The Regional Impact of Discriminatory Trade Liberalization on Colombian Agriculture

Abstract

A combined CGE-transportation model is used to assess the likely impact of trade liberalization on the Colombian agricultural sector at the regional/spatial level. The methodology allows for an explicit treatment of the exact location of economic activity, providing support for regionalized policy design. Results indicate that regional impacts in terms of harvested areas, production levels, and value of production are not negligible. Furthermore, some changes are of a magnitude enough to modify producing regions rankings. The diversity of outcomes at the regional level highlights the relevance of geographically detailed results for policy design.

Ricardo Argüello
Department of Economics
Universidad del Rosario
Bogota, Colombia

April, 2008

The Regional Impact of Discriminatory Trade Liberalization on Colombian Agriculture

1. Introduction

As many other developing countries, Colombia has been progressively liberalizing its trade regime. This process has included its accession to the WTO, a unilateral trade policy reform at the beginning of the 1990's, and the negotiation of several bilateral trade agreements. While the general effects of trade liberalization on the economy have been assessed in several instances (Arguello and Valenzuela, 2006; Botero, 2005; Duran et al, 2006; Martin and Ramirez, 2005; and Pardo et al, 2005), no attempt has been made so far to approximate its likely effects at the spatial level. This research intends to do so for the agricultural sector.

Specifically, the purpose of this research is to evaluate the potential impact of the implementation of a series of trade agreements undertaken by Colombia (including the already signed but not yet implemented trade accord with the US) on the spatial structure of most of its agricultural sector. By spatial structure it is meant the composition of crops cultivated by region as well as the extent of areas cultivated.

For attaining this objective, a two-step methodology is used. First, the effects of discriminatory trade liberalization are estimated by means of a multi-region general equilibrium model. Second, relevant price and quantity changes are transmitted to a simple transportation model that simulates the likely changes that trade liberalization will bring upon the spatial structure of agriculture.

Results indicate that potential changes in the spatial structure of agricultural production in Colombia, arising as a consequence of trade liberalization, are not negligible and may have important implications in several dimensions. First, they entail significant changes, both positive and negative, in harvested areas that will have an impact on producers at the local level. Second, they may bring significant impacts on regional income brought about by both changes in harvested areas and changes in production costs. Third, they may change the relative importance of production zones from both the individual products perspective and the overall agricultural activity.

The results are instrumental for policy design in several fronts. First, they not only allow identifying products that are winners and losers from trade liberalization, but also tracking changes in harvested areas, production volumes, and the value of production at the production zone level. Second, they help in assigning production zones an ordering in terms of their vulnerability before trade liberalization. This ordering is not trivial as it depends not only upon the particular mix of products that a zone has, but also on its relative competitiveness vis a vis other zones, regarding productions costs, yields, and proximity to markets. Third, they allow devising options (or the lack of) for producers to switch from products that are losers to products that are winners within a production zone.

The paper is organized as follows. Section two makes a brief literature review. Section three presents and discusses the methodology, while section four describes the data.

Section five describes the regional/spatial structure of Colombian agricultural supply and demand. Sections six and seven present the results. Section six outlines the general economic effects of trade liberalization and shows the variables linking the two models. Section seven describes the spatial effects of trade liberalization. Finally, section eight concludes.

2. Literature review

To the best of my knowledge this is the first attempt to assess the likely impact of trade liberalization on the regional/spatial structure of Colombian agriculture. Also, from the methodological standpoint I know of no other research that has previously taken the approach used here. However, there are plenty of examples in the literature that focus on the regional or spatial effects of different economic shocks on several dimensions of welfare or economic activity.

It is possible to distinguish two main approaches for this. First, regionalized computable general equilibrium models (CGEs). Second, some form of integrated CGE and microsimulation techniques.

As mentioned by Lofgren and Robinson (1999), since the mid 1990s there have emerged a growing number of regionally disaggregated CGEs to address the need to spatially consider the impact of economic policy in the face of evidence that suggests that regional effects may substantially differ from the national average. For instance, Harris (1999) uses a multi-regional CGE to assess the distributional impacts of macro shocks in the Mexican economy. Haddad and Hewings (2004) use an interstate CGE of the Brazilian economy, with 27 states and eight sectors in each state, following a bottom-up approach, to evaluate the effects of decreasing transportation costs.

The integrated CGE-microsimulation approach, pioneered among others by Bourguignon et al (2005), has resulted in a myriad of applications, especially regarding the poverty impacts of trade liberalization. Its regional or spatial dimension varies according to the nature of the underlying household data. Coady and Harris (2001) estimate the regional impact on welfare of the Progresa Program in Mexico by using a two-step, top down approach. They first fed the program's transfers into a CGE with four rural regions, each producing a set of 6 agricultural products, and then take the resulting direct and indirect income effects and price changes, and impose them on disaggregated household data. Fujii and Roland-Host (2008) use a combined CGE-microsimulation approach for estimating the likely effects of Vietnam's accession to the WTO on poverty. For attaining the objective of getting to spatially disaggregated measures of poverty and inequality, allowing supporting a geographically targeted policy design, they also make use of the Small Area Estimation technique (Elbers et al, 2003).

This pinpoints a useful distinction between regionally disaggregated results and spatially disaggregated results. As the former allow impacts estimation at the geographical level, this do not necessarily imply being able to exactly locate them or to explicitly treat the geographical space. The treatment of spatial phenomena in CGE models has its limitations. As Haddad (2004) mentions, it is possible to model the transportation technology by means of the iceberg transportation cost hypothesis, by assuming that transport services are provided though a special optimizing transport sector, or by introducing a satellite module for the transportation system. Alternatively, it can be modeled as a spatial network CGE (Lofgren and Robinson, 1999). In spite of making possible an explicit treatment of certain dimensions of geography, none of these options allow for an exact location of economic activity. The methodology used in this research allows both, disaggregation at the regional and at the spatial levels for the problem under examination, including exact location, provided there is data availability.

3. Methodology

As mentioned, a two-step process is used to estimate the potential spatial effects of trade liberalization on the Colombian agricultural sector. First, a computable general equilibrium model is used to estimate the economic effects of trade liberalization. Second, appropriate price and quantity changes arising from the first step are brought into a transportation model that simulates the potential impact that these changes may entail on crop location and area harvested at each location. This section describes the procedure employed and details some of the most relevant methodological issues.

3.1 The CGE

The static version of the GTAP model is used for simulating the impact of trade liberalization on the Colombian economy. This model, multi-region, constant returns to scale model, allows for a detailed implementation of Colombia's trade agenda. The model runs on version 6 of the database (as documented in Dimaranan and McDougall, 2005) and has 2001 as its base year. The 87 regions contained in the database are grouped into 20 regions, defined in such a way as to allow an appropriate simulation of trade agreements signed or under negotiation by Colombia. Analogously, the 57 sectors belonging to the database are grouped into 32 sectors following two criteria. First, keeping an adequate detail of the agricultural sector, and second, maintaining a certain degree of homogeneity in the level of protection within a sector.

Trade protection data in the database were amended to better reflect a set of preferences granted within the Western Hemisphere (including preferences already implemented by Colombia and its trade partners in the context of trade agreements in force by 2001) as well as other particular trade protection features, such as the Andean Price Band System that entails the application of variable levies for a set of agricultural products. These amendments were implemented through the GTAP's Altertax procedure.

The trade liberalization episodes, related to Colombia, implemented in the simulation are the following: inclusion of Peru in the Andean Community, FTA Mercosur-Andean Community, Complementation Agreement between Colombia and Chile, G-3 FTA, and FTA Colombia-USA.[1]

[1] The inclusion of Peru in the Andean Community, the G-3 FTA, and the implementation of the Complementation Agreement between Colombia and Chile were implemented as of 2001.

3.2 The Transportation Model

This model follows the basic structure of simple transportation models (Dantzig, 1963; Dantzig and Thapa, 1997; Hillier and Lieberman, 2001). It links a set of production zones with a set of markets through a transportation system comprising distances between pairs of zones-markets and transport fares. Transport models minimize the total transport cost involved in sending products from production zones to markets, in such a way that no zone produces more than its capability allows to and no market gets less than the amount it demands. Unlike this, this model maximizes total net revenue; that is, the difference between what markets pay for products shipped to them and what it costs producing these products in specific locations and deliver them. This way, competition between production zones is not solely based upon location but also on efficiency in production.

There are 18 production zones, covering most of the Colombian agricultural area, whose boundaries have been defined following two criteria. First, a relative homogeneity in terms of their agro-ecological characteristics, and second, they correspond to established commercial circuits. Identification of these zones is based upon soil, climate, and topographic information, as well as commercial information, kept in a Geographical Information System (Molina, et al, 2004). These zones produce a set of 34 products (not all products are produced in all zones), assumed homogeneous in consumption.

There is also a set of 141 technologies available for producing these products. A technology is a particular combination of resources (and resources prices) that leads to different yields and production costs; there are products that have only one technology while others may have several. A product that is grown in a particular zone is cultivated under a specific and only one technology, but technologies may be employed in more than one zone (as their agro-ecological conditions may be similar for cultivating a particular crop). This information is based on available cost data produced by different national organizations and reviewed for assuring its consistency (Samaca, 2004).

On the other hand, there are eight markets, seven domestic and an export market. Domestic markets have been defined roughly following consumption patterns and geographic proximity and correspond to consumption regions. This allows for having relative homogeneity in consumer prices and transportation costs within each domestic market. Quantities demanded in these markets amount to total urban and rural demand at the interior of the geographic area that defines the corresponding market and are estimated based upon Income and Expenditures Surveys as for final consumption. In the case of crops that are basically used as industrial inputs, such as oil palm kernel, quantities demanded are estimated from the Colombian Manufacturing Survey. Prices correspond to wholesale prices in the main urban market within each consumption region. Quantities in the export market come from national statistics and, for simplicity, a single export port is assumed to operate. (Tellez, 2004)

Production, domestic demand, and export quantities data are matched in the base year (2001 for consistency with the base year in the CGE database) so that total production exactly equals total domestic demand plus exports for each product (in terms of “final” product; crude palm oil for instance). Therefore, data for the base year is assumed to represent a spatial market equilibrium and the transportation model is just a device for giving an “economic rationale” to this equilibrium and for setting the basis for the whole production-and-trade system to react before price and quantity changes arising from the CGE simulation.

Therefore, as will be mentioned, there are two variants of the transportation model. A pre (CGE) simulation transportation model that “rationalizes” the base year spatial structure of agricultural production, and a post (CGE) simulation transportation model that allows the production-and-trade system to react before the trade shock.

Transport costs are the outcome of transport fares per weight unit and distance. Transport fares vary by market of destination, irrespective of the origin of the merchandise, according to data calculated by the Colombian Ministry of Transportation, based upon transport cost surveys (Colombian Ministry of Transportation). Only one transport modality is considered (light trucks) due to the fact that it is the most commonly used for mobilizing agricultural products. For calculating distances between production zones and markets, baricentric points were identified for each production zone and distances (by road) were taken from these points to the location of the main urban market for each pair production zone-domestic market. Regarding the export market, distances from each production zone were calculated using the average distance from the production baricenter to the two main Colombian ports (one on the Atlantic Ocean and one on the Pacific Ocean).

A general description of the transportation model is provided in Appendix 1.

3.3 Linking the Two Models

Given the ample way the GTAP database sectors span over individual products, only a fraction of them are captured and represented in the transportation model database. The 34 products actually covered represent 30% of total Colombian agricultural production in volume (88.1% of total agricultural production with a potential for being relocated) and cover the most representative products within each GTAP sector. There are, however, some exceptions to this rule and they all relate to products that share a common feature. They all are tradable products whose location is heavily concentrated and for which, due to the industrial structure in place, it is very unlikely that would suffer any kind of relocation before trade shocks of the type modeled here.

These products, that were excluded from the analysis, are export bananas, which are cultivated in the coastal north western part of the country where there is a port specialized in this type of product; sugar cane which is cultivated in the Valle del Cauca region, near the main port on the Pacific Ocean, under contractual arrangements with the sugar milling industry that is entirely located there; finally, cut flowers, cultivated around Colombia's capital city and in the Rionegro region (north western Andean region of the country) due to climate conditions and vicinity to main airports.

As a initial data consistency requirement between the two databases, for each GTAP sector it is needed that the set of individual products within it have, in the aggregate, the same (or reasonably close) shares for domestic consumption and exports as the GTAP sector has in the CGE database. This assures that the relative changes in quantities produced, domestically sold, and exported are consistently transmitted from the CGE simulation results to the post simulation transportation model. This consistency requirement applies to the whole set of individual products comprised within a GTAP sector, that is, including both products considered and excluded from the transportation model database.

