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DOCUMENTO DE TRABAJO

Núm. III - 1997

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MEXICAN AGRICULTURE: DISTRIBUTION AND EFFICIENCY EFFECTS OF ELIMINATING PRICE DISTORTIONS

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Abstract

This paper analyzes the impact that eliminating of all trade barriers on agriculture would have on efficiency and growth. To carry out this analysis I use a combination of a dynamic general equilibrium model for the Mexican economy, and a static agricultural model. The first model has twelve sectors, and the second one expands the agricultural sector into 31 activities. I find that the elimination of trade distortions increases agricultural GDP at world prices by 4.5%. However, this gain is not distributed evenly among factors of production. Rents for land decrease, and the richest landowners are hurt the most, indicating that they are the main beneficiaries of current distortions. Real wages in agriculture also fall, and this calls for complementary policies to alleviate poverty. Examples of such include public works in rural areas and expansion of educational opportunities among rural workers.

I. INTRODUCTION

The purpose of this paper is to analyze the impact that trade liberalization on agriculture would have on the efficiency of the agricultural sector, and on income

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*The author is grateful to Manuel Gollas and Johanna Koolemans for reading this version. and two anonymous referees for helpful comments on an earlier draft.

distribution within the sector. The study uses a combination of a dynamic and a static computable general equilibrium model (CGE).

Several applied general equilibrium models have recently been developed to quantify the impact of free trade on Mexican agriculture. These models emerged during negotiations between the three North-American countries that resulted in the North American Free Trade Agreement (NAFTA)[1].

Of the three models, only that of Levy and van Wijnbergen is dynamic, but the way in which they incorporate the dynamic aspect is restrictive for two reasons. First, they assume there is no capital in the rural sector and that the only investment in agriculture is that of government irrigation projects. Second, in their model the growth of capital stock is exogenous and only takes place in the manufacturing and service sectors. As a result, the authors assume that: 1) urban capitalists are the only ones who save and invest; 2) private investment is determined by the exogenous growth in capital stock in the industrial and service sectors and; 3) private savings are a constant proportion of the available savings of urban capitalists (a critique of the Levy and van Wijnbergen model can be found in Brown, 1992).

In this paper I simulate the elimination of all price distortions in the economy and assess their impact on agriculture[2].

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[1] Levy & van Wijnbergen, 1992; Robinson, et.al., 1991; Yúnez-Naude, 1992.

[2] The Mexican Government has already substituted price regulation in basic and oleaginous crops with a less distorting policy of direct transfer payments to producers according to area cultivated (PROCAMPO).

My modeling technique is different from that of Levy & van Wijnbergen since it includes rural capital and endogenously introduces the dynamics of capital formation. Furthermore, my model does not rely on calculated parameters based on "model calibration" (a technique based on information of only one year). Additionally, data about land used and rent payments was obtained from a cost survey by BANRURAL, FIRA and SARH (1992).

My analysis is based on two interrelated general equilibrium models. The economy wide model calculates the effects of trade liberalization on variables such as sectoral employment and capital stock for each time period. The agricultural model calculates the optimal agricultural production mix for each time period, using the optimal allocation of labor and capital in agriculture obtained from the economy-wide model.

In the economy-wide model, I use a multi-period, general equilibrium model of the Mexican economy developed to estimate the effects of NAFTA. This model assumes a small open economy that takes as given the world interest rates and world prices for each traded industry (except for the construction industry). The domestic interest rate is equal to the world rate plus a "risk-premium." For each traded good the domestic price is equal to the world price plus a ad valorem tariff. In line with the classification in the Sistema de Cuentas Nacionales de México, the model considers three capital goods industries (machines,

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This policy may influence production. I will not however model this policy explicitly since my main concern is to study the impact of trade liberalization on agriculture. In the paper the reader can interpret this as meaning either PROCAMPO is production neutral, or simply that this program is not considered.

construction and vehicles) and nine consumption/intermediate goods activities (see Table 1).

TABLE 1
SECTORS OF THE MODEL

Sector
1) Agriculture (AGR): agriculture, livestock, forestry, hunting and fishing
2) Mining (MIN): carbon, iron-mineral, non-iron minerals, quarrystone and other non-metallic minerals
3) Petroleum (PET): gas and oil extraction, manufacturing and basic petrochemicals
4) Edibles (EDI): processed foods and beverages, tobacco
5) Textiles (TEX): textiles, apparel, leather products
6) Chemicals (CHE): basic chemicals, fertilizers, resins, pharmaceuticals, cleaning products and other chemicals
7) Metals (MET): iron, steel, non-ferrous metals and metal products
8) Machinery (MAC): electrical and non-electrical machinery
9) Vehicles (VEH): motorized vehicles, parts and other transport equipment
10) Construction (CON): construction
11) Services (SER): electricity, trade, transport, communications, financial and other services
12) Others (OTH): wood products, paper, rubber, non-metallic mineral products and other industries

Classification: INEGI, Sistema de Cuentas Nacionales de México.

