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Country Department II,
Latin America and the Caribbean
The World Bank
August 1992
WPS 967

Transition Problems in Economic Reform

Agriculture in the Mexico-U.S. Free Trade Agreement

Santiago Levy
and
Sweder van Wijnbergen

How fast should Mexican agriculture be incorporated into the North American Free Trade Agreement? What policies should characterize the transition?

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This paper — a product of theCountry Operations Division 1, Country Department II, Latin America and the Caribbean — was partially financed by the OECD Development Center as part of their research project on Developing Country Agriculture and International Economic Trends, and by the World Bank under grant no. BB676-65M. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Margaret Stroude, room I8-159, extension 38831 (August 1992, 34 pages plus 19 pages of appendix).

Levy and van Wijnbergen use Mexican agriculture as a case study to analyze the transition problems that arise in most major economic reforms. They focus on the implications for policy design of the absence of efficient capital markets; on the welfare costs of reforming only gradually; on incentive problems created by trade adjustment policies; and on the redistributive aspects of policy reform in the presence of realistic limits on available intervention instruments.

They emphasize that adjustment should focus on increasing the value of assets owned by the groups affected, and not on direct income transfers or programs targeted to output or other characteristics controlled by the beneficiaries. That is, they contend that adjustment should be targeted to improving what people have, as opposed to what people do.

Transition Problems in Economic Reform:
Agriculture in the Mexico-U.S. Free Trade Agreement*

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Table of Contents

1.	Introduction	1
2.	Model Structure	3
	2.1 Static Relationships	3
	2.2 Intertemporal Relationships	7
	2.3 The Transition Path and the Steady-State	8
	2.4 Budget Constraints and Welfare Measures	9
3.	The Impact of Free Trade in Maize	11
4.	What Type of Trade Adjustment?	17
5.	On the Pace of Adjustment	24
6.	Conclusions	30
References		33
Appendix		34

* This paper was partially financed by the OECD Development Centre as part of their research project on "Developing Country Agriculture and International Economic Trends." The authors thank Ian Goldin and Hans Binswanger for helpful comments and discussions. An appendix with detailed equations and a discussion of data and calibration is available on request from Sweder van Wijnbergen.

1. Introduction

Agriculture contributes less than 8% of Mexico's GDP. Nevertheless, when in June 1990 Presidents Salinas and Bush announced negotiations on a Free Trade Agreement (FTA) between Mexico and the US, it was clear that agriculture would be a major stumbling block. At stake is much more than the efficiency gains that liberalizing agriculture, and particularly maize, would bring to Mexico, substantial as we find them to be. Maize protection is Mexico's de facto rural employment and anti-poverty program, so distributional concerns complicate the liberalization process. Further complications arise because, while high maize prices almost certainly contribute to rather than alleviate poverty, rapid liberalization would increase poverty on the transition path.

This paper focuses on the distributional effects of liberalizing maize in Mexico, the policies that can be put in place to alleviate them, and the incentive problems such policies in turn lead to. Our results, however, are of much wider interest than the FTA negotiations themselves. Agriculture has been a major stumbling block in trade negotiations everywhere. Agriculture has always been excluded from GATT negotiations until the recent Uruguay round, which almost collapsed because of it. In many cases the reasons are similar to the ones discussed in this paper.

Transition problems like the ones analyzed in this paper are likely to arise in most major economic reforms. In particular, we focus on the implications for policy design of the absence of well functioning capital markets; on the welfare costs of reforming only gradually; on the incentive problems created by trade adjustment policies; and on the redistributive aspects of policy reform in the presence of realistic limits on the array of intervention instruments available to the Government.

Maize is Mexico's key crop and main rural employer; it occupies the largest acreage, it is the most costly in terms of fiscal subsidies, and it is the most protected1/. It is grown by subsistence farmers, mostly in rain-fed lands; it is also grown by medium and large scale farmers in rain-fed and irrigated lands. Since irrigated lands have higher yields, the latter groups, who are not among the poor, receive large infra-marginal rents. Only 0.32 of every peso of subsidy reaches subsistence farmers (Levy and van Wijnbergen (1991)).

Tortillas, Mexico's main staple food, are mainly made from maize. The government subsidizes tortillas, but the subsidies fail to fully offset the effects of maize protection; thus the rural poor are taxed on their main consumption good. For landless workers and the 65% of maize producers whose land is so marginal that they are actually net maize buyers, this tax exceeds the subsidy they receive as producers.2/

We show that liberalization lowers the value of rain-fed land, thus hurting the sub-set of the rural poor who own land by reducing the rents derived from this asset. This would lower the value of the main asset farmers can collateralize, reducing their access to credit at the very moment when such access is needed most. Liberalization also lowers the demand for rural labor. And since migration links rural and urban labor markets,

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1/ Import controls support a price 70% above the world price (allowing for transport costs and quality differentials); 42% of the total arable land is allocated to this crop, which employs one out of three rural workers; subsidies to maize and tortillas cost about US$ 1 billion in 1991.

2/ In urban areas the tax is partly offset by deliveries of tortillas through the 'tortivale' program. Under this program each urban family earning less than two minimum wages receives one kilo of tortillas per day free. This is less than daily family consumption, so the program is infra-marginal.

liberalization of maize lowers wage rates across the board. The effects of liberalization thus spill-over to the urban poor.