The variables that transmit the effects of the trade shock from the CGE to the transportation model are a set of price and quantity percentage changes. Price changes affect both the "supply" and "demand" sides of the transportation model. On the supply side, production costs are affected through unskilled labor, skilled labor, fuels, chemical products, and machinery and equipment price changes, while it is assumed that technologies are of the fixed coefficients type. On the demand side the effect is entirely embodied in changes in demand prices. Quantity changes, basically affect the demand side. These are reflected in domestic demand and export volumes which, in turn, determine changes in production levels (consistency of the latter is assured thanks to the initial data consistency requirement mentioned above).

For allocating the sectoral (CGE) response to the trade shock among individual products, the following procedure is used. For each set of individual products (included and not included in the transportation model database) that integrate a GTAP sector, products are classified as exportable, importable or non tradable. Allocation of quantity changes is done first for exportables as it regards changes in exported volumes. For this, use is made of supply elasticities for each individual product and price changes are found that guarantee that the aggregate weighted change in exported volumes matches that arising from the simulation results coming from the CGE for the corresponding sector. The same set of price changes is used to determine changes in domestic consumption of exportables, but this time using demand elasticities for getting them.

Then allocation is done for non tradables. In this case, it is assumed that price changes for the GTAP sector directly apply to each individual product, so the corresponding demand elasticities allow calculating the respective changes in quantities demanded domestically. Lastly, changes are allocated to importables. Using the demand elasticities for each product, price changes are found that assure that the total aggregate weighted change in domestic demand for the whole sector matches that coming from the CGE simulation. By total aggregate weighted change in domestic demand it is meant the summation of the product of individual exportables, non tradables, and importables' percentage changes in domestic demand quantity and their corresponding shares within the sector. The set of percentage price changes obtained above is used for adjusting price levels in the transportation model database.

On the supply side, allocation of the CGE effects to individual products has a spatial implication given that production costs associated to each technology change accordingly to the relevant price changes and technologies are associated with production zones. However, on the demand side, allocation of the CGE effects has no spatial implication per se given that it is done on a product based and not on a market based manner. In this research no attempt is made to allocate price changes among markets given that there is no available information on demand elasticities per product and market that could be used for this purpose. Therefore the same price change is applied to all markets and this feature of the spatial dimension of the problem is lost.

A thorough description of this procedure is provided in Appendix 2.

There are two main differences between the pre and post simulation transportation models. First, the database is amended in the second case to reflect changes in unit production costs, quantities demanded, quantities exported, and market prices. Second, there is only one supply constraint in the pre simulation model, assuring that no production zone produces more of a product that the area actually cultivated in it allows to. In the post simulation model, however, there are three supply constraints. A first constraint applies only for products whose markets (for the product domestically supplied) have shrunk due to the trade shock. In this case the constraint is similar to the one used in the pre simulation model. The second and third constraints apply to products whose markets have grown after the trade shock. The first of these assures that production of a product that is originated in a zone cannot increase more than what the whole market has increased. The second assures that production levels for a product originated in a zone cannot decrease.

This way, for products whose markets shrink, the allocation of decreases in cultivated areas is done on the basis of competition between these areas, based upon their location with respect to markets and their (new) production costs. For products whose markets increase, the rationale for allocating new cultivated areas is similar but no production zone would experience decreases in areas under cultivation, only newly cultivated areas are allocated among them. The rationale for this is that while in this case prices have increased, there is no reason for a production zone that is already participating in the pre simulation spatial equilibrium to reduce its cultivated area. Instead, these zones compete for expanding its cultivated area so as to satisfy the additional demand.

4. Data

The transportation model database has three main modules, corresponding to supply, demand, and transportation. Each of these is the result of a relatively complex data elaboration process using different sources, as summarily explained below.

The supply module has data on production technologies, production zones, extraction rates, and harvested areas. Production technologies data comprises information on length of the cultivation cycle (several years for perennials and a few months for non-perennials), the number of cultivation cycles per year (in the case of non-perennials), yields per cultivation cycle, total production costs per hectare per ton per cycle, and the decomposition of production costs (for the post simulation adjustment process). This information was gathered from different specialized sources comprising governmental and nongovernmental organizations and was examined and tested for assuring consistency. A detailed description of the data is provided in Samaca (2005).

Data on production zones not only identifies them but also provides information on the type of homogeneous agro-ecological areas (that is, areas that are suitable for cultivation of a particular set of products) that are included in each of them and their extension in hectares. This way the data allows for determining the availability of land for cultivation of a particular set of products in each production zone. Identification of these zones entailed an extensive work based upon a Geographical Information System that has data on soil characteristics, climate, and topography, on the physical side, and data on roads and other relevant characteristics at the municipality level. The basic data come from the Colombian National Geographical Institute and other governmental agencies (chiefly the National Planning Department). A detailed description of this database and of the criteria for identifying the zones is found in Molina et al (2005).

Extraction rates are coefficients that allow adjusting the volume of raw production to production in its "final" form (meaning the form in which the product is considered in the model). These come from different sources, but especially from Colombian private specialized organizations. Lastly, data on harvested areas per product at the municipality level were obtained from the Colombian Ministry of Agriculture. Given that there is no general information on the age of crops, when it would be relevant, it was decided to work on the basis of annual average yields for the whole cultivation cycle.

The demand module identifies demand regions and provides data on quantities demanded and prices. Identification of demand regions implied an analysis of consumption patterns at the final consumer level to determine regional differences that are significant and may impinge upon price discovery. This way, it is expected that prices taken in the main urban center of each demand region adequately represent price levels for the whole region. Quantities demanded at the final consumption level (at the urban level) where determined from the Colombian National Income and Expenditures Survey 1995. Rural consumption was taken from Nutritional Surveys and both urban and rural final consumption were adjusted on a per capita basis to get to the base year and for getting total demand by region, using population growth rates coming from the literature on Colombian demographics. For products that are basically used as inputs, quantities demanded were estimated from the 2001 Colombian Annual Manufacturing Survey. A description of the procedure followed is provided in Villarreal (2005).

The transportation module is the simplest one. It contains data on transport fares per metric ton per kilometer, for cargo coming by road into the main urban market within each demand region. According to the Colombian Ministry of Transportation, transport fares have been found to differ according to the destination market and the database makes use of this variability. On the other hand, there is data on road distances between a baricentric point for each production zone and the main urban market within each demand region. As mentioned, in the case of exports distances were calculated as the average between each baricenter and the two main Colombian maritime ports.

5. Spatial Structure of Colombian Agricultural Supply and Demand

Excluding plant fibers and cut flowers, the composition of Colombian agriculture in terms of raw production shows that 56.7% of total production is due to sugar cane, followed by fruits with 11%, milk with 10%, and starchy roots with 8.8%. The lowest shares are found for pulses and fish and seafood, each with 0.3%, oil crops and eggs, each with 0.6%, and stimulants (coffee, cocoa, and spices) with 1.2%.

If fisheries goods, cut flowers, and livestock and animal products are excluded, so that we are left with the set of product groupings that are of interest for this research, raw production reached 50.94 million metric tons in 2001, representing 86.5% of total Colombian agricultural production.

The set of 34 products included in the transportation model database, roughly represent 99.4% of the 50.94 million metric tons. However, disregarding export bananas and sugar cane, this share decreases to around 30%. Recalling that export bananas and sugar cane are crops with practically no chance of relocation, the set of products selected for the study represent the bulk of products that may suffer some form of relocation arising from the trade shock (as a matter of fact, the 88.1% of them).

As shown in Table 1, among the 18 production zones, the Alto Magdalena zone has the highest share in production volume for the set of products included in the model. It is followed by the Sabanas and the Andina Central zones, accounting the three of them for 53.1 percent. The intensity with which these zones are cultivated, measured as cultivated area as a percentage of their total arable land, is 47.2%, 13.4%, and 110.5%, respectively. For the last two zones, this pattern highlights well known problems for Colombian agriculture. In the case of the Sabanas zone it is indicative of its high under exploitation for the most appropriate uses and of (although not evident from the data presented here) its usage for extensive livestock operations that seem to be damaging for the soil. In the case of the Andina Central zone, it is indicative of over exploitation of land resources as the intensity index signals that areas that should be under protection (as reserves or under other forms of protection) are actually being cultivated.

Table 1. Production Shares for the 18 Production Zones in the Model

Production Zone	Production Share	Production Zone	Production Share
Alto-Magdalena	19.2	Andina-Antioquia	3.0
Sabanas	17.5	Orinoquia	2.0
Andina-Central	16.3	Piedemonte	1.9
Andina-Santander	7.5	Andina-Norte	1.9
Meta	6.7	Andina-Nariño	1.7
Medio-Magdalena	5.4	Uraba	1.5
Sierra	5.0	Pacifica-Nariño	1.2
Eje-Cafetero	4.5	Altiplano	0.9
Valle	3.1	Andina-Cauca	0.6

Source: Transportation Model Database

The rest of production zones have relatively low shares in physical production, especially the Pacifica Nariño, Altiplano, and Andina Cauca zones. In general, intensity indexes for these zones show that there is relatively ample room for extending agricultural exploitation in them, at least from the standpoint of the set of products covered here, as they are below 37.3%. However there is an exception to this. The Eje Cafetero zone, a region located in the middle ranges of the Central Andean Chain, both in terms of altitude and latitude, and intensively devoted to coffee production, has an intensity index close to 96%.

Grouping the 34 products according to the GTAP database classification, there are six groupings in the transportation model database: rice (one product), cereals (two products), fruits and vegetables (26 products), oil crops (two products), sugar (one product), and other crops (two products). Appendix 3 provides the list of products belonging to each product grouping. The highest share in physical production belong to fruits and vegetables (70.8%), followed by rice (10.7%), and cereals (10%). The remaining groups have the following shares: oil crops, 4.3%; sugar, 1.2%, and other crops, 3%.

From the standpoint of each product grouping, production tends to be relatively concentrated in a few zones. As table 2 shows, oil crops is the most geographically concentrated as the four zones included in the table comprise 91.2% of total production. Sugar is the second one, with 90% of total production concentrated in the four zones shown in the table, and rice is the third one with 88.2%. For the three groups remaining, the four zones included in their respective sections of the table, concentrate between 67.8% and 69.6% of total production.

Table 2. Main Production Zones' Shares in Physical Production by Product Group

Rice		Cereals		Fruits and Vegetables	
Zone	Share	Zone	Share	Zone	Share
Alto-Magdalena	35.1	Sabanas	34.1	Andina-Central	22.1
Meta	27.6	Alto-Magdalena	14.9	Alto-Magdalena	18.5
Sabanas	15.3	Sierra	10.7	Sabanas	17.4
Orinoquia	10.2	Medio-Magdalena	8.1	Andina-Santander	8.9
Oil Crops		**Sugar**		**Other Crops**	
Zone	Share	Zone	Share	Zone	Share
Meta	40.6	Andina-Central	39.1	Eje-Cafetero	24.3
Medio-Magdalena	25.0	Alto-Magdalena	32.8	Alto-Magdalena	18.0
Sierra	17.3	Andina-Santander	11.4	Andina-Santander	16.8
Pacifica-Nariño	8.2	Andina-Antioquia	6.8	Valle	10.4

Source: Transportation Model Database

As the base year represents the initial spatial equilibrium, the composition of consumption exactly matches that of production in terms of product groupings as well as of individual products. Export markets are of significance only for fruits and vegetables, oil crops, and other crops, representing 1.2%, 8.5%, and 86.5% percent of total demand in volume.

Domestic demand tends to concentrate in the Centro region where most of the population of the country is located. However its degree of dominance over quantities demanded varies by product grouping, reflecting regional variation in consumer tastes and location for manufacturing demand in the case of inputs. The Centro region represents 29.5% of total demand; the Caribe region represents 16.4%, the Pacifico region 15.2%, and the Antioquia region 13.6%. The rest of regions account for the remaining 25.3% of total demand. Table 3, bellow, shows markets' shares in demand by product grouping.

Table 3. Markets' Shares in Quantities Demanded by Product Grouping

Market	Rice	Cereals	Fruits and Vegetables	Oilcrops	Sugar	Other Crops
Antioquia	12.4	16.7	14.0	11.9	10.0	3.0
Caribe	24.2	21.7	15.1	20.9	1.8	0.6
Centro	32.9	26.0	30.3	29.5	44.9	4.1
Eje Cafetero	4.8	1.0	8.5	4.2	4.5	2.1
Llanos-Amazonia	2.0	3.7	8.3	3.8	1.7	0.5
Pacifico	18.1	22.9	14.1	16.6	13.6	2.3
Santanderes	5.6	8.1	8.6	4.7	23.4	1.0
Exports	0.0	0.0	1.2	8.5	0.0	86.5

Source: Transportation Model Database

Lastly, Table 4 shows distances in kilometers between production zones and regional markets. Alto Magdalena, the zone with the highest share in physical production, has Centro as its closest regional market (which is the biggest domestic market). The Sabanas zone, with the second largest share in production, is closer to the Caribe regional market, the second largest domestic market. The Andina Central production zone is closer to the Centro regional market.

Table 4. Distances Between Production Zones and Regional Markets (Kms.)