In order to estimate the impact of trade liberalization on agriculture, I run the agricultural model one time for each period considered in the first model, i.e., given the optimal capital stock and employment in agriculture in period t, I calculated the optimal factor employment among agricultural activities for given world prices and tariffs of the 31 agricultural activities (see Table 9).

II. THE DUAL APPROACH TO POLICY MODELING

One major characteristic of the two models is the consistent use of duality. The monograph of Dixit and Norman (1980) established the dual approach as the standard method of presenting <u>theoretical</u> issues in international economics because of the clarity and economy that results when the first-order conditions for consumer and producer choice are impounded in the dual functions specifying their behavior. Duality also facilitates clarity and economy in the <u>empirical</u> modeling of international issues. The dual approach to estimating a sector's production function and determining its factor demands via the cost function is well known (see KPMG Peat Marwick (1992)). I take this approach one step further by stating all the equilibrium conditions of the model in terms of the estimated cost functions. Since these cost functions incorporate the optimal intra-period input choices of firms, this obviates the first-order conditions for these choices. In calculating the steady-state growth path of the economy, I also bypass the first-order conditions for output and investment by exploiting the inter-temporal relationship between the price of capital and the stream of future rents from capital.

These techniques imply that that the applied general equilibrium models does not require explicit computation of any first-order conditions. This sharply reduces the number of equations, yielding a compact, yet transparent, model which is readily computable.

III. THE ECONOMY-WIDE MODEL

The economy wide model that I use to obtain the optimal capital stock and employment in agriculture was developed by Leslie Young and José Romero (1994) in an effort to evaluate the impact of NAFTA on the Mexican economy.

This model has several features that make it particularly suitable for an analysis of the impact of trade liberalization on the Mexican Economy. Its construction requires the econometric estimation of twenty four separate cost functions (one unit cost function for the output and one unit cost function for physical capital in each industry).

An important feature of this model is that the dynamics of the response of the Mexican Economy to changes in relative prices is based on intertemporal optimization by firms. This is especially important for simulations of trade liberalization, since expected future alterations in trade policies will have consequences for decisions in the present.

All models with a finite horizon T encounter the problem of modeling investment in capital goods which would not be fully depreciated until after year T. The approach generally chosen is to assume that at time T capital stock and investment rates are at the levels corresponding to a steady-state growth path, where goods prices are steady but every sector's output, labor force and capital stock expand at a fixed rate g (rate of population growth), so that factor returns and capital goods prices are steady also.

Young and Romero first calculate a steady state model in which they obtain the optimal capital stock (given the level of world prices, tariffs, rate of population growth and other exogenous variables). Once the optimal capital stock is obtained they use it to build a transition model in which, starting from the actual values of the capital stock and employment, they reach the steady state values; investing in each period the optimal amount according with each period exogenous variables.

In each period the appropriate mix of capital goods acquired to produce the aggregate capital is that which minimizes the cost of production given the prices of the three capital goods during that period. In a similar fashion, the appropriate mix of intermediate goods used to produce the materials is that which minimizes the cost of production given the nine intermediate goods prices.

In their model, production takes place in two stages. In stage I, the representative firm in each sector produces two aggregates: (a) capital, using machines, buildings and vehicles; (b) materials, using various intermediate goods.

In stage II, the firm produces a single "product" using labor, capital and intermediate goods. The product of each industry has different uses; it can be used as an intermediate good in the same or another industry, it can be used to satisfy final demand, and some can be combined in various proportions to produce specific capital goods.

All producers seek to maximize profits. The variables of choice in each period are labor, intermediate goods and the level of investment. Labor and intermediate goods are selected to minimize costs, while the level of investment is selected such that producers reach their optimal capital intensity in the long run (long run profit maximization). The time required to reach this optimal intensity depends on how much it costs to adjust the economy so that it can produce the non traded capital goods (construction) needed for optimum investment in each period.

The Young and Romero model assumes full employment and an exogenous annual rate of total population growth of 2%. The amount of total employment in 1990 was 22.4 million workers. At an annual rate of growth of the labor force of 2%, that figure is expected to reach 32.9 million by 2008.

The authors find that, at the current real interest rates of 15%, the long run effect of trade liberalization is a 3.4% increase in Mexican gross domestic product at world prices. The gains are significantly greater if trade liberalization results in a reduction of real interest rates.