Lump-sum transfers are not a feasible option in Mexico, so other policies to protect the poor are needed. Moreover, Mexico's poor have limited access to capital markets, access which may in fact be reduced by the liberalization because it lowers land prices. Hence, these policies must not only focus on steady-state welfare, but also on the transition period. And because the FTA is a permanent shock, these policies should also facilitate change towards other activities.

In section 2 we sketch an inter-temporal model to trace the impact on households' welfare of Mexico-US free trade in agriculture, and of different adjustment policies. In section 3 we quantify the trade-offs between the speed of liberalization and the size of the efficiency gains; we also study the impact on labor and land markets. Section 4 designs a program to facilitate adjustment towards free trade in maize that protects the rural poor during the transition. Political economy considerations that bear on the design of this program are addressed in section 5. Section 6 concludes.

2. Model Structure

2.1 Static Relationships

The economy is divided into an urban and a rural sector. The urban sector produces only a tradeable industrial good and a non-tradeable services good. Each of these goods is produced with fixed intermediate inputs and a Cobb-Douglas technology for urban labor and sector-specific capital.

Land and rural labor produce five tradeable goods in the rural sector: maize, other basic grains, fruits and vegetables, other agricultural goods, and livestock. We distinguish between rain-fed (T1) and irrigated (T2) land, because yields and land/labor ratios for the same crop differ between types of land. We include tortillas as a pure consumption good. Tortillas are non-traded, but by assumption perfectly elastically supplied at the zero-profit, tax/subsidy inclusive price; their price depends only on the producer price of maize and any taxes or subsidies.

We distinguish six types of households, classified by ownership of factors of production. Four are in rural areas: landless rural workers, whose only asset is labor; subsistence farmers, who on average own two hectares of rain-fed land, work their own land and participate in the rural labor market; rain-fed farmers, who own the remainder of the rain-fed land and half of the land used for livestock; and owners of irrigated land, who own the irrigated land, and the other half of livestock land. Neither rain-fed nor irrigated farmers supply labor. Urban workers supply all urban labor, and urban capitalists own the urban capital stock.

Urban workers, landless rural workers and subsistence farmers all have the same preferences, as do rain-fed and irrigated land owners and urban capitalists. The first group allocates a much larger share of expenditure to rural goods than the second, so changes in food prices have a much larger impact on the first group[3/].

Migration plays an important role in determining the incidence of changes in agricultural protection. While migration to the US has attracted most international attention, rural-urban migration inside Mexico is quantitatively more important. Mexico's rapid urban growth has been largely

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3/ Preferences are given by a nested Cobb-Douglas/CES/CES utility function. The outer nest CD allocates expenditures between a composite rural good, industry and services. The next CES nest aggregates the five rural goods into a composite rural good. The last CES nest distributes maize consumption between raw maize and tortillas.

by such migration, and involves numbers in excess of any available estimate of the number of Mexican migrants currently in the US (Garcia y Griego (1989)).

We therefore focus on internal migration, and assume that migration flows keep the ratio of per-capita utility differentials between landless rural workers (the most likely migrants) and urban workers (the most likely target group) constant. We use utility differentials rather than wage differences (as in the Harris-Todaro model) because urban transfers like the tortivale program also affect migration choices. We capture all such effects by focusing on total utility. With L^{ru} the stock of migrants from rural to urban areas, U_r and U_u per capita utility of a worker in the rural and urban areas, respectively, and the superscript 0 an initial equilibrium, we get:

$$L^{ru} = k[(U_u/U_r)/(U_u^0/U_r^0)]^{\eta} - k \quad ; \quad k>0 \quad \eta \geq 0 \tag{1}$$

where η is the elasticity of migration to urban-rural utility differentials. Keeping utility differentials constant is achieved by setting η very high.

We distinguish <u>physical</u> (the actual physical hectares of land allocated to a particular crop) from <u>effective</u> land (the amount actually usable). The relationship between them is:

$$\tilde{T}_j = \tau_j . T_j^{\phi_j} \quad ; \quad \tau_j > 0, \quad 0 < \phi_j < 1 \tag{2}$$

where ~ denotes effective land; the subscript j refers to the four agricultural goods. Equation (2) is intended to capture incentives for crop rotation and other practices that preclude allocating all land to a single crop. Irrigated land is assumed to be better than rain-fed in that $\phi 1_j \leq \phi 2_j$, so that diminishing returns set in more slowly than in rain-fed lands. Hence, for the same price change, the supply response in irrigated lands is stronger.

Agricultural production functions exhibit constant returns to scale to labor and <u>effective</u> land; thus value added in maize, m, in rain-fed lands is:

$$VA1_m = LR1_m^{1-\alpha 1_m} \tilde{T}1_m^{\alpha 1_m} = LR1_m^{1-\alpha 1_m} \tau 1_m^{\alpha 1_m} T1_m^{\phi 1_m \alpha 1_m}$$
$$= \rho 1_m LR1_m^{1-\alpha 1_m} T1_m^{\lambda 1_m} \quad (3)$$

$LR1_m$, $T1_m$ are rural labor and rain-fed lands allocated to maize; $\rho 1_m = \tau 1_m^{\alpha 1m}$ and $\lambda 1_m = \phi 1_m . \alpha 1_m$. Similar functions apply to the other agricultural products in both types of land. Since $0 < \lambda < \alpha < 1$, there are diminishing returns to physical land for given labor intensity. Thus, for a wide range of prices there need not be full specialization in agriculture.

