reforms to Colombian agricultural policy, in particular the introduction of the Secure Agricultural Income Program (AIS). For this, we use a computable general equilibrium model that is geared towards the agricultural sector together with a microsimulation model.

Although sizable for Colombian agricultural policy standards, in terms of public sector budget allocations, the program is relatively small compared to the size of the agricultural sector. While the second of these implies relatively low subsidy rates and relatively low aggregate impacts at the sectoral level, the first feature often results in significant subsidies at the project (farmer) level, and may thus have large impacts at the individual level.

Therefore, access to the program is key in determining its distributive effects. It is known that resources allocated to medium- and large-scale farmers are exhausted rapidly once funds are allocated to the program by the government, while demand for funds by small farmers is limited. It is also known that disbursements for projects proposed by medium- and large-scale farmers comprise the largest share of funds. This makes it likely that the program is increasing the degree of concentration of agricultural subsectors. This issue does not fall within the scope of the present article, but should nevertheless be highlighted as an important area of research for Colombia.

The results of the CGE simulation show that the expected impacts in terms of percentage changes in value added at the subsector level are small, and are generally less than 1%. Higher changes could be expected in terms of factor and input usage, with changes in demand ranging from 4.9% to -0.25% for composite labour, from 5.2% to -2.7% for land use, and range between 1% and -21.5% for fertilizer use. Despite these wider changes, unit costs decrease by an average of 0.7%, and three subsectors see unit costs decrease by more than 1%. If the effect of subsidies on working capital is taken into account, the number of subsectors for which basic prices decline by more than 1% increases from three to five (of 19 subsectors). Estimated changes in productivity, caused by increases in the amount of land under irrigation and drainage projects and parameterized outside of the CGE, lead to yield gains that range from 0.2% to 17% and average 4.5%.

The macro model yields some gains in wages and capital rents, a relatively larger increase in land rents, and limited labour reallocation, together leading to small poverty impacts as calculated through the microsimulation model. The incidence of rural poverty decreases by less than 1 per cent while the poverty gap increases by a similar amount. Additionally, poverty reductions are concentrated among households near the middle of the income distribution, particularly among the third and fourth quintiles of rural households and the fourth quintile of urban households.

The above outcomes are related to the ability of individuals to obtain employment and their vulnerability of getting fired. It appears as though individuals in low income households are both less likely to land employment and are more prone to getting fired, so this group benefits the least from changes caused by the program.

Overall, the present approach to carrying out the AIS seems to have a limited capacity to achieve the objectives it was designed for. As an instrument to dull the adverse impact of increased foreign competition, it appears to fall short given that its estimated impacts on production are low. It does show more promise as an instrument to boost agricultural productivity and competitiveness, however, despite lacking broader reach across the sector and potentially inducing a greater concentration of agricultural subsectors at the expense of small farmers. Finally, although it is not a stated program objective, it is well worth highlighting that its ability to reduce rural poverty seems to be very limited.

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Appendix

A. Modelling agricultural production

The structure used to represent agricultural production uses the following set of equations:

$$VA_{jag} = v_{jag} * XST_{jag}$$

$$CI_{jag} = io_{jag} * XST_{jag}$$

$$CT_{jag} = ioct_{jag} * VA_{jag}$$

$$CK_{jag} = iock_{jag} * VA_{jag}$$

where:

$CI_{jag} = total\ intermediate\ consumption\ of\ agricultural\ activity\ j$
$VA_{jag} = value\ added\ of\ agricultural\ activity\ j$
$XST_{jag} = total\ aggregate\ output\ of\ agricultural\ activity\ j$
$CT_{jag} = composite\ land\ used\ in\ agricultural\ activity\ j$
$CK_{jag} = composite\ labour - capital\ used\ in\ agricultural\ activity\ j$
$io_{jag} = coefficient\ (Leontief - intermediate\ consumption)$
$v_{jag} = coefficient\ (Leontief - value\ added)$
$ioct_{jag} = coefficient\ (Leontief - composite\ land)$
$iock_{jag} = coefficient\ (Leontief - composite\ labour - capital)$

$$CT_{jag} = B_{jag}^{CT}\left[\beta_{jag}^{CT} TD_{jag}^{-\rho_{jag}^{CT}} + (1-\beta_{jag}^{CT}) FD_{jag}^{-\rho_{jag}^{CT}}\right]^{\frac{-1}{\rho_{jag}^{CT}}}$$

where:

$TD_{jag} = demand\ for\ land\ by\ agricultural\ activity\ j$
$FD_{jag} = demand\ for\ fertilizer\ by\ agricultural\ activity\ j$
$B_{jag}^{CT} = scale\ parameter\ (CES - composite\ land)$
$\beta_{jag}^{CT} = share\ parameter\ (CES - composite\ land)$
$\rho_{jag}^{CT} = elasticity\ parameter\ (CES - composite\ land);\ -1 < \rho_{jag}^{CT} < \infty$

$$TD_{jag} = \left[\frac{\beta_{jag}^{CT} RCT_{jag}}{RTT_{jag}}\right]^{\sigma_{jag}^{CT}} \left(B_{jag}^{CT}\right)^{\sigma_{jag}^{CT}-1} CT_{jag}$$

$$FD_{jag} = \left[\frac{(1-\beta_{jag}^{CT}) RCT_{jag}}{PC_{fert}}\right]^{\sigma_{jag}^{CT}} \left(B_{jag}^{CT}\right)^{\sigma_{jag}^{CT}-1} CT_{jag}$$

$$TD_{jag} = \left[\frac{\beta_{jag}^{CT}}{1-\beta_{jag}^{CT}} \frac{PC_{fert}}{RTT_{jag}}\right]^{\sigma_{jag}^{CT}} FD_{jag}$$

where:

RCT_{jag} = rental rate of composite land in ag. activity j
RTT_{jag} = rental rate of land in ag. activity j
PC_{fert} = price of composite fertilizer
σ_{jag}^{CT} = elasticity of substitution (CES − composite land); $0 < \sigma_{jag}^{CT} < 1$

$$\rho_{jag}^{CT} = \frac{1 - \sigma_{jag}^{CT}}{\sigma_{jag}^{CT}}$$

$$CK_{jag} = B_{jag}^{CK}\left[\beta_{jag}^{CK} LDC_{jag}^{-\rho_{jag}^{CK}} + (1 - \beta_{jag}^{CK}) KDC_{jag}^{-\rho_{jag}^{CK}}\right]^{\frac{-1}{\rho_{jag}^{CK}}}$$

where:

LDC_{jag} = demand for composite labour by agricultural activity j
KDC_{jag} = demand for composite capital by agricultural activity j
B_{jag}^{CK} = scale parameter (CES − composite labour − capital)
β_{jag}^{CK} = share parameter (CES − composite labour − capital)
ρ_{jag}^{CK} = elasticity parameter (CES − composite labour − capital); $-1 < \rho_{j}^{CT} < \infty$

$$LDC_{jag} = \left[\frac{\beta_{jag}^{CK}}{1 - \beta_{jag}^{CK}} \frac{RC_{jag}}{WC_{jag}}\right]^{\sigma_{jag}^{CK}} KDC_{jag}$$

$$KDC_{jag} = B_{jag}^{KD}\left[\sum_{k} \beta_{k,jag}^{KD} KD_{k,jag}^{-\rho_{jag}^{KD}}\right]^{\frac{-1}{\rho_{jag}^{KD}}}$$

$$KD_{k,jag} = \left[\frac{\beta_{k,jag}^{KD} RC_{jag}}{RTI_{k,jag}}\right]^{\sigma_{jag}^{KD}} \left(B_{jag}^{KD}\right)^{\sigma_{jag}^{KD}-1} KDC_{jag}$$

$$LDC_{jag} = B_{jag}^{LD}\left[\sum_{l} \beta_{l,jag}^{LD} LD_{l,jag}^{-\rho_{jag}^{LD}}\right]^{\frac{-1}{\rho_{jag}^{LD}}}$$

$$LD_{l,jag} = \left[\frac{\beta_{l,jag}^{LD} WC_{jag}}{WTI_{l,jag}}\right]^{\sigma_{jag}^{LD}} \left(B_{jag}^{LD}\right)^{\sigma_{jag}^{LD}-1} LDC_{jag}$$

where:

$LD_{l,jag}$ = demand for type l labour in ag activity j
$KD_{k,jag}$ = demand for type k capital in ag activity j
RC_{jag} = rental rate of composite capital in ag. activity j
RTI_{jag} = rental rate of type k capital in ag. activity j
WC_{jag} = wage rate of composite labour in ag. activity j
$WTI_{l,jag}$ = wage rate paid to type l labour in ag activity j
B_{jag}^{KD} = scale parameter (CES − composite capital)

$B_{jag}^{LD} = scale\ parameter\ (CES - composite\ labour)$
$\beta_{l,jag}^{KD} = share\ parameter\ (CES - composite\ capital)$
$\beta_{l,jag}^{LD} = share\ parameter\ (CES - composite\ labour)$
$\rho_{jag}^{KD} = elasticity\ parameter\ (CES - composite\ capital); -1 < \rho_{jag}^{KD} < \infty$
$\rho_{jag}^{LD} = elasticity\ parameter\ (CES - composite\ labour); -1 < \rho_{j}^{CLD} < \infty$
$\sigma_{jag}^{CK} = elasticity\ of\ substitution\ (CES - composite\ labour - capital); 0 < \sigma_{jag}^{CK} < \infty$
$\sigma_{jag}^{KD} = elasticity\ of\ substitution\ (CES - composite\ capital); 0 < \sigma_{jag}^{KD} < \infty$
$\sigma_{jag}^{LD} = elasticity\ of\ substitution\ (CES - composite\ labour - capital); 0 < \sigma_{jag}^{LD} < \infty$

$$\rho_{jag}^{CK} = \frac{1 - \sigma_{jag}^{CK}}{\sigma_{jag}^{CK}}$$

$$\rho_{jag}^{KD} = \frac{1 - \sigma_{jag}^{KD}}{\sigma_{jag}^{KD}}$$

$$\rho_{jag}^{LD} = \frac{1 - \sigma_{jag}^{LD}}{\sigma_{jag}^{LD}}$$

This completes the value added branch. Turning to the intermediate consumption branch:

$$DI_{i,jag} = aija_{i,jag} * CI_{jag}$$

where:

$DI_{i,jag} = demand\ for\ composite\ intermediate\ i\ by\ ag.activity\ j$
$aij_{i,jag} = input - output\ coefficient$

We need to add the following to the set of prices included in the model:

$$RCT_{jag} = \frac{RTT_{jag} * TD_{jag} + PC_{fert,jag} * FD_{jag}}{CT_j}$$

$$RCK_{jag} = \frac{WC_{jag} * LDC_{jag} + RC_{jag} * KDC_{jag}}{CK_{jag}}$$

$$PVA_{jag} = \frac{RTC_{jag} * TC_{jag} + RCK_{jag} * CK_{jag}}{VA_{jag}}$$

$$WC_{jag} = \frac{\sum_l (WTI_{l,jag} * LD_{l,jag})}{LDC_{jag}}$$

where:

$$RCK_j = rental\ rate\ of\ composite\ labour - capital\ in\ ag.activity\ j$$

B. **Modelling the supply of land services**

Supply of land services is done through this set of equations:

$$TS = B^{TS} \left[\beta^{TS} TSP^{\rho^{TS}} + (1 - \beta^{TS}) TSS^{\rho^{TS}}\right]^{\frac{1}{\rho^{TS}}}$$

where:

$TS = total\ supply\ of\ agricultural\ land$
$TSP = aggregate\ supply\ of\ land\ for\ perennial\ crops$
$TSS = aggregate\ supply\ of\ land\ for\ seasonal\ crops$
$B^{TS} = scale\ parameter (CET - total\ supply\ of\ land)$
$\beta^{TS} = share\ parameter\ (CET - total\ supply\ of\ land)$
$\rho^{TS} = elasticity\ parameter\ (CET - total\ supply\ of\ land); 1 < \rho^{TS} < \infty$

$$TSS = \left[\frac{\beta^{TS}}{1-\beta^{TS}}\frac{RTTS}{RTTP}\right]^{\sigma^{TS}} TSP$$

where:

$RTTP = composite\ rental\ rate\ of\ land\ paid\ by\ perennial\ crops$
$RTTS = composite\ rental\ rate\ of\ land\ paid\ by\ seasonal\ crops$
$\sigma^{TS} = elasticity\ of\ substitution\ (CET - total\ supply\ of\ land); 0 < \sigma^{TS} < \infty$

$$\rho^{TS} = \frac{1+\sigma^{TS}}{\sigma^{TS}}$$

$$TSP = B^{TSP}\left[\sum_{j=perennial} \beta_j^{TSP} TSPJ_j^{\rho^{TSP}}\right]^{\frac{1}{\rho^{TSP}}}$$

$$TSPJ_j = \frac{TSP}{(B^{TSP})^{(1+\sigma^{TSP})}}\left[\frac{RTS_j}{\beta_j^{TSP} RTTP}\right]^{\sigma^{TSP}}$$

$$TSPJ_j = TD_j$$

where:

$TSP_j = supply\ of\ land\ for\ perennial\ crop\ j$
$RTS_j = rental\ rate\ of\ land\ recieved\ from\ perennial\ crop\ j$
$B^{TSP} = scale\ parameter\ (CET - supply\ of\ land\ for\ perennial\ crops)$
$\beta_j^{TSP} = share\ parameter\ (CET - supply\ of\ land\ for\ perennial\ crops)$
$\rho^{TSP} = elasticity\ parameter\ (CET - supply\ of\ land\ for\ perennial\ crops); 1 < \rho^{TSP} < \infty$
$\sigma^{TSP} = elasticity\ of\ substitution\ (CET - supply\ of\ land\ for\ perennial\ crops); 0 < \sigma^{TSP} < \infty$

$$\rho^{TSP} = \frac{1+\sigma^{TSP}}{\sigma^{TSP}}$$

$$TSS = B^{TSS}\left[\sum_{j=seasonal} \beta_j^{TSS} TSSJ_j^{\rho^{TSS}}\right]^{\frac{1}{\rho^{TSS}}}$$

$$TSSJ_j = \frac{TSS}{(B^{TSS})^{(1+\sigma^{TSS})}}\left[\frac{RTS_j}{\beta_j^{TSS} RTTS}\right]^{\sigma^{TSS}}$$

$$TSSJ_j = TD_j$$

where:

$TSSJ_j = supply\ of\ land\ for\ seasonal\ crop\ j$
$RTS_j = rental\ rate\ of\ land\ recieved\ from\ seasonal\ crop\ j$
$B^{TSS} = scale\ parameter\ (CET - supply\ of\ land\ for\ seasonal\ crops)$
$\beta_j^{TSS} = share\ parameter\ (CET - supply\ of\ land\ for\ seasonal\ crops)$
$\rho^{TSS} = elasticity\ parameter\ (CET - supply\ of\ land\ for\ seasonal\ crops);\ 1 < \rho^{TSS} < \infty$
$\sigma^{TSS} = elasticity\ of\ substitution\ (CET - supply\ of\ land\ for\ seasonal\ crops);\ 0 < \sigma^{TSS} < \infty$

$$\rho^{TSS} = \frac{1 + \sigma^{TSS}}{\sigma^{TSS}}$$

Here, again, some price equations must be added to the model:

$$RTT_{jag} = RTS_{jag} * (1 + ttit_{jag})$$

$$RTTP = \frac{\sum_{j=perennial} RTS_j TSPJ_j}{TSP}$$

$$RTTS = \frac{\sum_{j=seasonal} RTS_j TSSJ_j}{TSS}$$

$$RT = (RTTP * TSP + RTTS * TSS)/TS$$

where:

$RT = rental\ rate\ of\ land$
$RTS_{jag} = rental\ rate\ of\ land\ recieved\ from\ agricultural\ activity\ jag$
$ttit_{jag} = tax\ rate\ paid\ for\ land\ by\ agricultural\ activity\ jag$

C. Modelling subsidized credit for working capital

$$SWK_j = \frac{gswk_j}{\left(PP_j * XST_j\right)}$$

$$PT_j = \left(1 + ttip_j - SWK_j\right) * PP_j$$

$$TIP_j = ttip_j * \left(1 - SWK_j\right) * PP_j * XST_j$$

$$SG = YG - \sum_{agng} TR_{agng,gvt} - G - \sum_j (SWK_j * PP_j * XST_j)$$

where:

$G = current\ government\ expenditures\ on\ goods\ and\ services$
$PP_j = activity\ j\ unit\ cost$
$PT_j = basic\ price\ of\ industry\ j's\ output$
$TIP_j =\ government\ revenue\ from\ taxes\ on\ industry\ j's\ production$
$TR_{agng,govt} = governmental\ transfers\ to\ non\ governmental\ agents$
$SG = governement\ savings$
$YG = total\ government\ income$
$SWK_j = subsidy\ rate\ for\ working\ capital\ for\ activity\ j$
$XST_j = total\ aggregate\ output\ of\ activity\ j$
$gswk_j = total\ amount\ of\ subsidy\ for\ working\ capital\ for\ actuvity\ j$
$ttip_j = tax\ rate\ on\ the\ production\ of\ activity\ j$

D. Modelling subsidized credit for productive capital

$$SKD_{k,j} = \frac{gskd_{k,j}}{KD_{k,j}}$$

$$TIK_{k,j} = ttik_{k,j} * R_{k,j} * KD_{k,j} * (1 - SKD_{k,j})$$

$$SG = YG - \sum_{agng} TR_{agng,gvt} - G - \sum_{k} \sum_{j} (R_{k,j} * SKD_{k,j} * KD_{k,j})$$

$$RTI_{k,j} = R_{k,j} * \left(1 + ttik_{k,j} - SKD_{k,j}\right)$$

where:

$R_{k,j} = rental\ rate\ of\ capital\ k\ in\ activiy\ j$
$SKD_{k,j} = rate\ of\ subsidy\ for\ capital\ k\ used\ in\ activity\ j$
$TIK_{k,j} = government\ revenue\ from\ taxes\ on\ capital\ k\ used\ in\ activity\ j$
$gskd_{k,j} = total\ amount\ of\ subsidy\ on\ capital\ k\ for\ activity\ j$
$ttik_{k,j} = tax\ rate\ on\ capital\ k\ used\ in\ industry\ j$

E. Modelling subsidized credit for land improvements and irrigation

$$tdi_j = \frac{gsti_j}{iuc}$$

$$tdie_j = tdi_j * ygap$$

$$STI_j = \left(tdi_j / TD_j\right) * tsub_j$$

$$CTPF_j = \left(\frac{tdie_j}{TD_j}\right) + 1$$

$$CT_j = CTPF_j * B_j^{CT}\left[\beta_j^{CT}TD_j^{-\rho_j^{CT}} + (1-\beta_j^{CT})FD_j^{-\rho_j^{CT}}\right]^{\frac{-1}{\rho_j^{CT}}}$$

$$SG = YG - \sum_{agng} TR_{agng,gvt} - G - \sum_j \left(RTS_{jag} * STI_{jag} * TD_{jag}\right)$$

$$RTT_{jag} = RTS_{jag} * \left(1 + ttit_{jag} - STI_{jag}\right)$$

where:

$CTPF_j = composite\ irrigated\ land\ productiviy\ factor\ in\ activity\ j$
$STI_j = subsidy\ rate\ on\ land\ rent\ due\ to\ irrigation\ subsidies\ in\ activity\ j$
$gsti_j = total\ amount\ of\ subsidy\ for\ land\ improvements\ in\ activity\ j$
$iuc = cost\ to\ government\ of\ a\ hectare\ of\ irrigated\ land$
$tdi_j = newly\ irrigated\ land\ in\ activity\ j$
$tdie_j = irrigated\ land\ in\ non-irrigated\ equivalent\ land\ in\ activity\ j$
$tsub_{jag} = subsidy\ rate\ on\ the\ value\ of\ irrigation\ projects\ i\ activity\ j, tsub_{jag} < 1$
$ygap_j = average\ yield\ gap\ between\ irrigated\ and\ non-irrigated\ land\ in\ activity\ j,\ ygap_j > 1$

F. Modelling mechanism to raise AIS funding

$$DTAIS = \frac{AISEXP}{\left[\sum_f YFK_f + \sum_h YH_h\right]}$$

$$TDH_h = PIXCON^n * ttdh0_h + [ttdh1_h + DTAIS] * YH_h$$

$$TDF_f = PIXCON^n * ttdf0_f + \left[ttdf1_f + DTAIS\right] * YFK_f$$

where:

$AISEXP = total\ expenditures\ on\ AIS\ subsidies$
$DTAIS =\ direct\ tax\ rate\ to\ finance\ AIS$
$PIXCON = consumer\ price\ index$
$TDH_h = income\ tax\ on\ type\ h\ households$
$TDF_f = income\ tax\ on\ type\ f\ firms$
$YH_h = total\ income\ of\ type\ h\ households$
$YFK_f = capital\ income\ of\ type\ f\ firms$
$ttdh0_h = intercept\ (income\ taxes\ of\ type\ h\ households)$
$ttdh1_h = marginal\ income\ tax\ rate\ of\ type\ h\ households$
$ttdf0_f = intercept\ (income\ taxes\ of\ type\ f\ firms)$
$ttdf1_f = marginal\ income\ tax\ rate\ of\ type\ f\ firms$
$n = price\ elasticity\ of\ indexed\ transfers\ and\ parameters$

G. Example of using the jobscore variable

Changes in employment levels resulting from the macro model are limited to reallocation of workers between subsectors (recall the model has full employment). We take advantage of the micro database to exploit a characteristic of agricultural production in a tropical setting: crops (subsectors) can be divided by climate zones. Assuming that workers can be reallocated between subsectors belonging to the same climate zone in the short run (since it does not imply migration to another area), we are able to simulate changes in employment at the level of climate zones.

We thus face the problem of defining who gets hired and fired at the level of climate zones. While some (like Ferreira and Horridge, 2004) prefer a stochastic procedure for solving this problem, others (like Savard, 2003) prefer a deterministic procedure where the most productive workers get hired first and less productive workers get fired first. We opted for the second alternative and hired and fired workers in order, according to their probability of being employed/unemployed.

The next challenge is how to manage the fact that percentage changes from the macro model may not result in an entire number of workers. To resolve this issue, we resort to Ferreira and Horridge's (2004) use of an indicator variable (jobscore) to obtain a full solution. A simplified example of how this procedure works follows.

The CGE model yields changes in employment that we can translate at the climate zone level. The results are presented in table 12 in the main text. In the case of rural skilled workers, effective demand across agricultural subsectors increases by 4.95%. In other words, if 100,000 workers are initially employed in this segment of the labour market in the database, the increase in employment leads to 4,950 "new" workers of this type entering into agriculture. Suppose the micro database shows the situation depicted in the table below.