Production Zone	Market							
	Antioq.	Caribe	Centro	Eje Cafetero	Llanos-Amazon.	Pacifico	Santand.	Exports
Altiplano	456	990	42	1096	158	482	422	807
Alto-Magd.	669	1436	387	417	503	571	762	1075
Andina-Ant.	35	802	449	236	591	491	409	718
Andina-Cau.	590	1399	671	411	787	173	1110	857
Andina-Cen.	455	989	41	335	157	481	421	806
Andina-Nar.	831	1650	922	662	1038	448	1361	1120
Andina-Nor.	593	956	614	1009	795	1163	221	1131
Andina-San.	795	1181	218	512	359	658	369	991
Eje-Cafetero	213	1066	306	12	458	236	559	722
Medio-Magd.	479	674	485	652	660	1028	105	922
Meta	613	1475	173	503	57	585	612	1101
Orinoquia	1018	1404	439	796	351	950	565	1248
Pacifica-Nar.	859	1678	950	690	1066	476	1389	1148
Piedemonte	924	1892	562	620	706	564	1029	1299
Sabanas	465	230	1003	669	1119	867	603	620
Sierra	880	474	978	1308	1094	1462	539	1039
Uraba	605	588	1157	909	1273	1147	1431	939
Valle	501	1257	485	269	573	45	968	722

Source: Transportation Model Database

Detailed data on the spatial structure depicted here is provided in Appendix 4.

6. Trade Liberalization Effects

Simulation of trade liberalization with the CGE model shows that the Colombian economy is bound to negligibly lose welfare. The loss amounts to 0.1% of GDP and is largely determined by deterioration in terms of trade. While allocative efficiency gains are positive, they are insufficient to compensate for terms of trade losses.

Table 5 shows the contribution of agricultural sectors to overall welfare results. Figures in the first and second columns represent allocative efficiency and terms of trade effects in

2001 millions (equivalent variation). The third column corresponds to the share of each sector line in the overall welfare result. A negative figure indicates a positive contribution to welfare while a positive figure indicates a negative contribution. From these figures it is clear that the weight of the agricultural sector in determining welfare results is relatively important.

Table 5. Contribution of Agricultural Sectors to Welfare Results

Sector	Allocative Efficiency	Terms of Trade	Share in Total Welfare
Paddy Rice	8.0	-0.3	-9.6
Wheat	-3.7	-0.4	5.2
Cereals	11.8	-1.1	-13.4
Fruits and Vegetables	-0.6	-5.7	8.0
Oil Crops	6.0	0.3	-7.9
Sugar	1.9	-4.2	2.9
Vegetable Fibers	-0.1	-0.1	0.3
Other Crops	0.8	26.9	-34.7
Livestock	0.0	-1.3	1.6
Raw Milk	0.0	0.0	0.0
Animal Fibers	0.0	0.0	0.0
Wood and Wood Products	-0.1	-1.0	1.4
Meat and Processed Meat	75.5	-0.5	-94.2
Vegetable Oils	19.3	-1.3	-22.6
Milk and Dairy	5.7	-1.2	-5.6
Processed Rice	1.0	0.2	-1.5
Processed Foods	3.3	-15.4	15.2
Total Agriculture	128.7	-5.2	-155.1

Source: CGE simulation
First and second columns in 2001 million dollars. Figures in the third column are percentages.

Moving to changes in quantities produced, domestically demanded, and exported, and prices, Table 6 presents the relevant figures in percentage terms. The second column refers to domestic demand for domestically produced goods. The fourth column shows percentage changes in physical production for each sector. It is the result of the weighted sum of percentage changes in demand for domestically produced goods and exports. The last column shows percentage changes in market prices. The set of sectors that are included in the transportation model database are shown in italics.

Table 6. Percentage Changes in Physical Production and Prices for Agricultural Sectors

Sector	Demand (domestic)	Exports	Production	Prices
Paddy Rice	*-11.9*	*0.0*	*-11.9*	*-3.5*
Wheat	-20.9	0.0	-20.9	-5.3
Cereals	*-13.2*	*0.0*	*-13.2*	*-3.8*
Fruits and Vegetables	*-0.1*	*3.7*	*0.6*	*-1.1*
Oil Crops	*-12.9*	*-19.9*	*-12.9*	*-3.7*
Sugar	*-1.0*	*10.8*	*0.8*	*-2.7*
Vegetable Fibers	-5.0	1.0	-4.9	-2.1
Other Crops	*-0.9*	*22.1*	*14.3*	*1.6*
Livestock	-4.4	5.6	-4.2	-2.1
Raw Milk	-4.2	0.0	-4.2	-2.1
Animal Fibers	-13.1	0.0	-13.1	-3.6
Wood and Wood Products	-1.2	0.7	-1.0	-1.1
Meat and Processed Meat	-7.7	7.3	-7.6	-2.1
Vegetable Oils	-16.1	14.3	-14.6	-4.3
Milk and Dairy	-2.0	-1.6	-2.0	-1.7
Processed Rice	-0.2	0.0	-0.1	-4.1
Processed Foods	-1.1	11.0	0.6	-3.0

Source: CGE simulation

The set of changes presented in the above table, for the sectors of interest, are transmitted to the transportation model. To these, there is need to add percentage changes belonging to the sectors that include factors and inputs that are relevant for determining unit production costs for each individual product in the database.

7. The Spatial Impact of Trade Liberalization

As a result of trade liberalization, market prices for unskilled labor, skilled labor, fuels, chemical products, and machinery and equipment, fall in the range between 0.2% and 1.61%. As a consequence, unit production costs for the whole set of 141 technologies fall 1.1% as an average (with a 0.0015 coefficient of variation), impinging upon the spatial structure of Colombian agriculture.

On the demand side, Table 7 shows percentage changes in quantities demanded (of domestic production) and exported, as well as prices for the product groupings considered. These figures are obtained by following the procedure referred to in the methodology section. Descriptive statistics are provided for groups with more than one individual product.

Table 7. Percentage Changes in Quantities Demanded and Exported by Product Grouping

Product Group	Statistic*	Demand (dom.)	Exports	Price
Rice	Average	-11.9	0.0	-3.5
Cereals	Average	-21.7	0.0	-3.8
	Coeff. Var.	-0.71	0.0	0.0
	Max.	-10.8	0.0	-3.8
	Min.	-32.5	0.0	-3.8
Fruits and Vegetables	Average	0.1	0.3	2.3
	Coeff. Var.	21.0	1.1	1.1
	Max.	6.7	1.4	8.6
	Min.	-7.6	0.0	1.0
Oil Crops	Average	-35.3	-9.9	-3.7
	Coeff. Var.	-1.9	-1.4	0.0
	Max.	12.8	0.0	-3.7
	Min.	-83.4	-19.9	-3.7
Sugar	Average	62.7	0.0	2.8

Other Crops	Average	-9.2	13.6	1.6
	Coeff. Var.	-0.4	0.5	0.0
	Max.	-6.3	18.8	1.6
	Min.	-12.1	8.4	1.6

*Non-weighted

These changes in quantities demanded result in decreases in harvested areas for rice, cereals, oil crops, and other crops, ranging from 7.5% to 36.8%. Sugar and fruits and vegetables show increases in harvested areas (53.5% and 0.2%, respectively). In total, the harvested area increases almost 337,000 hectares, a 6.6% increase. These changes are reflected in the spatial dimension as Table 8 illustrates.

Table 8. Changes in Harvested Areas at the Production Zone Level

Production Zone	Harvested Area (percentage change)	Initial Share (in harvested area)	Final Share (in harvested area)	Initial Intensity	Final Intensity
Altiplano	-1.1	0.5	0.4	6.9	6.8
Alto-Magdalena	-0.2	19.3	18.1	47.2	47.1
Andina-Antioquia	-0.3	4.8	4.5	27.2	27.1
Andina-Cauca	0.0	2.7	2.6	37.3	37.3
Andina-Central	13.6	13.3	14.2	110.5	125.4
Andina-Nariño	-0.2	1.8	1.7	15.1	15.0
Andina-Norte	-25.0	1.5	1.1	9.1	6.8
Andina-Santander	-1.5	8.5	7.8	34.7	34.2
Eje-Cafetero	0.0	11.4	10.7	95.7	95.7
Medio-Magdalena	122.1	4.8	10.0	11.4	25.3
Meta	-1.7	6.1	5.6	21.3	20.9
Orinoquia	-55.6	1.6	0.6	5.0	2.2
Pacifica-Nariño	-2.7	1.6	1.5	6.4	6.2
Piedemonte	-17.5	1.6	1.2	5.1	4.2
Sabanas	21.0	8.1	9.2	13.4	16.2
Sierra	-3.8	5.7	5.1	8.6	8.3
Uraba	-44.6	1.0	0.5	8.5	4.7
Valle	-4.1	5.7	5.1	35.5	34.1

Source: transportation model simulation

Basically all production zones but two (Andina Cauca and Eje Cafetero) show changes in net harvested areas. However, seven of the remaining 16 production zones show decreases in harvested areas that represent less than a 3% change with respect to the base year. Therefore, the spatial effects of trade liberalization concentrate on nine production zones.

Among these, the Medio Magdalena zone is the one with the highest increase in harvested area, both in absolute and relative terms. It shows an increase of nearly 209,300 hectares (a 122.1% in relative terms) bringing the zone to move from a 4.8% share in total harvested area to a 10% share. The second largest increase in absolute terms corresponds to the Andina Central zone with about 64,600 hectares (a 13.6% increase), that reflects in a small share gain in total harvested area (from 13.3% to 14.2%). The third largest increase in harvested area, in absolute terms, belongs to the Sabanas zone. Its harvested area increases around 61,100 hectares, for a 1.1 percentage points gain in share (from 8.1% to 9.2%).

On the decreasing side, the decrease ordering in absolute terms follows the same pattern as the relative decrease ordering. The highest one is found for the Orinoquia zone with about 31,900 hectares, the second one belongs to the Uraba zone with almost 15,200 hectares, the third one corresponds to the Andina Norte with 13,800 hectares, and the fourth one to Piedemonte zone with nearly 10,100 hectares. However, all these zones show quite low shares in total harvested area.

The three zones with the highest initial shares in harvested area (Alto Magdalena, Andina Central, and Eje Cafetero) show an slight decrease, an important increase, and no change in harvested areas (-0.2%, 13.6%, and 0%, respectively). All in all, the spatial structure of agriculture, form the viewpoint of harvested areas, shows non negligible changes as a consequence of trade liberalization.

From the angle of the intensity with which production zones are cultivated (harvested areas in the products of interest as a percentage of the zone's total arable land), the above changes imply that the Andina Central zone will be more heavily over cultivated, showing an over use of more than 25% (an increase of almost 15 percentage points). The Eje Cafetero zone, the other region with a high intensity index, shows to changes in usage intensity given that its harvested area practically have no change.

It is also useful to see how the spatial structure of physical production changes. The difference between spatial changes in harvested areas and production is due to both differences in productivity among production zones and differences in extraction rates among products. Production changes are presented in Table 9, bellow.

Table 9. Changes in Volume of Production at the Production Zone Level

Production Zone	Physical Production (percentage change)	Initial Share (in production volume)	Final Share (in production volume)
Altiplano	-1.2	0.9	0.9
Alto-Magdalena	-0.3	19.2	19.5
Andina-Antioquia	-0.1	3.0	3.1
Andina-Cauca	0.0	0.6	0.6
Andina-Central	1.3	16.3	16.8
Andina-Nariño	-1.5	1.7	1.7
Andina-Norte	-7.5	1.9	1.8
Andina-Santander	-0.2	7.5	7.6
Eje-Cafetero	0.1	4.5	4.6
Medio-Magdalena	15.5	5.4	6.3
Meta	-1.1	6.7	6.7
Orinoquia	-59.9	2.0	0.8
Pacifica-Nariño	-6.2	1.2	1.1
Piedemonte	-18.4	1.9	1.6
Sabanas	2.6	17.5	18.3
Sierra	-6.3	5.0	4.7
Uraba	-42.1	1.5	0.9
Valle	-8.0	3.1	2.9

Source: transportation model simulation

Total production volume decreases in nearly 354,800 tons, a 1.7% decrease. The production zone with the largest increase in harvested area (Medio Magdalena) shows the largest increase in production: 177,900 tons (a 15.5% increase). The Andina Central zone, that registered the second largest increase in harvested area, shows a 1.3% increase in production, equivalent to almost 44,000 tones. The third largest growing zone in harvested area, the Sabanas zone, shows an increase close to 96,800 tones (a 2.6% increase). Besides these three zones, only the Eje Cafetero zone shows an increase in production volume; a negligible one though (920 tones or 0.1%).