Trade interventions are modelled as combinations of production and consumption taxes/subsidies. We also model direct lump-sum transfers to urban workers through the tortivale program. Such tortilla deliveries are inframarginal, and thus equivalent to a direct income transfer. For given taxes and subsidies, domestic prices for tradeable goods follow world prices, as we assume domestic goods to be perfect substitutes for world goods, and take world prices to be exogenous. But services are non-traded, so this market, like the markets for rural and urban labor, and rain-fed and irrigated land, is cleared by prices. Our model thus determines, via the excess demand functions in (4), factor prices and the real exchange rate:

$$\begin{aligned}
&LR^D(P) + L^{ru}(P) - LR^0 = 0 \\
&LU^D(P) - L^{ru}(P) - LU^0 = 0 \\
&T1^D(P) - T1 = 0 \\
&T2^D(P) - T2 = 0 \\
&qs_s(P) - qd_s(P) = 0
\end{aligned} \quad (4)$$

P contains the rural and urban wage rates, the rental rates on rain-fed and irrigated land, and the price of services (the real exchange rate). The vectors of goods' supply and demand are, respectively, qs and qd, the subscript s refers to services, and the superscript D denotes the market demand for a particular type of labor or land. LR^0 and LU^0 are the initial distribution of the total labor force so that in the base case $L^{ru} = 0$.

2.2 Inter-Temporal Relationships

At each period the economy is described by the excess demand functions in (4). But from one time period to the next the economy changes as a result of exogenous and policy-induced changes. The exogenous changes are: (i) growth of labor and population[4/], (ii) Hicks-neutral technical change, (iii) growth of the urban capital stock[5/], (iv) government spending in non-agriculture items, and (v) the path of world prices. Importantly for our results, we assume that the rate of growth of productivity in rain-fed agriculture is lower than in irrigated agriculture. This reflects the fact that high yielding varieties, pesticides, fertilizers and other innovations are easier to implement in irrigated lands.

We model two policy-induced changes to alter the economy's growth path: trade policy and agriculture investments. Within trade policy, attention focuses on the sectors where liberalization occurs, on the date at which changes start, and on the speed at which they take place. Within agriculture investments, we focus on the size and time-profile of irrigation investments.

Investments in irrigation infrastructure change the endowments of irrigated and rain-fed land with a 1-period gestation lag:

4/ To reflect Mexico's demographic transition, the rate of growth of labor, 3%, is set higher than the rate of growth of population, 2%. During the transition period, see below, the rate of growth of labor slowly declines until in the steady-state it equals that of population. Thus, households who own labor initially grow faster than households who own only land or capital.

5/ In a fuller model of the impact of the FTA, investment rates in industry and services would clearly be endogenous. Here, however, we are interested in the effects of changes in agricultural liberalization only.

$$T1_t = T1_{t-1} - RI_{t-1} \quad ; \quad T2_t = T2_{t-1} + RI_{t-1} \tag{5}$$

RI is the number of hectares of rain-fed land transformed to irrigated land. Owners of rain-fed land (subsistence peasants and rain-fed farmers) are assumed to benefit from irrigation investments in proportion to the initial share of rain-fed land held by each group. The investments are paid for by the government. The real resource costs of irrigation are an increasing function of the stock of irrigated land, reflecting the fact that as these investments increase, lands of poorer-quality are encountered (greater distance from water resources, etc.). We capture this by:

$$Q_t = q\left(\frac{\sum_{i=0}^{t-1} T2_i}{T2_0}\right)^{\gamma}; \quad q>0;\ \gamma>1 \tag{6}$$

where Q_t is an index of marginal costs of irrigation investments.

The rates of growth of labor in each period, gl_t, are exogenous, but migration responds to endogenously determined utility differentials, implying in turn that the urban and rural labor force are determined endogenously by:

$$LR_t = (LR_{t-1} - L^{ru}_{t-1})\,(1 + gl_{t-1}) \quad ; \quad LU_t = (LU_{t-1} + L^{ru}_{t-1})\,(1 + gl_{t-1}) \tag{7}$$

2.3 The Transition Path and the Steady-State

We divide the future into a transition path and a steady-state. The transition path lasts T-1 years; the steady-state obtains from period T onwards, going out to infinity. All policy-induced changes take place during the transition period. During this period the rate of growth of labor also converges to that of the population. In the steady-state, on the other hand, all households grow at the same rate, and the rate of growth of aggregate output, which equals the rate of growth of the capital stock, is given by the sum of labor and productivity growth.

Hence, by assumption, static and intertemporal relative prices remain unchanged over the interval $[T,\infty)$. This allows us to Hicks-aggregate the steady-state path of the economy. It suffices to simply calculate period T values, since all future periods will be identical up to a uniform scale factor (growth rate) for all quantities. The aggregation process therefore only affects discount factors between T-1 and T; these are larger than those between earlier periods because this 'period' is replicated an infinite number of times (again, up to a uniform scale factor for all quantities).