These estimates of the benefits from trade liberalization are higher than estimates from existing static models. The reason could be that. since existing nominal rates of protection in Mexico are quite low (see Table 2), removing these distortions leads to only minor gains in a model where both consumption and production losses from tariffs are essentially proportional to nominal rates of protection. In the Young Romero model, the consumption losses from tariffs are likewise quite small (on the order of 0.25% of GDP). However, the richer structure of inter-sectoral flows in their model captures more of the distortionary impact of the existing tariff structure on the value added in various sectors. They therefore obtain higher estimates of the production losses arising from inter-sectoral discrepancies in effective rates of protection (Corden (1966, 1975)). The high real interest rates prevailing in Mexico imply that tariffs on capital goods lead to particularly severe inter-sectoral discrepancies in effective rates of protection. Their model also captures additional gains from trade liberalization, improved efficiency in input use within sectors and in the inter temporal allocation of resources within and across sectors.

TABLE 2
AVERAGE AD VALOREM TARIFFS

Sector:	AGR	MIN	PET	EDI	TEX	CHE	MET	MAC	VEH	BUI	SER	MIS
Tariff:	13.38%	9.75%	9.36%	14.00%	16.15%	11.22%	12.99%	13.37%	16.00%	0.00%	0.00%	11.90%

Source: SECOFI, de Comercio y fomento industrial.

Although this model assumes full employment, it imposes restrictions on labor mobility to replicate the recent history of Mexico (see Table 3). The experiments assume that each industry's share of the labor force can deviate from its current share by a maximum of 20% either way.

TABLE 3
INDUSTRY'S SHARE OF THE LABOR FORCE

YEAR	AGR	MIN	PET	EDI	TEX	CHE	MET	MAC	VEH	CON	SER	OTH	Total
1970	34.4%	1.2%	0.6%	3.5%	2.7%	1.1%	1.4%	1.1%	0.6%	6.3%	44.2%	3.1%	100%
1975	30.3%	1.2%	0.5%	3.4%	2.5%	1.1%	1.3%	1.3%	0.7%	7.5%	47.5%	2.8%	100%
1980	25.9%	1.3%	0.6%	3.1%	2.4%	1.1%	1.3%	1.3%	0.7%	8.9%	50.5%	2.9%	100%
1985	27.6%	1.2%	0.5%	3.0%	1.9%	1.0%	1.0%	0.9%	0.8%	8.9%	50.8%	2.5%	100%
1990	26.8%	1.2%	0.5%	3.0%	1.8%	1.1%	0.9%	0.9%	0.8%	9.7%	50.8%	2.5%	100%

Source: INEGI, "Sistema de Cuentas Nacionales de México."

Earlier models assumed perfect labor mobility, yet estimated much smaller gains from trade liberalization. In general, they found that the gains from trade liberalization are greater, the greater the deviations allowed in the structure of employment. Thus, the benefits from trade liberalization to Mexico would be substantially enhanced by government policies which facilitate labor mobility, such as an expansion of educational opportunities.

The model is used to predicts the effects of trade liberalization, on variables such as: production, employment, capital stock, wages, rentals, etc., for each of the twelve sectors.

In Table 4 we present the results of the economy wide model under two scenarios. Scenario, "A", consists of a simulation of how the Mexican economy would evolve until the year 2008 (the beginning of the steady state: long run equilibrium) if the current scheme of price distortions continue; and scenario "B", how the same economy would evolve if price distortions were eliminated.

TABLE 4
RESULTS UNDER BOTH SCENARIOS
(2008 Values)

	GDP	GDP	CHANGE	EMPLOYMENT	EMPLOYMENT	CHANGE	CAPITAL	CAPITAL	CHANGE
	(A)	(B)	(B-A)/A	(A)	(B)	(B-A)/A	(A)	(B)	(B-A)/A
AGR	39.70	41.50	**4.53%**	7,037.40	7,037.40	**0.0%**	42.30	43.30	**2.4%**
MIN	6.70	6.90	**2.99%**	318.50	318.50	**0.0%**	11.20	11.60	**3.6%**
PET	23.00	20.40	**11.30%**	196.20	180.80	**-7.8%**	205.50	170.70	**16.9%**
EDI	39.10	38.10	**-2.56%**	1,185.40	1,185.40	**0.0%**	35.20	33.60	**-4.5%**
TEX	9.10	9.00	**-1.10%**	479.30	479.30	**0.0%**	4.40	4.30	**-2.3%**
CHE	16.00	16.90	**5.62%**	429.50	429.50	**0.0%**	44.50	46.20	**3.8%**
MET	11.50	11.60	**0.87%**	355.40	355.40	**0.0%**	23.00	23.00	**0.0%**
MAC	11.60	11.50	**-0.86%**	365.00	365.00	**0.0%**	12.00	11.70	**-2.5%**
VEH	8.90	10.80	**21.35%**	316.30	300.90	**-4.9%**	12.20	16.40	**34.4%**
CON	44.60	39.30	**11.88%**	2,615.70	2,736.60	**4.6%**	6.50	5.80	**10.8%**
SER	462.10	489.80	**5.99%**	18,540.20	18,450.10	**-0.5%**	257.90	278.40	**7.9%**
OTH	29.90	30.60	**2.34%**	1,021.20	1,021.20	**0.0%**	29.70	30.40	**2.4%**
Total	702.20	726.40	**3.45%**	32,860.10	32,860.10	**0.0%**	684.40	675.40	**-1.3%**

A: without eliminating distortions.
B: eliminating distortions and giving support to producers.
GDP: Gross Domestic Product in billions of 1980 pesos.
Employment: in thousands of people.
Capital: capital property in hundreds of billions of 1980 pesos.