The rest of production zones show decreases in production volumes (except the Andina Cauca zone that has no change). The biggest ones locate in zones with relatively low initial shares in total production; mainly in Orinoquia, Uraba, and Piedemonte. Basically all changes in zones' shares in production are lower than one percentage point. The only exception is Orinoquia, whose share decreases 1.18 percentage points. This implies that the change in the spatial distribution of production volumes is lesser than that of harvested areas. As a matter of fact, the standard deviation of changes in production shares is 0.47, while the corresponding to harvested areas is 1.41.

In terms of product groupings, losses in rice production concentrate in the Orinoquia zone (nearly 86% of them), amounting to 91.3% of production losses for the zone. Cereals production losses concentrate in the Uraba, Piedemonte, and Sabanas zones (27.8%, 26.7%, and 21.1%, correspondingly). This product group represents 56.4% and 100% of production losses for the Uraba and Piedemonte zones, while it is the only source of production losses for the Sabanas zone, which in net shows production gains. Fruits and vegetables production volume shows a net decrease, with seven zones increasing its production and nine decreasing it. The three zones contributing the most to this loss are Uraba, Sierra, and Orinoquia (with losses equivalent to around 400%, 270%, and 150% of net losses for the product group). These losses amount to 43.6% 61%, and 8.7% of the respective losses in total production for their zones.

In the case of oil crops, the group shows net production gains, but there are regions showing increases while others show decreases. The production zone determining the net increase in production is Medio Magdalena, with an increase equivalent to near 460% of the net production gain that accounts for almost 30% of the total production gain for the zone. The sugar group shows an increase in production, mainly associated to increases in two production zones: Medio Magdalena and Sabanas. In the case of Medio Magdalena, the production increase represents almost 74% of the group's increase and more than 66% of the zone's production increase. For the Sabanas zone, the corresponding figures are 26% and 42%, respectively. Lastly, the group other crops shows a net increase in production, with just one zone (the Andina Central zone) contributing positively to this result while five zones contribute negatively. The production increase in the Andina Central zone amounts to almost 107% of the net increase for the group and to 95% of the production increase for the zone.

Finally, for completeness, Table 10 shows changes in the value of production per zone. The table is constructed according to production levels for each product and zone as estimated by the transportation model, both in the pre CGE simulation (when it is given) and post CGE simulation (when it is estimated) versions. Production is valued using annual unit production costs, as determined according to the procedure depicted in the methodology section. Therefore, it is assumed that producers operate with zero benefits and that trade margins accrue to agents that do not belong to any production zone.

Table 10. Changes in Production Value at the Production Zone Level

Production Zone	Production Value (percentage change)	Initial Share (in production value)	Final Share (in production value)
Altiplano	-2.4	1.2	1.2
Alto-Magdalena	-1.6	21.6	21.6
Andina-Antioquia	-1.5	4.7	4.7
Andina-Cauca	-1.0	1.9	1.9
Andina-Central	6.6	12.8	13.8
Andina-Nariño	-1.5	1.9	1.9
Andina-Norte	-24.0	2.5	1.9
Andina-Santander	-1.7	8.6	8.5
Eje-Cafetero	-0.9	8.0	8.1
Medio-Magdalena	85.9	3.5	6.6
Meta	-4.4	8.0	7.8
Orinoquia	-79.2	3.0	0.6
Pacifica-Nariño	-6.2	1.1	1.1
Piedemonte	-29.7	1.4	1.0
Sabanas	8.0	8.4	9.2
Sierra	-6.0	5.3	5.0
Uraba	-49.9	1.1	0.6
Valle	-11.1	5.1	4.6

Source: transportation model simulation

As an average, changes in the value of production are relatively close to changes in the volume of production (-6.71% vs. -7.42%) and change variability roughly doubles that for the volume of production (a coefficient of variation of -4.73 vs. -2.35). However, at the individual production zone level, changes in the value of production do not necessarily follow the same direction or keep the same size that changes in the volume of production show. The zone with the highest increase in production level (Medio Magdalena) also shows the highest increase in the value of production and the zone with the highest decrease in production level (Orinoquia) also shows the highest decrease in the value of production. Nonetheless, zones with small increases or decreases in production levels show comparatively high increases or decreases in the value of production. Such is the case of the Andina Central zone, whose production level increases 1.3% while its value of production increases 6.6%; the Meta zone, whose production level decreases 1.1% and its production value decreases 4.4%; and the Andina Norte zone, whose production level decreases 7.5% but its production value decreases 24%.

In spite of what these changes may suggest, the adjustment in the regional structure in the value of production is lesser than that taking place in the regional structure of harvested areas. It is, however, more important than the adjustment in the regional structure of production volumes.

These results indicate that potential changes in the spatial structure of agricultural production in Colombia, arising as a consequence of trade liberalization, are not negligible and may have important implications in several dimensions. First, they entail significant changes, both positive and negative, in harvested areas that will have an impact on producers at the local level. Second, they may bring significant impacts on regional income brought about by both changes in harvested areas and changes in production costs. Third, they may change the relative importance of production zones from both the individual products perspective and the overall agricultural activity.

Data detailing changes at the product level are provided in the tables in Appendix 5.

8. Conclusions and Policy Implications

This research attempts to estimate the likely impact of discriminatory trade liberalization on the agricultural sector from a regional/spatial perspective. For this, an approach linking a computable general equilibrium model with a transportation model is proposed and implemented.

Results center around three dimensions: changes in harvested areas, changes in physical production levels, and changes in the value of production. These are tracked for both individual products and the whole set of products of interest by production zone. The results, presented in the previous section, highlight the following conclusions:

- Changes in the spatial structure of agriculture may be significant in the three dimensions explored. Total harvested areas may increase by 6.6%, implying percentage changes at the production zone level ranging from 122.1% to -55.6%. There is a negative change in total production volume of 1.7%, which translates in individual zones' changes between 15.5% and -60%. Lastly, the total value of production decreases 1.47%, leading to individual zones' changes from 85.9% to -79.2%.

- Although it is the general case, not necessarily all dimensions of these impacts move in the same direction for each production zone. As a matter of fact, there are production zones for which harvested areas and volume of production show slight increases while the value of production shows slight decreases. However, in all cases showing percentage changes above 0.1% (in absolute terms) the three variables explored move in the same direction.

- Percentage changes in the three dimensions analyzed, do not necessarily match in size. This is particularly true of changes in harvested areas and changes in production volumes, as the former tend to be sizably larger than the latter. In contrast, changes in harvested areas and in the value of production tend to be closer, especially for production zones that show gains.

- Gains and losses, in terms of percentage changes in the three dimensions, tend to concentrate in relatively few zones. Eight zones take the bulk of losses while three zones reap almost all benefits (leaving the remaining seven zones with relatively small impacts). This is an important result for policy design.

- Percentage changes in the three dimensions are high enough to sensibly modify production zones' hierarchies, even at the level of zones at the third to fifth ranking for values of production and harvested areas.

- From another perspective, potentially damaging environmental effects may take place in the Andina Central zone as a consequence of harvested area expansion. According to the estimates, harvested area could increase to over 25% above available arable land (a 15% increase with respect to the baseline).

The richness of these results illustrates the complexity that policies to ease the transition from the old to the new agricultural environment may have to be effective. There is clearly the need for these policies to have a product dimension, designed along the lines of each product's particular situation in terms of its competitiveness. Identifying winners and losers among the products may help in focusing policies on agents linked to them; whether for easing their transition or for helping them take advantage of the new opportunities.

However, policies also need a regional/spatial dimension as production zones encompass a mix of products that are winners or losers and the net result for a zone depend not only upon its particular mix but also on factors such as its relative competitiveness vis a vis other zones, its proximity to markets, etc. Having an estimation of the expected relative impact of trade liberalization on a particular production zone is instrumental for policy design. This is so from the point of view of the tradeoffs that a production zone faces, given its particular product mix, as well as from the point of view of the magnitude of these impacts as compared with those from other zones. In both senses, the results of this research provide valuable information for policy design.

References

Argüello, Ricardo and Ernesto Valenzuela. 2006. “Implicaciones en Acceso a Mercados”, Chapter 3 in Secretaría General de la Comunidad Andina (ed.) Las Negociaciones Hemisféricas y la Comunidad Andina. Evaluación de Impacto, Comunidad Andina-Banco Interamericano de Desarrollo, Lima, April

Botero, Jesus. 2005. Estimacion del impacto sobre el empleo de los tratados de libre comercio en Colombia; analisis de equilibrio general computable, Serie estudios y perspectivas, No. 8, Oficina de la Cepal en Bogota, July

Bourguignon, Francois, Anne Robilliard, and Sherman Robinson (2005) “Representative Versus Real Households in the Macroeconomic Modeling of Inequality”, in T.J. Kehoe, T.N. Srinivasan, and John Whalley (eds) Frontiers in Applied General Equilibrium Modelling, Cambridge, Cambridge University Press

Coady, David and Rebecca Harris (2001) “A Regional General Equilibrium Analysis of the Welfare Impact of Cash Transfers: An Analysis of Progresa in Mexico”, IFPRI, TMD Discussion Paper No. 76, Washington, D.C., June

Colombian Ministry of Transportation, http://www.mintransporte.gov.co/

Dantzig, George (1963) Linear Programming and Extensions, Princeton University Press

Dantzig, George and M.N: Thapa (1997) Linear Programming 1: Introduction, Springer, New York

Duran, Jose, Carlos de Miguel, and Andres Schuschny. 2006. Andean Countries and USA: how much can be expected from FTAs?, ECLAC, UN, Santiago

Elbers, Chris, Jean Lanjouw, and Peter Lanjouw (2003) “Micro Level Estimation of Poverty and Inequality”, Econometrica, 71(1): 355-364

Fujii, Tomoki and David Roland-Host (2008) “How Does Vietnam’s Accession to the World Trade Organization Change the Spatial Incidence of Poverty?”, World Bank, Policy Research Working Paper 4521, Washington, D.C., February

Haddad, Eduardo (2004) “Linking Inter-Regional CGE Models with Geo-Coded Transportation Network Infrastructure Models”, TD Nereus 04, University of Sao Paulo

Haddad, Eduardo and Geoffrey Hewings (2004) “Handling Market Imperfections in a Spatial Economy. A CGE Approach”, TD Nereus 10, University of Sao Paulo

Harris, Rebecca (1999) “The Distributional Impacts of Macroeconomic Shocks in Mexico: Threshold Effects in a Multi-Region CGE Model”, IFPRI, TMD Discussion Paper No. 44, Washington, D.C., January

Hillier, Frederic and Gerald Lieberman (2001) Introduction to Operations Research, seventh edition, McGraw Hill

Lofgren, Hans and Sherman Robinson (1999) "Spatial Networks in Multi-Region Computable General Equilibrium Models", IFPRI, TMD Discussion Paper No. 35, Washington, D.C., January

Martin, Clara and Juan M. Ramirez. 2005. Impacto economico de un acuerdo parcial de libre comercio entre Colombia y Estados Unidos, Serie estudios y perspectivas, No. 7, Oficina de la Cepal en Bogota, July

Molina, Juan et al (2004) "Componente Regional. Regionalizacion y Jerarquizacion: Aspectos Metodologicos", in Ricardo Arguello (coord.) Cuantificacion de los Beneficios y Costos de la Reconversion de la Agricultura Colombiana. Informe de Avance. Corporación Colombia Internacional, contrato DNP

Molina, Juan et al (2005) "Componente de Regionalizacion. Informe Final", in Ricardo Arguello (coord.) Cuantificacion de los Beneficios y Costos de la Reconversion de la Agricultura Colombiana. Informe Final. Corporación Colombia Internacional, contrato DNP

Pardo, Oliver, Alvaro Perdomo, Catalina Delgado, and Carolina Lozano. 2005. Colombia y el TLC: Efectos sobre la distribucion del ingreso y la pobreza, Archivos de Economia, No. 289, Departamento Nacional de Planeacion –DNP, Bogota, August

Samaca, Henry (2004) "Componente Costos de Produccion. Sistema de Costos de Produccion", in Ricardo Arguello (coord.) Cuantificacion de los Beneficios y Costos de la Reconversion de la Agricultura Colombiana. Informe de Avance. Corporación Colombia Internacional, contrato DNP

Samaca, Henry (2005) "Centro de Costos para el Modelo de Cuantificacion de Beneficios y Costos de la Reconversion Agropecuaria", in Ricardo Arguello (coord.) Cuantificacion de los Beneficios y Costos de la Reconversion de la Agricultura Colombiana. Informe Final. Corporación Colombia Internacional, contrato DNP

Tellez, Carlos (2004) "Componente Inteligencia de Mercados. Identificacion de Productos", in Ricardo Arguello (coord.) Cuantificacion de los Beneficios y Costos de la Reconversion de la Agricultura Colombiana. Informe de Avance. Corporación Colombia Internacional, contrato DNP

Villarreal, Alvaro (2005) "Componente Inteligencia de Mercados", in Ricardo Arguello (coord.) Cuantificacion de los Beneficios y Costos de la Reconversion de la Agricultura Colombiana. Informe Final. Corporación Colombia Internacional, contrato DNP