Let the common and constant post-T growth rate be g and the real world interest rate r^w. Define $\delta=1/(1+r^w)$ and $\delta_a=(1+g)/(1+r^w)$, where δ_a is the period-to-period growth-adjusted discount factor. Then the following expressions obtain for discount factors from year i back-to-period-1, $\delta(i)$:

$$\begin{aligned} \delta(i) &= \delta^{i-1} && \textit{for } i < T \\ &= \sum_T^\infty \delta^{i-1} = \frac{\delta^{T-1}}{1-\delta} && \textit{for all } i > T \textit{ combined} \end{aligned} \tag{8}$$

Consider now the Net Present Value, NPV_y, of (y_t), where $y_t=y_{t-1}(1+g)$ for all $t > T$:

$$\begin{aligned} NPV_y &= \sum_1^\infty y_t.\delta^{t-1} = \sum_1^{T-1} y_t.\delta^{t-1} + \delta^{T-1}.\sum_T^\infty y_T.(1+g)^{t-T}\delta^{t-T} \\ &= \sum_1^{T-1} y_t.\delta^{t-1} + \delta^{T-1}\sum_T^\infty y_T.\delta_a^{t-T} = \sum_1^{T-1} y_t.\delta^{t-1} + \frac{\delta^{T-1}}{1-\delta_a}.y_T \end{aligned} \tag{9}$$

Thus the infinite horizon is captured by calculating period T only (out of all $[T,\infty)$ periods), but adjusting the period T discount factor to equal:

$$\delta(T) = \frac{\delta^{T-1}}{1-\delta_a} \tag{10}$$

2.4 Budget Constraints and Welfare Measures

Only urban capitalists save and invest. Private investment is driven by the exogenously given growth of the capital stock. Private savings is a constant proportion of urban capitalist's income. This proportion is exogenous during the transition period, but is endogenized in the steady-state to satisfy their inter-temporal budget constraint. Thus, if during the transition period they accumulated debt (assets), the steady-state savings rate is increased (decreased) so that the discounted value at time T of future savings over investment equals the value of the debt (assets) accumulated up through period T-1; see the appendix for details.

Household's welfare is the present discounted value of the time-paths of utility $(U^h_0 \ldots U^h_{T-1}; U^h_T)$. Let the rate of time-preference, ρ, be constant and equal for all households, and use a CRRA utility function to aggregate utility over time. If σ is the inter-temporal elasticity of substitution, we calculate welfare of household h as:

$$W_h = \sum_1^{\infty} \frac{u_h(c_t)}{(1+\rho)^t} = \sum_1^{T-1} u_h(c_t) . \delta_{pref}^t + \frac{u_h(c_T)}{(1+\rho)^T} \sum_T^{\infty} \frac{(1+\sigma^{-1}.gc)^{t-T}}{(1+\rho)^{t-T}}$$

$$= \sum_1^{T-1} u_h(c_t) . \delta_{pref}^t + \frac{u_h(c_T) . \delta_{pref}^T}{1-\delta_{prefA}} \quad (11)$$

$$\text{where } \delta_{pref} = \frac{1}{1+\rho} \quad \text{and} \quad \delta_{prefA} = \frac{1+\sigma^{-1}.gc}{1+\rho}$$

where gc is the steady-state rate of growth of per-household consumption.

Because all private households satisfy their inter-temporal budget constraint, the present discounted value (PDV) of the government deficit (surplus), equals the PDV of the trade deficit (surplus), B. We do not impose the condition that B = 0. Rather, we measure the difference between the PDV of the government deficit in the base path, denoted by B°, and any B generated by an alternative path, and interpret the difference as the change in resources generated by the policy change. For each path we calculate the lump-sum transfers (taxes) required so that each household in each period has the same current utility as in the base path. When the value of these income compensations are included as part of government's expenditures, as if in fact these compensations had been given, the difference between B° and B is the aggregate efficiency gain of any policy change.

3. The Impact of Free Trade in Maize

We study the implications of liberalizing maize by comparing a reference path for the economy that leaves maize and tortilla policies at their present levels with various alternatives where maize and tortilla prices are freed-up; on the reference path there is no irrigation investment[6/], and US protection of its Fruits & Vegetables (F&V) sector stays at its present level.[7/]

Table 1 shows the efficiency gains and distributional impact of eliminating all taxes and subsidies to maize and tortillas. The efficiency gains measure the increase in national income assuming the government delivers lump-sum transfers (or levies) so that every household has always the same utility as in the reference path. The welfare changes measure the impact of various alternative adjustments, but exclude the effects of such transfers.

In this section we only focus on the first two columns, where we evaluate the effects of liberalization without any adjustment policies. The first column shows the impact of an immediate elimination of all maize and

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6/ Also, on the reference path real government spending and the capital stock in industry and services grow at 4% annually. Productivity in the urban sector grows at 2%, and in rain-fed (irrigated) agriculture at 0.5 (1.5%).

7/ We assume that protection to other agricultural sectors, basic grains in particular, is removed over a 5 year horizon. This allows sharper focus on whether to include maize in the FTA, and what kind of supporting policies are advisable. Because liberalization of grains is already incorporated in the base scenario, these results only provide measures of the efficiency gains (costs) from including (excluding) maize in the FTA.

tortilla taxes and subsidies; the second column shows the effects of a gradual change where maize moves linearly to world prices over 5 years (so that in the sixth year domestic and world prices are equal).