HH ID	Weight	Area	Type	Gender	Age	Probability of being employed	Status
26	3100	Urban	Skilled	Male	34	0.1	Unemployed
27	700	Urban	Skilled	Male	23	0.08	Unemployed
28	2300	Rural	Skilled	Female	43	0.97	Unemployed
29	1500	Rural	Skilled	Female	21	0.92	Unemployed
30	1700	Rural	Skilled	Male	52	0.7	Unemployed
31	2100	Rural	Skilled	Female	35	0.2	Unemployed

As rural skilled employment in the agricultural sector increases by 4,950 workers, picking the three individuals from household records 28, 29, and 30 would yield an increase in employment of 5,500 workers once we account for weights. To avoid either exceeding or failing to reach the required 4,950 workers, we split the last household and its weight (determined by the variable jobscore) into two records (including all individuals and variables) such that one is recorded as having a weight of 1,150 and the other a weight of 550. The worker in the first record represents the 1,150 workers needed to reach the 4,950 required and the worker in the second record remains unemployed. This allows us to increase (or decrease, as needed) the level of employment specified by the macro model without altering the microdata, as we now have two households with the exact same general characteristics and appropriate weights, but one has a member that found a job and the other did not.

H. Main elasticities and parameters used in the model

Elasticity	Value	Comment
CES - composite labour-capital: ag subsectors	1.5	There are no recent available estimates for this elasticity for Colombia. Thirks' (1974) estimate yields 1.42 across a set of seven crops. Boys et al (2007) finds an average international elasticity of substitution of 4.08.
CES - composite land: ag subsectors	0.5	There are no estimates for this elasticity in Colombia. According to Townsend (2010) it is 0.58 for the US and should be lower for a country similar to South Africa.
CES - composite labour	0.5	Recent estimates for Colombia report elasticities in the range of 1.16 to 1.47 (Medina and Posso, 2010). Unel (2007) uses a 1.5 elasticity for the US. Das (2003) reports elasticity values between 0.67 and 0.83 over a cross-section of countries. We use a lower value than the one reported by Medina and Posso, to account for our short term horizon.
CET - land supply	0.5	There are no estimates for this elasticity in Colombia. We assume a low value to reflect limited land use substitutability between seasonal and perennial crops. Brooks et al (2010) use a 0.1 value (between permanent crops and rice in the DEVPEM model).
CES - composite commodity	1	According to Hernandez (1998) elasticities range from 0.85 to 0.13, while according to Lozano (2004) they range from 0.26 to 0.89. We use a value of 1 to allow some latitude due to our time frame.
CET - land supply for perennials	0.5	There are no estimates for this elasticity in Colombia. As per above (see land supply elasticity) we assign a low value given the significant sunk costs in perennials production.
CET - land supply for seasonal	2	There are no estimates for this elasticity in Colombia. As per above (see land supply elasticity) we assign a relatively high value given the easiness of switching from one seasonal crop to another.
CES - value added: nonag subsectors	1	The elasticity of factoral substitution in Colombia, according to Arango and Rojas (2004), is 0.7. We use a slightly larger elasticity considering our time horizon and based on Zuleta et al (2009), that finds evidence in favor of a larger than unity elasticity of substitution between capital and labour for the manufacturing sector.

Elasticity	Value	Comment
Income elasticity of consumption: Cereals	0.7	Income elasticities were calibrated from survey data (National Income and Expenditures Household Survey 2006-7)
Corn	0.7	
Potatoes	0.7	
Beans	0.7	
Vegetables	1.5	
Tubers	0.7	
Bananas	1	
Plantain	0.7	
Fruits	1.5	
Oilseeds	0.5	
Other	1	
Animals	1.2	
Forestry	1	
Agroindutry	2	
Basic products	1	
Beverages, tobacco, manufactures	1.5	
Fertilizers	0.7	
Agrochemicals	0.7	
Chemicals and minerals	1.2	
Machinery and construction	1.1	
Services	1.2	
Financial services	2.6	
Frisch parameter	-1.5	Calibrated from survey data (National Income and Expenditures Household Survey 2006-7)
Average yield gap between irrigated and non-irrigated land	1.2	Based on available information for some sectors and experts judgment.
Subsidy rate on irrigation projects	0.755	Calibrated from AIS expenditures.