The economy wide model considers the year 2008 as the beginning of the long run equilibrium. By then, total employment in the economy will be 33 million people, an increase of 50% with respect to 1992. Nevertheless, under both scenarios employment in agriculture will only increase 17%, and the absolute figure will be the same under both scenarios. The wage differentials between agriculture and the rest of the economy are so large (see Table 5) that people will try to leave agriculture under any scenario, indicating that trade policy has no effect on retaining workers or in accelerating migration from agriculture. Under both scenarios, the model-imposed limit of 20% reduction in agriculture's share of total employment is reached[3].

The assumption of imperfect labor mobility of agricultural workers is due to limited education opportunities in this sector, and by the limited absorption capacity of the rest of the economy. Labor supply in the agricultural sector is thus essentially determined by the number of people living in the countryside who can't find a job elsewhere.

TABLE 5
AVERAGE WAGE

Sector:	AGR	MIN	PET	EDI	TEX	CHE	MET	MAC	VEH	CON	SER	OTH
Wage:	1.2	5.6	21.4	7.6	8.3	14.0	15.2	13.9	16.0	5.4	6.8	9.9

Average wage: in millions of 1990 pesos.

Table 6 shows the results for aggregated and agricultural GDP under both scenarios. This results are for the transition between the current situation and long-term equilibrium.

[3] This figure is similar to the observed reduction between 1970 and 1990 (see Table 3).

TABLE 6

AGRICULTURAL AND TOTAL GDP DURING THE TRANSITION

(Billions of 1980 pesos)

YEAR	GDP (A)	GDP (B)	CHANGE (B-A)/A	GDP-AGR (A)	GDP-AGR (B)	CHANGE (B-A)/A
1990	491.3	491.3	0.0%	33.2	33.2	0.0%
1995	542.5	547.7	0.9%	34.9	35.3	1.2%
2000	599.1	610.5	1.9%	36.7	37.6	2.5%
2005	661.6	680.6	2.9%	38.5	40.0	3.8%
2006	674.9	695.5	3.1%	38.9	40.5	4.0%
2007	688.4	710.8	3.3%	39.3	41.0	4.3%
2008	702.2	726.4	3.4%	39.7	41.5	4.5%

IV. THE AGRICULTURAL MODEL

For the construction of the agricultural model we divide agriculture in twelve sectors. These sectors and their tariff (price distortion) appear in Table 7.

TABLE 7

AGRICULTURAL ACTIVITIES

(1992 values)

Divisions:	SHARE OF AGRICULTURAL GDP	TARIFF* (DISTORTION)
1) Corn	13.8%	65.0%
2) Sorghum	4.0%	0.0%
3) Wheat	3.3%	13.0%
4) Dry Beans	2.7%	89.0%
5) Soybeans	1.4%	14.0%
6) Rice	0.8%	8.0%
7) Saffron	0.2%	10.0%
9) BSC: onion, sesame and cotton	1.7%	26.0%
8) SUG: sugar cane, coffee, tobacco, cacao and henequen	4.2%	6.0%
10) CAT: cattle, livestock	37.5%	3.0%
11) FOR: forestry, fishing	8.7%	18.0%
12) OTH: other agricultural activities	21.9%	6.0%

Tariff: Difference between domestic and US prices.
Source: SARH

Most of the information used for the agricultural model is based on the study: "Analysis of Productivity and Marketability for Seven Basic Crops" (APMSC) jointly conducted by the

"Secretaría de Agricultura y Recursos Hidraulicos" (SARH), "Fideicomisos Instituidos en Relación con la Agricultura, del Banco de México" (FIRA) and the "Banco Nacional de Crédito Rural" (BANRURAL).

The APMSC examines the farming of rice, saffron, beans, corn, sorghum, soyabens, and wheat based on a survey of 1,260 agricultural production units for the 1990 Spring/Summer growing season (March to September of 1990), and the 1990-1991 Autumn/Winter growing season (October 1990 to February 1991). The sample was obtained from regions which together represent at least 80% of total production.