Table 1: Welfare and Efficiency Effects

	Maize 1Y no CNA no F&V	Maize 5Y no CNA no F&V	Maize 1Y CNA no F&V	Maize 5Y CNA no F&V	Maize 5Y CNA F&V	Maize 6Y CNA early F&V
Subsistence Farmer[a]	0.967	0.971	1.007	1.011	1.013	1.015
Landless Rural Worker[a]	0.984	0.985	0.993	0.995	1.000	1.001
Rain-Fed Farmer[a]	0.943	0.949	0.996	1.001	1.000	1.003
Irrigated Farmer[a]	1.028	1.024	1.019	1.015	1.028	1.025
Urban Worker[a]	0.984	0.986	0.993	0.995	1.000	1.001
Urban Capitalist[a]	1.018	1.017	1.013	1.012	1.007	1.006
Efficiency Gains[b]	42.44	40.08	51.96	49.57	44.81	43.18
Cumulated Fiscal Gain[b]	23.17	21.94	18.04	16.76	13.64	12.50

a/Measured as a percentage of the reference case.

b/1989 US$ billion; Mexico's GDP was 207 billion in 1989.

Instantaneous liberalization leads to very large efficiency gains. The PDV of these gains is US$ 42.4 billion. With a growth-adjusted discount rate of about 3%[8], these efficiency gains translate into US$ 1.22 billion of

8/ We assume a (risk-adjusted) world real interest rate of 7%, and long term rates of technical progress and population growth such that steady-state growth is 4%. The growth-adjusted discount rate thus is 2.9% (=(1.07/1.04-1)*100), implying a growth-adjusted discount factor of 0.972.

additional consumption per annum, or 0.6% of 1989 GDP. This is a very significant number for gains from removing taxes and subsidies to only two commodites: maize and tortillas. The efficiency gains of gradual liberalization are less, at US$ 40.1 billion, but actually not by very much. Distributing the adjustment over a five year period reduces the net discounted value of the efficiency gains by only 5.5%. Thus the efficiency costs of a more gradual approach do not seem large when compared to the benefits that maize liberalization eventually leads to.

But the aggregate efficiency gains have substantial distributional effects. To understand how different groups are affected by the policy change, first look at what happens to the prices of the factors of production. The more straightforward one is labor. As Figure 1 shows, rural product wages are adversely affected by the cut in maize prices. While maize is less labor-intensive than fruits and vegetables, it is more labor-intensive than all other activities in agriculture, hence rural product wages fall once maize prices go down.

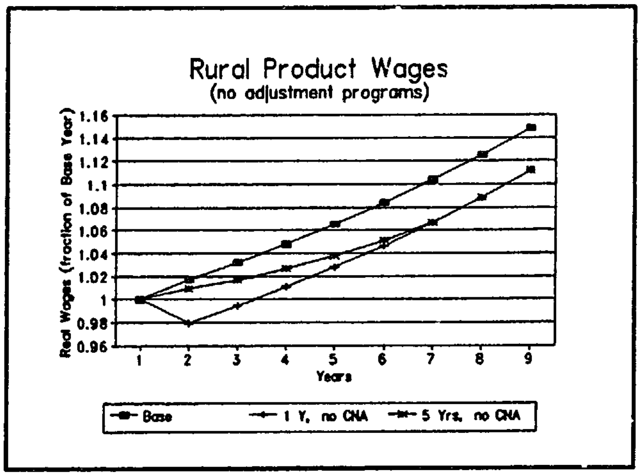

Figure 1

Table 2 shows the discounted value of all current and future rental income for both types of land. Column 1 indicates that the value of rain-fed land drops by almost 25% under immediate liberalization, clearly a very significant capital loss. This is because most maize is grown in rain-fed lands, where substitution possibilities towards other crops are much more limited than on irrigated land. The value of irrigated land actually goes up.

Because both substitution possibilities and labor-intensity are higher in irrigated lands, the positive effect of lower rural product wages offsets the negative impact of lower maize prices.

Table 2: Land Values and Land-Holdings[a]				
	Rain-fed Land	Irrigated Land	Land-holdings of Subsistence and Rain-fed farmers	Land-holdings of Irrigated farmers
Base Case	12.065	40.169	12.065	40.169
Case 1: 0 year adjustment, no CNA Program	9.231	40.800	9.231	40.800
Case 2: 5 year adjustment, no CNA program	9.443	40.725	9.443	40.725
Case 3: 0 year adjustment, with CNA program	9.180	40.668	11.499	40.668
case 4: 5 year adjustment, with CNA program	9.390	40.597	11.703	40.597
case 5: 5 year adjustment, with CNA program, access to US F&V market	9.608	42.175	12.030	42.175
case 6:as 5, but maize price cuts take last 6 years & start one year after CNA program	9.726	42.137	12.141	42.137
a/ million pesos of 1989 per hectare.				

Contrasting the fall in land values with the reduction in rural product wages, it is clear that a larger part of the adjustment falls on land. The reason for this is that labor is more mobile than land. Labor can be re-allocated within agriculture towards other crops with much more ease than rain-fed land, and in addition some of the impact on labor is shifted to urban workers through rural-to-urban migration.