Appendix 1

Description of the Transportation Model

Pre CGE simulation transportation model

Sets

J	Crops
Z	Production zones
M	Markets
P(J)	Products (34 products defined over 141 crops –technologies)

Parameters

C(J)	Crops' cicles (years)
AC(J)	Crops' cicles per year (number per year)
Y(J)	Crops' yields per cicle (tons per ha per cicle)
CP(J)	Crops' production cost per cicle (Col$ per ha per cicle)
ER(J)	Extraction rate per crop
TR(M)	Transport cost rate per market (Col$ per km per ton)
HA(J,Z)	Harvested area (cultivated area in ha per zone)
D(Z,M)	Distance between production zones and markets (km)
QD(J,M)	Initial quantity demanded per market (tons per year)
DP(J,M)	Initial demand price per market (Col$ per ton)
EXR	Exchange rate (Col$ per US$)
AY(J)	Annual yields (ay(j) = (y(j) / c(j))) (tons)
QP(J,Z)	Annual quantity of crop j produced in zone z (qp(j,z) = ay(j) * ha(j,z) * er(j)) (tons)
UCC(J)	Unit cost per cicle (ucc(j) = (cp(j) / exr) / y(j)) (US$ per ton)
AUC(J)	Annual unit cost (auc(j) = ucc(j) * ac(j)) (US$ per ton per year)
TC(Z,M)	Unit transport cost (tc(z,m) = (tr(m) / exr) * d(z,m)) (US$ per ton per km)

Variables

TF(J,Z,M)	Trade flow of product j from zone z to market m (tons)
NR	Net revenue

Equations

Objetive function: NR

$$NR = \sum_j \sum_z \sum_m [(dp(j,m) \div exr) - auc(j) - tc(z,m)] \times tf(j,z,m)$$

Constraints:

Supply: $\forall j, z$

$$\sum_m tf(j,z,m) \leq qp(j,z)$$

Demand: $\forall p, m$

$$\sum_{z}\sum_{p} tf(p,z,m) = \sum_{p} qd(p,m)$$

Post CGE simulation transportation model

Sets

J	Crops
Z	Production zones
M	Markets
P(J)	Products (34 products defined over 141 crops –technologies)
QDDOWN(J)	Crops with lower new demand
QDUP(J)	Crops with higher new demand

Parameters

C(J)	Crops' cicles (years)
AC(J)	Crops' cicles per year (number per year)
Y(J)	Crops' yields per cicle (tons per ha per cicle)
CP1(J)	Crops' new production cost per cicle (Col$ per ha per cicle)
ER(J)	Extraction rate per crop
TR(M)	Transport cost rate per market (Col$ per km per ton)
HA(J,Z)	Harvested area (cultivated area in ha per zone)
D(Z,M)	Distance between production zones and markets (km)
QD(J,M)	Initial quantity demanded per market (tons per year)
QD1(J,M)	Final quantity demanded per market (tons per year)
DP1(J,M)	Final demand price per market (Col$ per ton)
EXR	Exchange rate (Col$ per US$)
AY(J)	Annual yields (ay(j) = (y(j) / c(j))) (tons)
QP(J,Z)	Annual quantity of crop j produced in zone z (qp(j,z) = ay(j) * ha(j,z) * er(j)) (tons)
UCC1(J)	New unit cost per cicle (ucc1(j) = (cp1(j) / exr) / y(j)) (US$ per ton)
AUC1(J)	New annual unit cost (auc1(j) = ucc1(j) * ac(j)) (US$ per ton per year)
TC(Z,M)	Unit transport cost (tc(z,m) = (tr(m) / exr) * d(z,m)) (US$ per ton per km)
DELTAQD(J,Z,)	Change in total quantity demanded (deltaqd(j,z) = sum(m, qd1(j,m) - qd(j,m))

Variables

TF1(J,Z,M)	Trade flow of product j from zone z to market m (tons)
NR1	Net revenue

Equations

Objetive function: NR1

$$NR1 = \sum_{j}\sum_{z}\sum_{m}[(dp1(j,m) \div exr) - auc1(j) - tc(z,m)] \times tf1(j,z,m)$$

Constraints:

Supply1: $\forall qddown, z$

$$\sum_{m} tf1(qddown,z,m) \leq qp(qddown,z)$$

Supply2: $\forall qdup, z$

$$\sum_{m} tf1(qdup,z,m) \leq qp(qdup,z) + deltaqd(qdup,z)$$

Supply3: $\forall qdup, z$

$$\sum_{m} tf1(qdup,z,m) \geq qp(qdup,z)$$

Demand: $\forall p, m$

$$\sum_{z}\sum_{p} tf1(p,z,m) = \sum_{p} qd1(p,m)$$

Appendix 2

Description of the procedure for allocating sectoral changes to individual products

1. Initial data consistency requirement:

$$ShrD_{GTAP} \approx ShrD_{TM} \text{ and } ShrX_{GTAP} \approx ShrX_{TM}$$

Where, $ShrD_{GTAP}$ and $ShrX_{GTAP}$ are the share of demand for domestically produced goods and the share of expors for a GTAP sector and $ShrD_{TM}$ and $ShrX_{TM}$ are the corresponding shares for the set of products included and not included in the transportation model database, that belong to the GTAP sector, and

$$ShrD_{TM} = \sum_i ShrD_{TM_i} + \sum_j ShrD_{TM_j}$$

$$ShrX_{TM} = \sum_i ShrX_{TM_i} + \sum_j ShrX_{TM_j}$$

$$\sum_i ShrD_{TM_i} + \sum_j ShrD_{TM_j} + \sum_i ShrX_{TM_i} + \sum_j ShrX_{TM_j} = 1$$

Where, i is the set of products belonging to the GTAP sector that are included in the transportation model database and j is the set of products belonging to the GTAP sector that are not included in the transportation model database.

2. Individual Products Classification

For each group of products, classification among exportables, importables, and non-tradables is done on the basis of the net trade position of the individual product.

3. Allocating Changes from the CGE to Individual Products

Allocation is done first for exportable products. The consistency rule that must be followed is:

$$dqx_{GTAP} \times ShrX_{GTAP} = \sum_i dqx_i \times ShrX_i + \sum_j dqx_j \times ShrX_j$$

and

$$\sum_i dqx_i \times ShrX_i = \sum_i \varepsilon_i \times dp_i \times ShrX_i$$

$$\sum_j dqx_j \times ShrX_j = \sum_j \varepsilon_j \times dp_j \times ShrX_j$$

Where, dqx is the percentage change in quantity exported, Ɛ is the product's supply elasticity, dp is the percentage change in price, and the rest is as defined above.

For exportables, the following must also hold:

$$dqd_i = \mu_i \times dp_i$$
$$dqd_j = \mu_j \times dp_j$$

Where, dqd is the percentage change in quantity demanded in the domestic market, and μ is the product's demand elasticity.

Non tradables are assumed to get the same quantity and price changes as the GTAP sector as a whole. Therefore, the following must hold:

$$dqd_{GTAP} = dqd_l = k, \forall l, k$$
$$dp_{GTAP} = dp_l = dp_k, \forall l, k$$

Where l is the set of non-tradables included in the transportation model database and k is the set of non-tradables not included.

Lastly, percentage price changes are found for the set of importable products, such that:

$$\begin{aligned} dqd_{GTAP} \times ShrD_{GTAP} \\ &= \sum_i dqd_i \times ShrD_i \\ &+ \sum_j dqd_j \times ShrD_j \\ &+ \sum_l dqd_l \times ShrD_l \\ &+ \sum_k dqd_k \times ShrD_k + \sum_g dqd_g \times ShrD_g + \sum_h dqd_h \times ShrD_h \end{aligned}$$

Where, g is the set of importables that are included in the transportation model database and h is the set of importables not included, and

$$\sum_g dqd_g \times ShrD_g = \sum_g \mu_g \times dp_g \times ShrD_g$$
$$\sum_h dqd_h \times ShrD_h = \sum_h \mu_h \times dp_h \times ShrD_h$$

Where μ is the demand elasticity and the rest of variables are as defined above.

As mentioned in the text, the corresponding price and quantity changes at the individual product level apply to all domestic markets equally.

Appendix 3

List of Products Included in the Transportation Model Database and their Corresponding GTAP Product Groupings

GTAP Code	GTAP Name	Products Included	Product Code
1	Paddy rice	Rice	Rice
3	Cereals	Corn, Sorghum	Corn, Sorg
4	Fruits and vegetables	Avocado, Hot pepper, Garlic, Green beans, Bananas, Onions, Shallots, Citrus fruits, Strawberry, Red beans, Physalys, Sour sop, Guava, String beans, Lulo, Mango, Passion fruit, Black berry, Potato, Papaw, Pineapple, Plantain, Tomato, Tree tomate, Cassava, Carrot	Avoc, Hpep, Garl, Gbea, Bana, Onio, Shal, Citr, Stra, Rbea, Phys, Ssop, Guav, Sbea, Lulo, Mang, Pass, Bber, Pota, Papa, Pine, Plan, Toma, Tarb, Cass, Carr
5	Oil seeds	Oil palm, Soy beans	Palm, Soyb
6	Sugar	Molasses	Mola
8	Other crops	Cocoa, Coffee	Coco, Coff

Appendix 4

Table A4.1 Harvested Areas by Product and Zone (has)

Product	Production zone								
	Altiplano	Alto-Magdalena	Andina-Antioquia	Andina-Cauca	Andina-Central	Andina-Narriño	Andina-Norte	Andina-Santander	Eje-Cafetero
Avoc		3,706	839		149		62	2,985	843
Hpep									19
Garl			1				12	47	
Rice		81,644	65				6,482	4,925	
Gbea	2,742	1,453	120		1,096	1,730	117	3,310	77
Bana		3,899	261		13,894		1,042		1,878
Coco		4,276	1,375	43	1,113		10,368	4,450	1,221
Coff		187,598	101,505	80,989	7,141	25,931		164,639	338,450
Mola		138,343	28,568	8,771	230,153	11,716	12,161	48,156	
Onio	298	45	10		110	58	1,520	1,928	5
Shal		33	51		8		6	205	2
Citr		5,764	1,406	46				116	
Stra	10,488		48		3,900		64	41	1
Rbea	618	13,281	6,227	526	485	3,312	2,419	8,594	1,034
Phys		2,663	146		120		1	80	772
Ssop		1,450	170		593		6	28	82
Guav		3,013	1,020		67,116		10	5,644	447

Continue

Table A4.1 Harvested Areas by Product and Zone (has) - Continued

Product	Production zone								
	Altiplano	Alto-Magdalena	Andina-Antioquia	Andina-Cauca	Andina-Central	Andina-Nariño	Andina-Norte	Andina-Santander	Eje-Cafetero
Sbea	63	560	130		457		43	280	79
Lulo		10,979		111	2,113		59	280	732
Corn	153	27,335	2,787	1,023	8,096	2,630	4,055	10,335	2,813
Mang		4,722	1,491	11	27,449		7	21	
Pass		20,150	162	5	4,680		159	151	400
Bber7		5,241	866	243	23,674	108	501	1,298	577
Palm							170		
Pota	1,632	1,156	6,753	11	4,680	11,003	1,181	20,355	
Papa		2,246		13			141	310	107
Pine		1,033	28			129	102	1,908	257
Plan		142,578	15,714	5,664	63,623	6,558	12,481	11,783	55,306
Sorg		19,080							141
Soyb		83							75
Tarb		4,863	1,770	6	11,865	75	392	693	152
Toma	20	2,723	365	70	518	252	1,063	1,017	747
Cass	30	531			3,458		430	9,033	591
Carr	255	37	724		104	665	106	354	4

Continue

Table A4.1 Harvested Areas by Product and Zone (has) - Continued

Product	Production zone								
	Medio-Magdalena	Meta	Orinoquia	Pacifica-Nariño	Piedemonte	Sabanas	Sierra	Uraba	Valle
Avoc	20					239	1,104	152	721
Hpep						214	182		259
Garl									2
Rice	6,216	75,949	29,072		121	39,508	8,896	2,739	3,742
Gbea									95
Bana	173			250			11,200	310	3,631
Coco	21,852	542	6,072	9,460	391	96	2,739	2,205	292
Coff	22,053	13,402		13,345	16,530		84,344		145,879
Mola	992	563	1,133	3,606	3,222	612	1,014		5,277
Onio	39					40	168		65
Shal						37			273
Citr	3,604					12,238	1,825		82
Stra									
Rbea	444	672		160	121	1,925	4,065	34	446
Phys									441
Ssop						69			229
Guav	341	66				2,938			892