Each crop survey's information was classified according to two basic characteristics that indicate the producer's technological level: the use of irrigated or dry land, and the use or lack of credit. Consequently, the agricultural model divides producers of each of the seven basic crops into four categories:

1. Producers with irrigated lands who receive credit: (IR,CR)
2. Producers with irrigated lands who do not receive credit: (IR,WC)
3. Producers with dry lands who receive credit: (DR,CR)
4. Producers with dry lands who do not receive credit: (DR,WC)

(where IR = irrigated, DR = dry, CR = with credit, and WC = without credit).

The relative weight of each type of production in each activity is presented in the following table:

TABLE 8
COMPOSITION OF LAND HARVESTED

	Irrigated with credit	Irrigated without credit	Dry land with credit	Dry land without credit	TOTAL
CORN	6%	11%	8%	75%	100%
SORGHUM	15%	28%	21%	36%	100%
WHEAT	79%	21%	0%	0%	100%
DRY BEANS	6%	9%	17%	68%	100%
SOYBEANS	71%	11%	8%	11%	101%
RICE	18%	3%	29%	50%	100%
SAFFRON	10%	6%	17%	67%	100%

Source: SARH, FIRA and BANRURAL survey.

The expansion of the basic crops into four categories expands the agricultural model into thirty-one activities (see Table 9).

TABLE 9
AGRICULTURAL ACTIVITIES

1) Corn (IR,CR)	19) Soybeans (IR,CR)
2) Corn (IR,WC)	20) Soybeans (IR,WC)
3) Corn (DR,CR)	21) Soybeans (DR,CR)
4) Corn (DR,WC)	22) Soybeans (DR,WC)
5) Sorghum (IR,CR)	23) Saffron (IR,CR)
6) Sorghum (IR,WC)	24) Saffron (IR,WC)
7) Sorghum (DR,CR)	25) Saffron (DR,CR)
8) Sorghum (DR,WC)	26) Saffron (DR,WC)
9) Wheat (IR,CR)	27) BSC: Barley, sesame and cotton
10) Wheat (IR,WC)	28) SUG: sugar cane, coffee, tobacco, cocoa and hemp
11) Dry Beans (IR,CR)	29) CAT: cattle and livestock
12) Dry Beans (IR,WC)	30) FOR: forestry and fishing
13) Dry Beans (DR,CR)	31) OTH: other activities
14) Dry Beans (DR,WC)	
15) Rice (IR,CR)	
16) Rice (IR,WC)	
17) Rice (DR,CR)	
18) Rice (DR,WC)	

The model assumes that production occurs in two stages. In the first stage, the representative production unit produces a composite intermediary good M_i using various inputs. In the second, the production unit produces the good i using land T_i, capital K_i, Labor L_i and materials M_i.

We assume that M_i is produced by a Cobb-Douglas technology, for which its unit cost function is a Cobb-Douglas function of vector $\mathbf{p} = (p_1 \ldots p_n)$ of intermediary goods prices: $C_{iM}(\mathbf{p}) = p_1^{Si1} p_2^{Si2} \ldots p_n^{Sin}$, where s_{ij} is the share of intermediate good j in the total cost of the intermediate goods used in the production of good i.

In the second stage we assume that output y_i is produced by a CES technology, for which its unit cost function is a CES function of the wage rate w, the rental price of capital r, the rent of the relevant type of land R_{hl} (were h = IR or DR; and l = CR or WC) and the price of the composite intermediary good $C_{iM}(\mathbf{p})$ i.e., $c_i(w,r,R_{hl},\mathbf{p}) = C_i(w, r, R_{hl}, C_{iM}(\mathbf{p}))$.

From the Shephard-Samuelson relationships, the input demand per a unit of production, is obtained by differentiating c_i with respect to the corresponding price: a_{iL} for labor, a_{iK} for capital and a_{ihl} for land.

The parameters of the Cobb Douglas unit cost function for materials for each activity (the seven basic crop plus the other five) is obtained directly from the Mexican 1980 Input-Output Matrix.

Given that our information is based on cross-section data from 1990 and 1991 a direct estimation of unit cost functions was not possible. In its place, we estimate a CES production functions for all these activities and once we obtain the CES parameters, we use them to construct a CES unit cost function. Thus the unit cost function for each division of the seven crops were estimated indirectly. The cost structure of the seven crops subdivided according to their various technologies appear in Appendix I.

The model assumes constant returns to scale and perfect competition, i.e.: price is equal to average and marginal cost.

(1) $p_i = c_i(w, r_i, R_{hl}, \mathbf{p})$.

All of the agricultural products are tradable, therefore their domestic prices are internationally determined given the tariff (τ_i). Domestic price (p_i) is equal to world prices (p^w_i) plus price distortion: $p_i = (1+\tau_i)p^w_i$.

Labor and capital demand and capital in sector i are given, respectively as:

(2) $a_{iL}(w, r_i, R_{hl}, \mathbf{p})y_i = L_i$;
(3) $a_{iK}(w, r_i, R_{hl}, \mathbf{p})y_i = K_i$;

where a_{ij} is the demand for factor j per a unit of output in industry i, and y_i represents output in sector i.