Figure 2 shows the migration response. Note first that under the reference case migration is substantial. Long-term productivity trends do not favor agriculture, particularly not rain-fed agriculture. This, together with the exhaustion of land on the extensive margin, makes it clear that even with current maize policies future migration will be substantial. The model predicts a cumulative migration of almost 1.2 million workers over the next decade. Such large migration suggests that maize protection as a rural

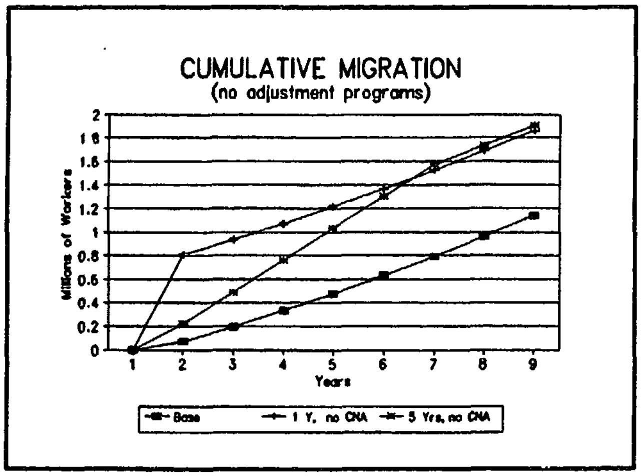

Figure 2

employment policy is likely to fail increasingly or, alternatively, become much more expensive than it already is.

Immediate liberalization has a large impact on migration, adding 700,00 workers in a <u>single</u> year (F' ıre 2). Gradual liberalization also increases migration over the reference case, but does so at a slower pace. However, after the adjustment is over, the cumulative amount of migration is the same. Table 1 shows what these factor price developments imply for households' welfare. Rural landless workers lose out as rural wage rates fall. But their welfare drops less in percentage terms than rural product wages do, because they are also consumers of maize and profit from lower maize prices. As Figure 3 shows, the drop in the rural consumption wage is less than the fall in the rural product wage.

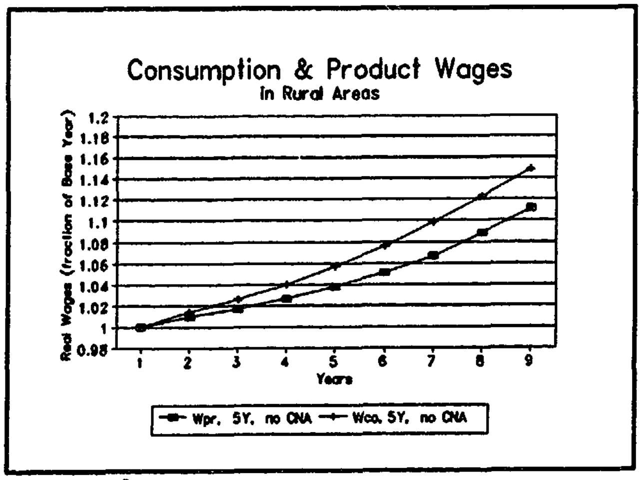

Figure 3

Subsistence farmers own rain-fed land and hire out as day laborers to other farmers; they are thus doubly hit as both the value of their land drops by 25%, and their labor income declines in line with the drop in rural wages (though they also benefit from lower consumer prices). The situation is more complex for rain-fed and irrigated farmers. They both lose because of lower maize prices, but they gain because of lower rural wages (since they are both net users of labor). These two factors are capitalized in land prices, and the balance is clear from table 2: rain-fed farmers lose substantially, while irrigated farmers experience a small gain. Note that under gradual liberalization values of rain-fed land fall less than under immediate, since protection-induced rents can be reaped for five additional years.

Figure 4 illustrates how this affects rain-fed farmers. The shaded area measures the differences in utility between immediate ('cold turkey') and gradual liberalization. The gradual path gives them additional rents during the transition (although at declining rates), but it produces no further gain once the transition is over.

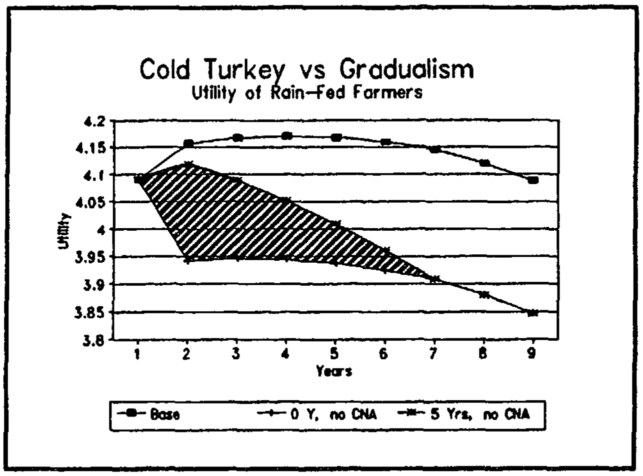

Figure 4

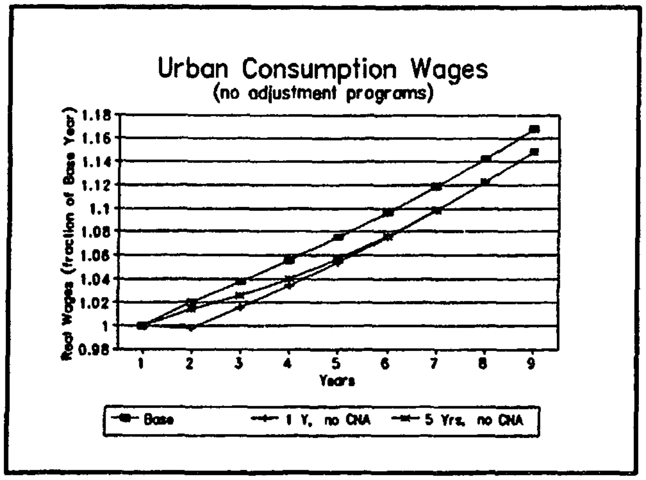

Figure 5

Migration slows the drop in rural wages at the cost of increased downward pressure on urban wages. Figure 5 shows that despite lower consumer prices for maize, urban worker's real consumption wages fall relative to the base case. And with the marginal product of capital increasing as a result of higher urban employment, capitalists are better off.