Continue

Table A4.1 Harvested Areas by Product and Zone (has) - Continued

Product	Production zone								
	Medio-Magdalena	Meta	Orinoquia	Pacifica-Nariño	Piedemonte	Sabanas	Sierra	Uraba	Valle
Sbea	65	9				39			191
Lulo		17			151		574		666
Corn	21,934	17,484	5,512	959	13,871	120,619	27,323	10,510	12,194
Mang	95					7,844	1,635		212
Pass	165	86				363	147	5	892
Bber7	147						466		901
Palm	57,173	78,335	2,401	18,721	394	10,800	39,565		
Pota				3,756					6
Papa	132	251	185			1,553	472	57	219
Pine	7,540	2,081	28		482			25	980
Plan	9,499	13,075	11,209	7,111	22,186	39,562	5,287	17,999	13,983
Sorg	6,960	109				2,675	5,692		4,110
Soyb		14,184							5,882
Tarb	13	8		124			572		372
Toma	156	368		19		213	977		715
Cass	11,851					49,275	5,289		584
Carr				20					19

Table A4.2 Production by Product and Zone (Tons)

Product	Production zone								
	Altiplano	Alto-Magdalena	Andina-Antioquia	Andina-Cauca	Andina-Central	Andina-Narriño	Andina-Norte	Andina-Santander	Eje-Cafetero
Rice		796,031	488				29,169	41,555	
Corn	638	202,718	11,625	10,711	33,770	10,972	16,915	67,063	9,127
Sorg		114,593							1,158
Avoc		28,561	8,247		1,763		610	35,323	8,292
Hpep									486
Garl			16				166	680	
Gbea	23,993	9,151	1,440		8,709	7,783	527	39,720	920
Bana		36,495	2,443		130,043		9,753		17,583
Onio	10,651	900	494		5,753	2,760	54,425	92,556	90
Shal		1,014	5,508		864		990	22,140	227
Citr		86,460	18,985	804				1,740	
Stra	97,892		446		36,400		593	383	9
Rbea	2,962	44,588	22,399	1,387	2,325	15,886	11,602	41,217	3,719
Phys		21,304	949		783		7	520	5,018
Ssop		10,750	1,088		3,792		38	179	608
Guav		77,421	23,154		1,523,533		227	128,107	10,144
Sbea		796,031	488				29,169	41,555	

Continue

Table A4.2 Production by Product and Zone (Tons) - Continued

Product	Production zone								
	Altiplano	Alto-Magdalena	Andina-Antioquia	Andina-Cauca	Andina-Central	Andina-Nariño	Andina-Norte	Andina-Santander	Eje-Cafetero
Lulo	1,811	16,214	3,780		15,902		1,243	8,114	2,276
Mang		65,871		663	9,509		266	1,260	3,256
Pass		36,830	11,630	106	263,511		67	202	
Bber		268,667	3,240	100	56,160		1,908	1,812	7,994
Pota		50,314	6,079	1,944	166,191	759	3,514	10,384	4,615
Papa	34,262	13,756	175,046	131	98,270	166,140	30,605	500,943	
Pine		25,949		173			1,877	4,133	1,427
Plan		44,075	1,173			5,504	4,352	81,417	10,944
Tarb		1,710,935	188,572	67,967	763,479	78,696	149,770	141,398	663,672
Toma		58,353	23,595	80	158,197	997	5,220	9,244	2,033
Cass	841	163,535	19,711	3,784	27,994	13,622	57,460	54,972	31,396
Carr	480	9,696			55,328		6,880	144,528	14,765
Palm	14,688	1,480	55,588		5,962	38,275	8,122	27,149	307
Soyb							689		
Mola		339							318
Coco		83,670	17,278	5,304	99,685	5,074	5,267	29,125	
Coff		2,001	289	9	234		2,177	934	528

Continue

Table A4.2 Production by Product and Zone (Tons) - Continued

Product	Production zone								
	Medio-Magdalena	Meta	Orinoquia	Pacifica-Nariño	Piedemonte	Sabanas	Sierra	Uraba	Valle
Rice	60,606	626,579	231,118		1,175	348,160	78,396	22,593	33,680
Corn	134,197	133,483	42,079	7,108	102,867	715,608	202,627	77,938	127,733
Sorg	38,586	604				12,357	26,297		33,797
Avoc	154					1,842	10,856	1,171	5,554
Hpep						5,136	4,362		6,726
Garl									29
Gbea									598
Bana	1,619			2,340			292,562	8,098	33,987
Onio	1,950					2,013	3,350		1,298
Shal						1,137			8,387
Citr	54,060					237,111	27,375		1,425
Stra									
Rbea	1,276	1,934		535	405	5,540	11,698	98	1,178
Phys									3,525
Ssop						512			1,700
Guav	8,764	1,696				75,507			22,917
Sbea	60,606	626,579	231,118		1,175	348,160	78,396	22,593	33,680

Continue

Table A4.2 Production by Product and Zone (Tons) - Continued

Product	Production zone								
	Medio-Magdalena	Meta	Orinoquia	Pacifica-Nariño	Piedemonte	Sabanas	Sierra	Uraba	Valle
Lulo	1,884	246				1,116			5,524
Mang		142			903		4,783		2,962
Pass	741					61,183	12,753		1,651
Bber	2,200	1,032				4,538	1,838	59	12,665
Pota	1,411						3,728		8,652
Papa				61,974					71
Pine	660	1,255	925			7,765	2,360	377	2,526
Plan	321,707	88,789	1,195		20,555			1,071	41,813
Tarb	113,992	156,900	134,508	85,332	266,232	474,744	63,444	215,993	167,794
Toma	156	96		827			3,813		2,479
Cass	9,339	22,102		1,483		12,778	58,679		30,040
Carr	142,212					1,724,639	63,468		10,658
Palm				576					547
Soyb	231,646	317,386	9,728	75,851	1,596	43,758	160,304		
Mola		58,785							25,110
Coco	600	341	685	2,181	1,949	370	439		3,192
Coff	10,227	254	2,623	4,087	183	41	1,183	953	61

Table A4.3 Quantity Demanded by Product and Market (tons)

Product	Market							
	Antioquia	Caribe	Centro	Eje Cafetero	Llanos-Amazonia	Pacifico	Santanderes	Exports
Rice	281,040	550,078	745,860	107,987	46,193	411,107	126,969	314
Corn	356,774	398,822	430,786	20,810	76,079	453,166	170,717	25
Sorg	21	64,140	124,084	187	2,175	34,762	2,025	0
Avoc	5,620	47,450	19,148	3,297	0	11,145	15,713	0
Hpep	1,446	1,565	4,579	722	211	6,912	1,276	0
Garl	16	199	178	18	14	142	67	256
Gbea	14,930	999	57,084	1,963	2,349	10,238	5,275	0
Bana	399,366	128,870	4,064	377	251	1,420	575	0
Onio	36,372	19,044	7,724	33,928	22,627	5,208	43,664	7,673
Shal	2,267	1,116	19,360	3,283	1,657	9,922	2,662	0
Citr	37,871	30,897	198,547	20,226	22,505	73,382	43,915	618
Stra	4,983	1,871	90,393	8,854	7,010	17,541	4,992	80
Rbea	27,862	18,204	55,060	9,073	3,029	44,383	11,058	80
Phys	2,004	0	4,125	5,260	0	17,836	2,561	318
Ssop	2,105	870	8,470	1,243	406	2,499	3,075	0
Guav	185,116	301,594	919,068	65,374	34,416	168,550	197,353	0
Sbea	3,199	288	38,433	811	0	5,693	9,686	0

Continue

Table A4.3 Quantity Demanded by Product and Market (tons) - Continued

Product	Market							
	Antioquia	Caribe	Centro	Eje Cafetero	Llanos-Amazonia	Pacifico	Santanderes	Exports
Lulo	741	12,071	50,993	4,194	3,304	17,413	898	0
Mang	49,323	103,166	81,214	20,839	7,658	116,545	5,208	4,720
Pass	29,639	35,994	127,584	46,937	12,325	92,902	16,649	181
Bber	16,861	16,688	127,618	14,397	7,843	40,294	33,889	0
Pota	101,428	54,480	595,165	42,507	30,699	152,883	71,804	32,232
Papa	3,099	2,075	25,562	2,621	822	8,019	6,781	448
Pine	47,835	63,128	267,320	27,565	18,220	138,239	60,231	57
Plan	712,075	654,911	953,122	833,670	1,004,399	803,502	354,103	127,643
Tarb	75,094	67,978	186,459	33,965	15,332	80,487	46,532	1,886
Toma	110,814	12,804	110,736	2,619	175	16,951	10,992	0
Cass	217,338	683,706	547,112	82,701	52,307	259,922	329,260	308
Carr	25,667	13,781	61,161	9,360	4,863	26,763	10,949	151
Palm	97,725	175,922	253,126	33,879	27,024	134,479	40,471	78,333
Soyb	12,020	17,820	19,615	4,595	8,032	19,173	3,299	0
Mola	25,637	4,628	114,666	11,416	4,357	34,766	59,690	0
Coco	8,445	189	10,693	2,038	230	2,823	506	858
Coff	10,573	3,462	15,259	11,110	3,054	11,788	5,595	547,102

Table A4.4 Demand Prices by Product and Market (Col$ per ton)

Product	Market							
	Antioquia	Caribe	Centro	Eje Cafetero	Llanos-Amazonia	Pacifico	Santanderes	Exports
Avoc	1,389,348	1,101,398	1,524,501	1,414,645	1,120,778	1,629,459	1,651,766	1,348,394
Hpep	741,264	639,143	506,163	1,194,414	915,029	1,502,892	791,982	1,007,936
Garl	1,656,185	2,731,067	1,894,403	1,557,989	2,270,812	2,518,865	2,104,887	2,312,064
Rice	1,161,598	1,029,858	1,078,424	1,169,418	1,121,139	1,060,153	1,013,278	1,075,196
Gbea	1,034,101	68,182	1,803,913	1,397,486	1,733,265	1,081,710	1,448,126	1,551,198
Bana	299,373	211,988	387,622	423,484	360,173	284,944	446,657	279,227
Coco	2,380,000	2,380,000	2,309,000	2,281,000	2,275,000	3,191,000	2,323,000	2,431,172
Coff	7,022,757	6,822,693	138,077	7,884,584	143,137	6,720,000	136,506	4,404,796
Mola	1,078,292	1,083,244	1,044,465	1,147,096	65,419	1,072,685	1,064,777	1,045,037
Onio	888,833	802,000	803,667	836,134	1,097,192	799,083	949,648	905,462
Shal	1,103,540	862,480	868,924	586,617	919,299	935,560	541,149	855,763
Citr	613,497	445,406	552,596	253,773	370,896	389,649	357,436	478,496
Stra	3,549,078	2,513,128	3,364,906	3,192,308	4,269,862	1,128,868	2,468,187	3,073,266
Rbea	3,079,548	2,270,000	3,008,927	3,118,503	2,241,726	2,602,000	2,677,017	2,804,121
Phys	1,636,907	1,093,646	1,486,673	27,473	1,582,649	1,298,517	1,555,132	1,154,605
Ssop	1,556,137	1,101,912	2,527,022	2,085,720	1,872,173	2,179,481	1,082,206	2,022,973
Guav	422,519	981,330	938,445	691,542	907,994	427,782	471,183	789,873

Continue

Table A4.4 Demand Prices by Product and Market (Col$ per ton) - Continued

Product	Market							
	Antioquia	Caribe	Centro	Eje Cafetero	Llanos-Amazonia	Pacifico	Santanderes	Exports
Sbea	1,376,353	841,128	898,133	681,726	752,296	666,999	612,236	850,853
Lulo	1,756,374	1,811,538	2,444,470	1,587,025	2,621,533	2,150,890	2,575,953	2,264,200
Corn	1,125,000	647,427	551,313	639,238	652,000	490,045	498,264	664,402
Mang	889,846	479,110	671,234	833,517	685,754	567,624	541,320	623,580
Pass	910,495	848,736	830,260	778,555	668,453	1,003,640	633,962	861,918
Bber7	1,454,333	1,997,750	1,736,083	1,308,137	1,198,903	1,602,667	1,525,067	1,645,686
Palm	889,681	889,681	885,000	914,839	919,790	914,839	885,000	894,500
Pota	611,821	611,821	672,578	452,000	769,538	553,169	611,821	635,884
Papa	846,587	287,078	631,605	710,053	547,693	664,063	729,090	652,211
Pine	700,371	710,080	554,623	702,326	1,620,770	670,737	537,233	643,431
Plan	576,688	497,683	654,978	287,611	460,360	502,181	586,772	503,086
Sorg	522,396	431,764	522,396	522,561	516,778	522,561	507,855	496,674
Soyb	894,000	696,000	628,000	590,000	690,000	768,000	687,000	718,018
Tarb	1,029,028	1,256,108	1,442,385	1,196,749	1,359,686	1,191,137	1,188,946	1,231,539
Toma	680,070	640,368	876,236	588,783	926,472	693,123	640,245	746,795
Cass	741,000	358,000	835,000	713,000	809,000	953,000	520,000	636,573
Carr	430,386	635,279	544,812	645,778	549,443	528,384	493,802	533,531