Demand for each type of land in sector i is given by:

(4) $a_{iIRCR}(w, r_i, R_{hl}, \mathbf{p})y_i = T_{iIRCR}$;

(5) $a_{iIRWC}(w,r_i,R_{hl},p)_i = T_{iIRWC}$;

(6) $a_{iDRCR}(w,r_i,R_{hl},p)_i = T_{iDRCR}$;

(7) $a_{iDRWC}(w,r_i,R_{hl},p)_i = T_{iDRWC}$;

The equilibrium condition for labor and capital markets are given respectively as:

(8) $L_A = \Sigma_{i=1}^{n} L_i$;

(9) $K_A = \Sigma_{i=1}^{n} K_i$;

where L_a and K_a are the sector's share of labor and capital. In equilibrium this quantities must be equal to the combined demand of the 31 activities (n=31).

The equilibrium conditions for the markets for each type of land are given as:

(10) $T_{IRCR} = \Sigma_{i=1}^{n} T_{iIRCR}$;

(11) $T_{IRWC} = \Sigma_{i=1}^{n} T_{iIRWC}$;

(12) $T_{DRCR} = \Sigma_{i=1}^{n} T_{iDRCR}$;

(13) $T_{DRWC} = \Sigma_{i=1}^{n} T_{iDRWC}$.

Where T_{IRCR}, T_{IRWC}, T_{DRCR} and T_{DRWC} are the endowments of each type of land that are available for the combined demands of the 31 activities.

The model can be solved to find production levels, given the values of the exogenous variables: p_i, T_{IRCR}, T_{IRWC}, T_{DRCR}, T_{DRWC}, L_A and K_A. The values for L_A and K_A are obtained from the results of the economy-wide model. There are thirty-one agricultural activities and all of the goods are tradable. Therefore, equations (1) to (3) represent 93 (31x3) equations with 99 unknowns (w, r, R_{hl}, y_i, L_i, y K_i). Equations (4) and (5) represent a total of 14 (7x2) equations and fourteen unknowns. Equation (6) represents six equations and six unknowns, and equation (7) represent eleven equations and eleven unknowns. Equations (8) to (13) represent six equations and they do not have any unknowns. Therefore, we have 130 equations and 130 unknowns. This means that, given the exogenous variables, the model can be solved.

Free trade is represented as a reduction in domestic prices, caused by the elimination of "tariffs" (distortions).

V. RESULTS

The models described distinguish two different ways in which trade liberalization affects agriculture. The first is trough the reallocation of resources between sectors: the model finds that trade liberalization results in a 2.4% increase in the capital stock devoted to agriculture. The second way in which trade liberalization affects the agriculture sector is trough the reallocation of those resources among 31 agricultural activities.

Table 10 shows the returns to production factors for the steady state (the year 2008) under two scenarios: without and with trade liberalization and Table 11 shows agriculture GDP for twelve agricultural sectors[4].

[4] Appendix II shows the desegregation of agriculture GDP into thirty one activities.

TABLE 10
RETURNS TO PRODUCTION FACTORS
(1990=100)

	A Without Free Trade	B With Free Trade	(B-A)/A %
Wage Rate	100.00	80.64	-19.4%
Rental Price of Capital	100.00	107.83	7.8%
Rent of Irrigated land with credit	100.00	54.99	-45.0%
Rent of Irrigated land without credit	100.00	70.53	-29.5%
Rent of Dry land with credit	100.00	64.28	-35.7%
Rent of Dry land without credit	100.00	84.99	-15.0%

TABLE 11
GDP AT WORLD PRICES
(Millions of 1980 Pesos)

	A Without Free Trade	B With Free Trade	(B-A)/A %
Corn	10,129.57	8,659.86	-14.51%
Sorghum	5,585.36	3,453.63	-38.17%
Wheat	4,272.41	2.152.61	-49.62%
Dry Beans	3,095.78	1,825.61	-41.03%
Soybeans	684.37	714.02	4.33%
Rice	523.73	450.27	-14.03%
Saffron	70.08	108.45	54.76%
Bsc	319.4	596.85	86.87%
Sug	861.84	2,096.46	143.25%
Cat	8,786.02	12,700.38	44.55%
For	2,312.76	3,331.16	44.03%
Oth	3,058.74	5,395.74	76.40%
Agriculture	**39,700.06**	**41,485.02**	**4.50%**

Among all the agricultural activities corn is of major importance due to its social impact. Table 11 shows that value added in corn production decreases 14.5%. Since it is one of the most protected crops, one would have expected its value added to decline more sharply. This moderate reduction is probably due to the fact that corn is the most important crop and a very labor intensive activity (see Appendix I).

As we previously explained, workers will try to leave agricultural activities with or without trade liberalization, and employment in agriculture will be the same under both scenarios.