To sum up: the efficiency gains of liberalization in the absence of adjustment policies are substantial, but unevenly distributed. Immediate liberalization produces larger gains, but gradualism is not very costly; the aggregate efficiency gains foregone during the five year transition are small. But the converse of this is that gradualism barely mitigates the welfare loss for the groups affected. Of course, prolonging the liberalization over more than five years further insulates the groups concerned from welfare losses, but also further reduces the aggregate efficiency gains. The issue is therefore not only how fast to liberalize, but also what measures are taken during the transition to transfer some of the efficiency gains to the groups most affected by it. How this can be done is the subject of the next section.

4. What Type of Trade Adjustment?

The inclusion of Mexican agriculture into the FTA is a permanent change. A poverty-minded adjustment program for such a change should therefore have two objectives: first, transfer income to those among the poor that are adversely affected. Second, facilitate their finding alternative sources of income. The major problem in the design of such a program is that the first objective usually conflicts with the second.[9/]

A program designed to help maize producers would provide incentives to increase, or at least maintain, maize production, because benefits would decrease with lower output; such a program would discourage farmers from searching for alternative activities. Moreover, if the benefits are significant, the program would also provide incentives for rent-seeking and

9/ cf Diamond (1982) for this point.

graft; the number of 'registered' maize producers would soon exceed the rural population. This is particularly important in Mexico, where administrative capacity is weak, as are records of farm size and output. But, more fundamentally, a program focused on transfering income to maize producers fails to alter underlying conditions in agriculture. For the adjustment program to be transitory, it must increase the productivity of the factors owned by the groups affected by the policy change, so that after the program ends these groups do not need further assistance. Section 3 indicates that in Mexico's case this translates into programs that can increase land values and stimulate the permanent demand for rural labor.

Table 2 indicates that at free trade prices the average rental rate on irrigated land is four times that of rain-fed land. Thus a program of investments in land improvements has a substantial potential for increasing land productivity.[10/] Such a program is particularly promising because private irrigation investment has been discouraged by land tenure problems and explicit regulation, while public investment has been curtailed for budgetary reasons.[11/] As a consequence, the return on such a program is likely to be high.

A public investment program focused on land improvements generates transitory demand for rural labor. By supporting the rural wage rate during the construction period it eases the transition towards free trade for landless rural workers and subsistence farmers; and by slowing down migration

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10/ We refer to a program of 'land improvements' to emphasize that it involves not only irrigation infrastructure, but also investments in drainage, land levelling, ditch-clearing, etc.

11/ See Sanchez Ugarte (1991) for a description of water's regulatory regime in Mexico.

it helps insulate urban workers from the policy change. And because irrigated land is about 2.4 times more labor-intensive than rain-fed (at the free trade crop composition), the program stimulates the permanent demand for rural labor. Thus, once the program is finished it continues to provide employment opportunities in the rural areas.

But the program also helps to increase the value of the land owned by subsistence and rain-fed farmers. As some of their land is improved with irrigation and drainage, the capital loss suffered due to removal of protection is reduced. This in turn restores the value of their main collateral and enhances their access to credit. In addition, transforming land from rain-fed to irrigated lowers risks faced by farmers and augments crop choice. This facilitates a permanent adjustment away from maize cultivation.

Simulations three and four explore such a program. In both simulations we assume that a total of 1.1 million hectares of land are transformed from rain-fed to irrigation, with investments beginning in the second year and lasting a total of five years[12/]; in simulation three maize and tortilla prices are liberalized immediately, while simulation four assumes a pari-passu five year adjustment path for price liberalization and irrigation investments.

Table 1 shows that the efficiency gains of maize liberalization accompanied by irrigation investments are over 20% higher than in the absence of irrigation (with slightly larger gains when liberalization is immediate). Moreover, the efficiency gains when gradual liberalization is accompanied by the irrigation program exceed by almost 17% the gains from immediate

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12/ The program is assumed to irrigate 0.25 million hectares in each of the first three years, 0.20 in the fourth and 0.15 in the fifth. This program is feasible given Mexico's previous experience in this area. We refer to the program as the 'CNA program' because it would be implemented by the Comision Nacional del Agua, Mexico's agency in charge of irrigation construction.

liberalization without adjustment program. Clearly, the potential gains from irrigation investments are large. This increased efficiency has two sources: one, the four-to-one difference in the level of productivity of irrigated vs. rain-fed land. Two, an increase in the average rate of technical change in agriculture: technical change is faster in irrigated land, and the program increases the share of total arable land that is irrigated.

Equally interesting are the distributive effects of the program. Column 4 of table 1 indicates that the two groups directly dependent on the value of rain-fed land are both better off when gradual liberalization is accompanied by the irrigation program. The reason for this is shown in table 2: although land prices are almost the same as in simulations 1 and 2 (the differences resulting from different behavior of wage rates), the value of the land holdings of these two groups is almost restored to the pre-liberalization levels, as now these groups hold a mix of rain-fed and irrigated land.