Appendix 5

Table A5.1 Percentage Changes in Total Production Costs (Col$ per ton per cycle)

Technology	Total cost per cycle	Percentage change	Technology	Total cost per cycle	Percentage change	Technology	Total cost per cycle	Percentage change
Avoc1	14,538,573	-1.19	Gbea5	2,676,397	-1.04	Shal2	7,329,893	-0.92
Avoc2	44,052,309	-1.25	Bana1	57,145,616	-0.82	Shal3	8,325,272	-1.04
Avoc3	27,775,621	-1.14	Bana2	9,643,932	-1.23	Citr13	14,859,946	-1.09
Hpep1	3,165,157	-1.17	Coco1	20,438,003	-1.16	Citr15	17,569,036	-0.92
Hpep2	3,152,914	-0.93	Coco10	11,947,991	-0.86	Citr16	16,874,613	-1.11
Hpep3	3,424,479	-1.22	Coco8	11,129,807	-0.88	Citr18	20,385,039	-1.19
Garl1	6,337,292	-1.04	Coco9	11,014,564	-0.97	Citr21	16,469,661	-1.16
Rice11	1,664,319	-1.21	Coff4	17,425,129	-0.92	Stra1	17,109,381	-0.92
Rice17	1,830,490	-1.20	Coff5	10,737,090	-1.08	Rbea1	2,240,992	-1.23
Rice2	1,949,864	-1.24	Coff6	15,668,550	-1.09	Rbea2	1,430,505	-0.93
Rice21	2,239,847	-1.11	Coff7	14,016,039	-1.08	Rbea3	2,589,978	-1.20
Rice4	2,092,001	-1.17	Mola2	14,169,251	-0.92	Rbea4	916,561	-0.91
Rice5	2,392,121	-1.16	Mola4	28,741,958	-0.88	Rbea5	1,489,991	-0.96
Rice6	1,789,549	-1.22	Mola5	20,262,689	-0.95	Rbea6	3,166,478	-1.12
Rice7	2,013,509	-1.05	Onio1	4,609,999	-1.11	Rbea9	1,454,436	-1.06
Rice9	2,455,172	-1.12	Onio3	5,580,339	-0.97	Phys1	23,060,501	-1.02
Gbea1	5,821,942	-1.05	Onio4	7,234,393	-1.11	Phys2	26,141,938	-1.30
Gbea2	2,204,152	-0.96	Onio6	12,662,517	-0.96	Ssop3	33,998,759	-1.14
Gbea3	2,659,218	-0.89	Onio7	4,385,731	-1.05	Ssop4	52,421,106	-1.28
Gbea4	3,296,613	-1.09	Shal1	9,979,060	-1.18	Guav1	18,185,089	-0.92

Continue

Table A5.1 Percentage Changes in Total Production Costs (Col$ per ton per cycle) - Continued

Technology	Total cost per cycle	Percentage change	Technology	Total cost per cycle	Percentage change	Technology	Total cost per cycle	Percentage change
Guav2	19,239,484	-1.09	Corn8	1,036,207	-0.96	Pota4	3,691,330	-1.12
Sbea1	3,616,985	-1.15	Mang2	19,965,252	-1.11	Pota6	3,976,978	-1.17
Sbea2	3,184,299	-1.08	Mang3	23,343,894	-0.91	Papa11	12,016,395	-0.74
Sbea3	3,044,645	-0.94	Pass1	12,953,663	-1.18	Papa14	6,923,666	-1.06
Sbea4	3,765,339	-1.10	Pass11	8,247,825	-1.03	Papa15	8,754,122	-1.26
Lulo12	5,876,994	-1.13	Pass12	13,185,818	-1.10	Papa9	7,665,419	-1.05
Lulo14	7,390,213	-1.10	Pass2	5,970,948	-0.53	Pine1	24,309,890	-1.06
Lulo3	5,283,200	-0.89	Pass7	21,468,814	-1.20	Pine2	8,013,478	-0.64
Lulo7	8,502,291	-1.11	Pass9	6,252,182	-0.69	Plan11	14,431,789	-1.14
Lulo9	13,346,204	-0.93	Bber7	19,111,332	-0.94	Plan3	12,755,984	-1.28
Corn1	1,221,169	-1.12	Bber8	8,743,031	-0.60	Plan6	12,145,811	-1.07
Corn11	921,284	-1.15	Bber9	15,742,943	-0.94	Plan9	15,718,689	-1.10
Corn12	1,111,445	-1.29	Palm3	18,965,104	-0.86	Sorg1	692,395	-1.14
Corn13	1,193,508	-1.21	Palm4	20,374,072	-0.91	Sorg2	884,236	-1.13
Corn18	1,189,704	-1.04	Palm8	18,067,330	-1.04	Sorg4	833,935	-1.31
Corn2	1,604,519	-1.20	Palm9	23,377,088	-1.02	Sorg5	697,912	-1.21
Corn23	1,043,678	-0.79	Pota1	3,030,881	-1.20	Sorg7	1,098,323	-1.25
Corn4	1,425,441	-1.29	Pota12	5,291,079	-1.04	Soy1	1,906,302	-1.04
Corn5	1,243,224	-0.84	Pota13	9,227,288	-1.16	Soy2	1,011,431	-1.13
Corn7	887,222	-1.01	Pota2	5,348,052	-1.00	Soy3	1,170,349	-1.31

Continue

Table A5.1 Percentage Changes in Total Production Costs (Col$ per ton per cycle) - Continued

Technology	Total cost per cycle	Percentage change
Soy4	1,073,251	-1.14
Tarb1	6,939,681	-1.06
Tarb4	15,949,669	-0.93
Tarb6	6,487,342	-0.99
Toma1	5,998,962	-1.28
Toma2	6,632,554	-1.25
Toma4	7,780,064	-1.18
Toma5	6,898,064	-1.33
Toma6	4,017,738	-0.97
Cass1	2,105,253	-0.78
Cass10	3,217,836	-0.85
Cass11	1,673,813	-0.93
Cass14	1,696,773	-0.93
Cass15	3,373,770	-0.87
Cass6	1,498,084	-0.85
Cass7	1,415,280	-0.86
Cass8	1,033,381	-0.92
Carr1	5,701,790	-1.16
Carr2	3,849,864	-1.14
Carr3	2,783,744	-1.17
Carr4	3,017,987	-1.17

Table A5.2 Changes in Harvested Area by Product and Zone (has)

Product	Production zone								
	Altiplano	Alto-Magdalena	Andina-Antioquia	Andina-Cauca	Andina-Central	Andina-Narriño	Andina-Norte	Andina-Santander	Eje-Cafetero
Rice		-977					-6,482		
Corn									
Sorg									
Avoc									
Hpep									2
Garl									
Gbea					249				
Bana									
Onio									
Shal									8
Citr									
Stra	-151								
Rbea			-155						
Phys		-41							
Ssop							32		
Guav									
Sbea					6				

Continue

Table A5.2 Changes in Harvested Area by Product and Zone (has) - Continued

Product	Production zone								
	Altiplano	Alto-Magdalena	Andina-Antioquia	Andina-Cauca	Andina-Central	Andina-Nariño	Andina-Norte	Andina-Santander	Eje-Cafetero
Lulo									
Mang									
Pass		-283							
Bber									
Pota									
Papa									
Pine						-129		-67	
Plan									
Tarb									
Toma	-20								
Cass									
Carr									
Palm									
Soyb		-83							
Mola									
Coco			-413	-43	-1,113		-7,335	-4,450	
Coff					65,501				

Continue

Table A5.2 Changes in Harvested Area by Product and Zone (has) - Continued

Product	Production zone								
	Medio-Magdalena	Meta	Orinoquia	Pacifica-Nariño	Piedemonte	Sabanas	Sierra	Uraba	Valle
Rice			-29,072						
Corn				-959	-10,079	-7,873		-10,510	
Sorg	-171	-109				-2,672	-5,692		-4,094
Avoc	894								
Hpep									
Garl									
Gbea									
Bana				-250			-1,161	-310	
Onio	-11								
Shal									
Citr						-133			
Stra									
Rbea									
Phys									
Ssop									
Guav						4,750			150
Sbea									

Continue

Table A5.2 Changes in Harvested Area by Product and Zone (has) - Continued

Product	Production zone								
	Medio-Magdalena	Meta	Orinoquia	Pacifica-Nariño	Piedemonte	Sabanas	Sierra	Uraba	Valle
Lulo		92					27		
Mang						-520			
Pass									
Bber									297
Pota				-341					
Papa						-102			
Pine									
Plan			-1,845					-4,349	
Tarb	141								
Toma									-43
Cass							-906		
Carr				-17					
Palm	12,989	7,269							
Soyb		-10,878							-5,882
Mola	195,444					67,627			1,444
Coco									-292
Coff									

Table A5.3 Changes in Production Level by Product and Zone (tons)

Product	Production zone							
	Altiplano	Alto-Magdalena	Andina-Antioquia	Andina-Cauca	Andina-Central	Andina-Narriño	Andina-Norte	Andina-Santander	Eje-Cafetero
Rice		-9,525					-29,169		
Corn									
Sorg									
Avoc									
Hpep									59
Garl								-1	
Gbea					1,982				
Bana									
Onio									
Shal									860
Citr									
Stra	-1,411								
Rbea			-556						
Phys		-330							
Ssop							206		
Guav									
Sbea					204				

Continue

Table A5.3 Changes in Production Level by Product and Zone (tons) - Continued

Product	Production zone								
	Altiplano	Alto-Magdalena	Andina-Antioquia	Andina-Cauca	Andina-Central	Andina-Nariño	Andina-Norte	Andina-Santander	Eje-Cafetero
Lulo									
Mang									
Pass		-3,767							
Bber									
Pota									
Papa									
Pine						-5,504		-2,865	
Plan									
Tarb									
Toma	-841								
Cass									
Carr									
Palm									
Soyb		-339							
Mola									
Coco			-87	-9	-234		-1,540	-934	
Coff					42,002				

Continue

Table A5.3 Changes in Production Level by Product and Zone (tons) - Continued

Product	Production zone								
	Medio-Magdalena	Meta	Orinoquia	Pacifica-Nariño	Piedemonte	Sabanas	Sierra	Uraba	Valle
Rice			-231,118						
Corn				-7,108	-74,749	-46,709		-77,938	
Sorg	-950	-604				-12,343	-26,297		-33,671
Avoc	6,888								
Hpep									
Garl									
Gbea									
Bana				-2,340			-30,334	-8,098	
Onio	-541								
Shal									
Citr						-2,577			
Stra									
Rbea									
Phys									
Ssop									
Guav						122,065			3,862
Sbea									

Continue

Table A5.3 Changes in Production Level by Product and Zone (tons) - Continued

Product	Production zone								
	Medio-Magdalena	Meta	Orinoquia	Pacifica-Nariño	Piedemonte	Sabanas	Sierra	Uraba	Valle
Lulo		766					225		
Mang						-4,057			
Pass									
Bber									2,849
Pota				-5,629					
Papa						-508			
Pine									
Plan			-22,143					-52,194	
Tarb	1,691								
Toma									-1,824
Cass							-10,870		
Carr				-503					
Palm	52,629	29,451							
Soyb		-45,081							-25,110
Mola	118,205					40,901			873
Coco									-61
Coff									

Table A5.4 Changes in Value of Production by Product and Zone (US$)

Product	Production zone								
	Altiplano	Alto-Magdalena	Andina-Antioquia	Andina-Cauca	Andina-Central	Andina-Narriño	Andina-Norte	Andina-Santander	Eje-Cafetero
Rice		-8,116,280	-2,763				-25,514,700	-211,392	
Corn	-1,295	-657,046	-15,098	-33,058	-68,518	-22,261	-21,968	-149,472	-12,863
Sorg		-264,439							-3,412
Avoc		-23,401	-16,964		-1,726		-1,254	-34,578	-17,056
Hpep									12,046
Garl			-128				-1,333	-6,294	
Gbea	-269,430	-111,333	-20,213		1,429,045	-111,684	-7,555	-557,536	-12,908
Bana		-40,545	-2,714		-144,476		-10,836		-19,534
Onio	-26,684	-3,624	-1,450		-10,476	-8,096	-136,357	-271,500	-362
Shal		-5,005	-6,036		-947		-1,137	-24,263	101,150
Citr		-51,353	-18,822	-481				-1,193	
Stra	-615,463		-1,098		-89,587		-1,459	-942	-23
Rbea	-55,310	-930,117	-1,492,630	-19,015	-43,420	-111,766	-216,671	-334,453	-81,498
Phys		-172,952	-3,026		-2,495		-21	-1,658	-15,998
Ssop		-42,943	-2,893		-10,082		47,543	-476	-2,429
Guav		-27,797	-7,487		-492,655		-73	-41,425	-3,280
Sbea	-10,327	-91,642	-21,554		18,291		-7,088	-46,264	-12,866