If we liberalize corn, other things being equal, this will tend to reduce employment in this activity, since it is such protected and labor intensive crop. Given that only a limited number of workers can leave agriculture (for reasons discussed earlier), the only way to restore full employment in agriculture is by reducing real wages. But since corn uses 19% of total agricultural employment, the reduction in wages needed to restore equilibrium will be large. This reduction stimulates employment in all the sector but especially in the more labor intensive activities, including corn. This explains why the elimination of tariffs does not reduce value added in corn activities by more than 14.5%.

The overall welfare effects on agriculture of trade liberalization can be divided into: a) a production gain and b) a consumption gain[5]. The production gain consists in a 4.5% increase in agricultural GDP measured at world prices. The consumption gain can be calculated assuming Cobb-Douglas preferences. Ttrade liberalization reduce the cost of living by 3.59 percent, while 3.36 percent of domestic expenditure is returned to the mexican economy as tariff revenue. Thus, the consumption gain from trade liberalization is about 0.23 percent[6]. This is very small compared to the production gains.

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[5] If we consider transfer payments, we can assume that the amount of subsidies contained in price supports will be replaced by a lump sum transfers (PROCAMPO). The net effect of the change in the transfer system is zero. This assumes that the price distortions in the agricultural sector are mainly due to subsidies. If there are other sources of distortions which the government does not pays directly (like quotas), then PROCAMPO will not fully compensate producers for the loss of income.

[6] See Young Romero (1994), pages 311-313.

Therefore the total gains from trade liberalization for the agricultural sector will be 4.7%; a consumption gain of 0.2% plus a production gain of 4.5%.

VI. CONCLUSIONS

We can conclude that trade liberalization has favorable dynamic consequences for improving welfare in the agricultural sector. The application of this policy carries with it a potential improvement of 4.7% of this sector's welfare compared to that of no trade liberalization. However, as could be expected, benefits are not distributed uniformly among factors of production.

The rental price of capital increases by 7.8%. Rents for all types of land decrease, but especially for those used by producers either with irrigation or credit, wich serves as an indication that the richest agricultural landowners are the main beneficiaries of the current levels of protection.

Workers will also experiment a loss of income. Their real wages are reduced by 14.3%. This reduction in wages will take place in an already complex situation in which many rural workers already require food and other relief programs.

The agricultural sector in Mexico currently employs 26.8% of the labor force, and produces only 6.8% of GDP. See Table 12.

TABLE 12
SHARE OF AGRICULTURE IN TOTAL GDP AND IN TOTAL EMPLOYMENT IN MEXICO AND USA

(1990 Values)

MEXICO		USA	
GDP	**EMPLOYMENT**	**GDP**	**EMPLOYMENT**
6.8%	26.8%	2.0%	2.8%

Source: INEGI, "Sistema de Cuentas Nacionales de México".
Source: Survey of Current Business U.S. Department of Commerce. May, 1993
Source: Labor Statistics Annual. International Office of Labor. Geneva, 1992.

The share of agriculture in total employment declined only 7.6% between 1970 and 1990 (see Table 3). This small reduction over such a long period is surprising, considering the large disparity in wages among sectors (see Table 5). The average agricultural wage is only 22% of that of construction and only 6% of that in the oil sector. The low skill level of the agricultural labor force reduces the possibilities for employment outside agriculture, and forces agricultural workers to live in extreme poverty. Next to emigration, only construction and services are alternatives for this type of labor (see Table 3).

Poverty in rural Mexico is not caused by inefficiencies in the agricultural sector. Trade liberalization makes agriculture more efficient, increases agricultural output. This gain in efficiency, however, harms rural workers.

We could retain the benefits of trade liberalization and mitigate its adverse consequences on workers by complementing trade liberalization in agriculture with a temporary program aimed at increasing labor income, without relying on price distortions. This could be achieved by an employment program of public works in rural areas, providing desperately needed infrastructure, such as irrigation, roads, schools, hospitals, housing etc. Such a program could temporarily increase wages if expenditures are large enough[7].

Poverty in rural Mexico is a consequence, among other things, of the lack of labor mobility. To fight this problem, the country's rural labor force must be trained so that it can find permanent employment in non-agricultural activities. The need to facilitate labor mobility can be illustrated with a simple exercise. Assuming that the agricultural sector will continue generating 6.8% of the GDP (estimations indicate that this percentage will be lower in the future), and assuming that Mexican agricultural labor is only half as productive as in the United States, one concludes that the Mexican agricultural sector cannot efficiently employ more than 19% of the total labor force.[8] The excess of workers must look for efficient employment elsewhere. This calls for extensive educational programs that will help people in rural areas to find a job outside agriculture (not necessary in urban areas).