Continue

Table A5.4 Changes in Value of Production by Product and Zone (US$) - Continued

Product	Production zone								
	Altiplano	Alto-Magdalena	Andina-Antioquia	Andina-Cauca	Andina-Central	Andina-Nariño	Andina-Norte	Andina-Santander	Eje-Cafetero
Lulo		-226,820		-1,142	-30,774		-859	-4,078	-13,096
Mang		-45,766	-14,452	-102	-254,732		-65	-195	
Pass		-980,422	-1,118	-47	-58,405		-1,984	-1,884	-2,759
Bber		-23,897	-13,708	-3,151	-374,729	-1,710	-7,922	-16,831	-7,480
Pota	-33,330	-18,471	-316,489	-176	-95,597	-200,087	-55,335	-475,472	
Papa		-29,023		-140			-1,516	-3,337	-1,152
Pine		-7,677	-204			-459,024	-3,857	-308,566	-9,699
Plan		-2,050,420	-179,948	-82,205	-923,422	-95,182	-181,145	-171,020	-633,321
Tarb		-52,337	-38,295	-130	-256,758	-1,619	-8,472	-15,003	-3,300
Toma	-525,762	-990,443	-56,099	-10,769	-79,674	-38,768	-163,536	-156,454	-245,161
Cass	-168	-3,805			-19,404		-2,413	-116,365	-3,160
Carr	-19,739	-2,128	-84,303		-8,012	-51,437	-12,317	-41,173	-466
Palm							-1,489		
Soyb		-171,050							-1,602
Mola		-990,962	-303,007	-62,824	-3,181,490	-161,954	-168,106	-510,777	
Coco		-24,947	-257,026	-28,143	-678,554		-4,489,010	-2,713,300	-15,873
Coff		-1,767,080	-894,278	-713,527	49,797,400	-215,401		-1,367,630	-2,981,820

Continue

Table A5.4 Changes in Value of Production by Product and Zone (US$) - Continued

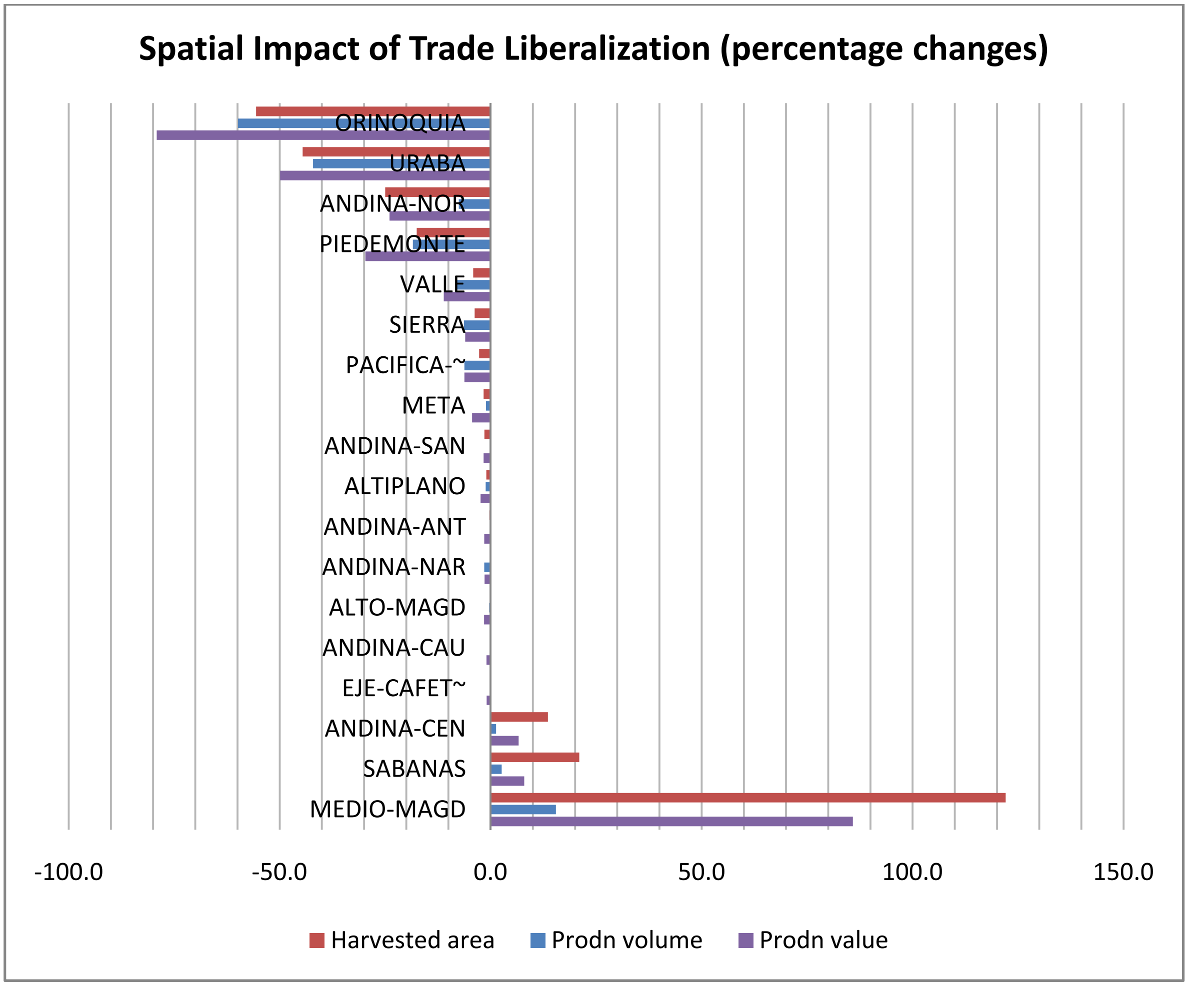
Product	Production zone								
	Medio-Magdalena	Meta	Orinoquia	Pacifica-Nariño	Piedemonte	Sabanas	Sierra	Uraba	Valle
Rice	-300,603	-2,827,830	-122,274,000		-5,827	-1,517,360	-341,667	-105,850	-132,516
Corn	-408,397	-441,288	-139,112	-2,012,430	-21,258,900	-14,031,200	-475,812	-22,065,300	-394,240
Sorg	-386,039	-160,065				-3,280,220	-6,988,250		-7,914,450
Avoc	470,353					-1,509	-22,331	-960	-4,551
Hpep						-11,046	-11,863		-19,020
Garl									-232
Gbea									-7,276
Bana	-1,799			-212,092			-6,228,630	-1,552,080	-37,759
Onio	-246,466					-8,567	-13,488		-5,227
Shal						-5,612			-41,407
Citr	-32,109					-235,766	-16,259		-853
Stra									
Rbea	-9,358	-14,179		-11,170	-8,439	-40,618	-85,772	-717	-16,144
Phys									-13,134
Ssop						-2,044			-6,793
Guav	-3,147	-609				3,942,944			117,386
Sbea	-8,876	-1,392				-5,257			-26,028

Continue

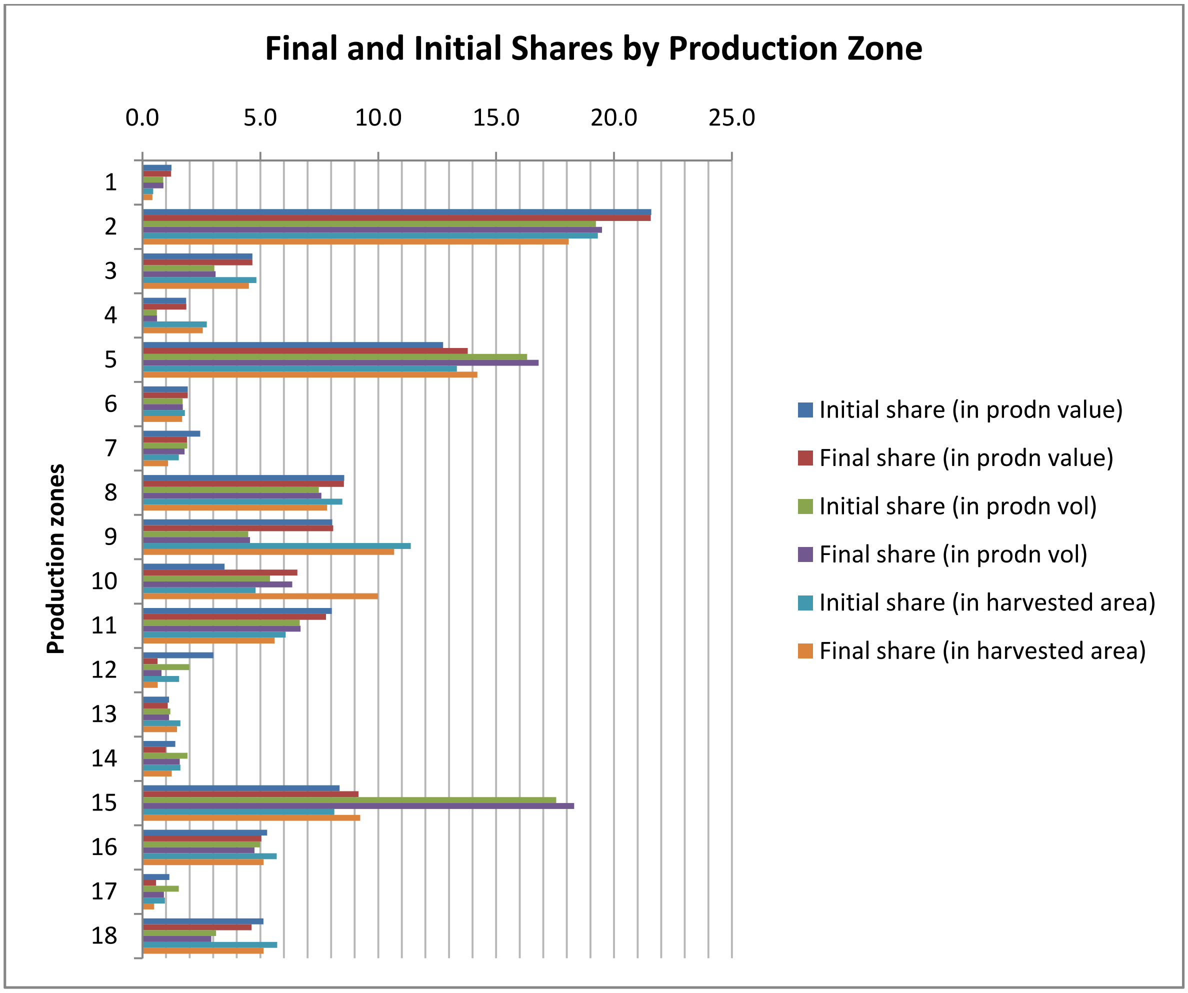
Table A5.4 Changes in Value of Production by Product and Zone (US$) - Continued

Product	Production zone								
	Medio-Magdalena	Meta	Orinoquia	Pacifica-Nariño	Piedemonte	Sabanas	Sierra	Uraba	Valle
Lulo		88,723			-3,109		20,813		-11,912
Mang	-921					-527,226	-15,847		-2,052
Pass	-3,688	-1,073				-6,866	-2,781	-89	-18,916
Bber	-670						-6,043		221,306
Pota				-874,653					-96
Papa	-2,139	-4,067	-2,997			-154,041	-7,647	-665	-2,825
Pine	-56,033	-15,465	-208		-3,580			-187	-7,283
Plan	-143,889	-188,032	-2,690,000	-102,264	-319,058	-568,943	-80,084	-6,213,200	-201,087
Tarb	141,499	-86		-1,161			-5,356		-3,482
Toma	-47,253	-111,827		-6,911		-64,650	-296,888		-1,360,820
Cass	-49,525					-338,088	-1,329,730		-4,046
Carr				-92,860					-1,183
Palm	8,577,321	4,523,047	-14,342	-127,307	-2,679	-73,984	-271,034		
Soyb		-19,403,600							-19,690,900
Mola	150,384,500	-4,033	-8,116	-38,248	-23,079	52,033,430	-14,017		1,073,118
Coco	-127,495	-3,162	-78,908	-122,937	-2,281	-1,248	-35,595	-28,655	-190,933
Coff	-207,728	-126,243		-110,859	-155,700		-535,498		-1,285,230

Graph A5.1 Percentage Changes in Harvested Area, Quantity Produced, and Production Value per Zone



Graph A5.2 Changes in Shares by Production Zone



Code	Zone	Code	Zone	Code	Zone	Code	Zone
1	Altiplano	6	Andina-Nariño	11	Meta	16	Sierra
2	Alto-Magdalena	7	Andina-Norte	12	Orinoquia	17	Uraba
3	Andina-Antioquia	8	Andina-Santander	13	Pacifica-Nariño	18	Valle
4	Andina-Cauca	9	Eje-Cafetero	14	Piedemonte		
5	Andina-Central	10	Medio-Magdalena	15	Sabanas		