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[7] A. Casco and Romero J. (1996) has calculated that if Mexico spends 1.4% of total GDP in public works in ural areas this will increase real wage by 12% for 7.4 million workers. Also E. Davila. Levy S. and Calva L.L. (1995) have recomend public work in rural areas as a way to fight poverty.

[8] This figure is obtained dividing 5..6% (two times the participation of the United States agricultural sector in total employment) into 2.0% (contribution of the United States agricultural sector in total GDP) and then multiplying the quotient by 6.8% (contribution of the Mexican agricultural sector in the total GDP). If we assume the same productivity as the United States this figure is reduced by halve.

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APPENDIX I
COST STRUCTURE OF THE SEVEN BASIC CROPS

In Tables 9 to 12 we present the cost structure of each of the four technologies for each one of the seven basic crops (source: SARH, FIRA, and BANRURAL survey.).

TABLE AI.1
IRRIGATED CROPS WITH CREDIT
(Cost Structure)

	CORN	SORGHUM	WHEAT	DRY BEANS	SOYBEANS	RICE	SAFFRON
Labor	24%	39%	39%	33%	31%	29%	33%
Capital	16%	24%	20%	16%	51%	28%	20%
Inputs	25%	16%	21%	16%	4%	17%	21%
Land	35%	22%	20%	35%	14%	26%	27%

TABLE AI.2
IRRIGATED CROPS WITHOUT CREDIT
(Cost Structure)

	CORN	SORGHUM	WHEAT	DRY BEANS	SOYBEANS	RICE	SAFFRON
Labor	35%	40%	45%	50%	31%	37%	48%
Capital	16%	8%	9%	8%	30%	22%	0%
Inputs	9%	13%	29%	12%	20%	6%	24%
Land	40%	39%	17%	30%	20%	35%	28%

TABLE AI.3
DRY LAND CROPS WITH CREDIT
(Cost Structure)

	CORN	SORGHUM	DRY BEANS	SOYBEANS	RICE	SAFFRON
Labor	28%	53%	47%	40%	33%	21%
Capital	27%	12%	12%	9%	22%	25%
Inputs	19%	21%	18%	9%	27%	21%
Land	26%	15%	23%	42%	19%	33%

TABLE AI.4
DRY LAND CROPS WITHOUT CREDIT
(Cost Structure)

	CORN	SORGHUM	DRY BEANS	SOYBEANS	RICE	SAFFRON
Labor	46%	59%	43%	46%	45%	49%
Capital	18%	2%	13%	1%	4%	9%
Inputs	13%	15%	17%	13%	12%	10%
Land	23%	24%	27%	40%	39%	31%

APPENDIX II

TABLE AII.1
GDP AT WORLD PRICES
(Millions of 1980 Pesos)

	A Without Free Trade	B With Free Trade	(B-A)/A %
CORN (IR,CR)	404.56	629.94	55.71%
CORN (IR,WC)	684.46	1,066.03	55.75%
CORN (DR,CR)	617.21	552.52	-10.48%
CORN (DR,WC)	8,423.34	6,411.37	-23.89%
SORGHUM (IR,CR)	338.17	526.67	55.74%
SORGHUM (IR,WC)	2,285.86	1,272.89	-44.31%
SORGHUM (DR,CR)	1,171.06	456.05	-61.06%
SORGHUM (DR,WC)	1,790.27	1,198.03	-33.08%
WHEAT (IR,CR)	3,951.97	1,653.55	-58.16%
WHEAT (IR,WC)	320.43	499.06	55.75%
DRY BEANS (IR,CR)	130.79	203.67	55.72%
DRY BEANS (IR,WC)	253.01	391.92	54.90%
DRY BEANS (DR,CR)	260.22	274.83	5.61%
DRY BEANS (DR,WC)	2,451.76	955.17	-61.04%
SOYBEANS (IR,CR)	334.26	520.30	55.66%
SOYBEANS (IR,WC)	180.45	81.13	-55.04%
SOYBEANS (DR,CR)	83.28	59.07	-29.07%
SOYBEANS (DR,WC)	86.39	53.51	-38.06%
RICE (IR,CR)	237.19	114.48	-51.74%
RICE (IR,WC)	40.12	18.69	-53.42%
RICE (DR,CR)	52.69	81.96	55.56%
RICE (DR,WC)	193.73	235.14	21.38%
SAFFRON (IR,CR)	11.52	17.92	55.53%
SAFFRON (IR,WC)	15.82	24.63	55.72%
SAFFRON (DR,CR)	6.27	9.77	55.80%
SAFFRON (DR,WC)	36.47	56.13	53.92%
BSC	319.40	596.85	86.87%
SUG	861.84	2,096.46	143.25%
CAT	8,786.02	12,700.38	44.55%
FOR	2,312.76	3,331.16	44.03%
OTH	3,058.74	5,395.74	76.40%
Agriculture	**39,700.05**	**41,485.02**	**4.50%**

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