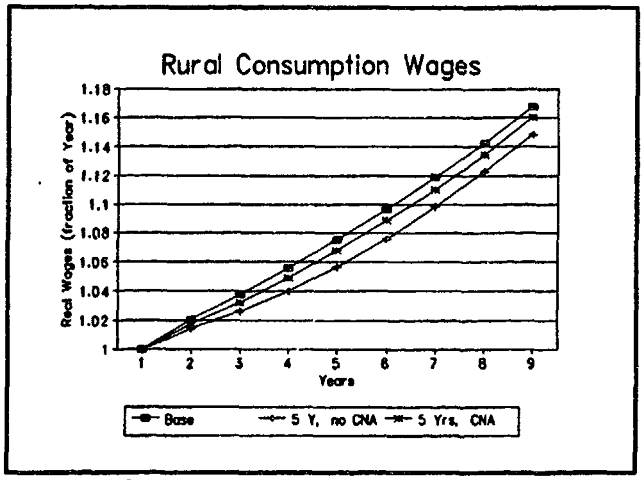

Figure 6

Figure 6 shows that rural wage rates are also higher when liberalization is accompanied by the irrigation program, generating benefits for landless rural workers and subsistence farmers and, by further slowing migration, for urban workers as well. As a consequence, the welfare of landless rural workers and urban workers is almost restored to the protection level (cf. table 1). The converse of this tightening in the labor market is reflected in urban capitalists and irrigated farmers' welfare, which is correspondingly diminished (though still higher than under protection).

Figure 7 depicts the time-path of utility for rain-fed farmers for the five year liberalization paths with and without the CNA program. With the CNA program rain-fed farmers are initially worse-off, reflecting the interaction between the rural labor market and the gestation period of irrigation investments. For them, the initial impact of the CNA program is a tightening of the rural labor market, with negative implications for second-period utility. It is only after the third year, when the irrigation works come on stream, that the benefits of land improvements out-weigh the costs of higher rural wages. And though their welfare is higher than on the reference path, it takes five years for current-period utility to be higher. This interaction between the path of price declines on the one hand, and the timing of irrigation investments, on the other, determines <u>when</u> the different groups receive the benefits of the adjustment program. All this is masked by the discounted value of utility, but such timing issues can be very important for the political economy aspects of the reform (cf the next section).

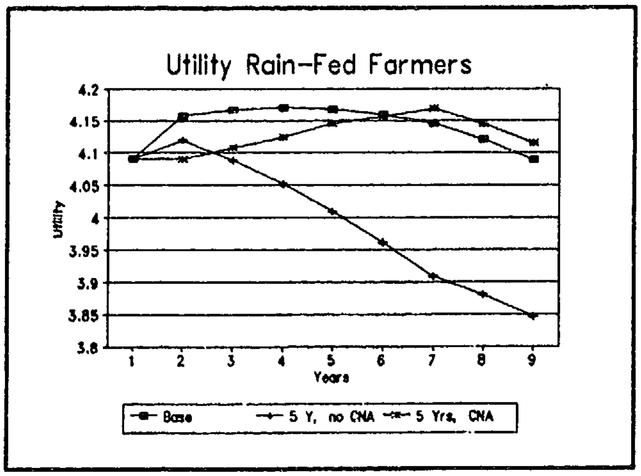

Figure 7

The scenarios presented so far have ignored any change in US protection towards Mexico's export crops. Simulation five considers a scenario where the gradual liberalization of the Mexican maize market is accompanied by a gradual liberalization over the same five year period of the US market for fruit &

vegetables, the sector with the most significant agricultural trade barriers in the US[13/]. We assume that this simultaneous trade liberalization is accompanied by the same five year CNA program considered before.

Consider first the distributional effects of improved market access to the US fruit & vegetable market. This policy combination generates a Pareto improvement vis-a-vis the reference case: the welfare of all households is at least equal to the protection situation, and for some there is a gain.

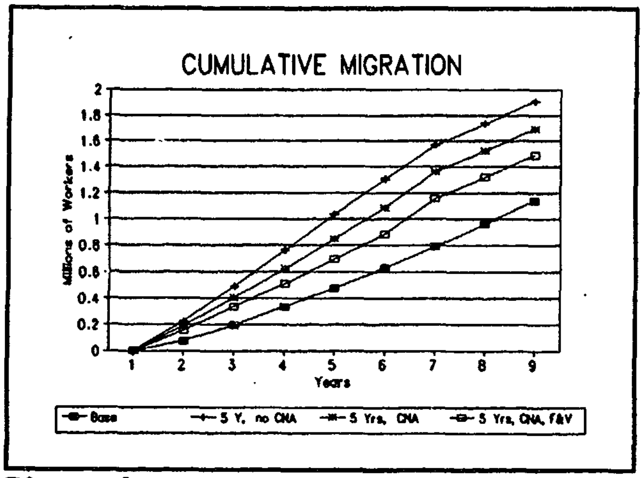

Figure 8

Because fruits and vegetables is the most labor-intensive crop, a price increase shifts out the demand for rural labor, which translates into higher rural wages, reduced migration (Figure 8), and higher urban wages. Thus, the opening of the US market has a positive distributional effect via higher wage rates. By reducing labor displacement, it facilitates the transition towards free trade in maize.

Irrigated farmers are more than compensated for the higher rural wages by higher prices for fruits & vegetables: their welfare increases (table 1). But rain-fed farmers profit little from improved export prices for fruits and vegetables, but must pay higher wages; thus, they constitute the only group in the rural areas who do not benefit directly from a comprehensive FTA.

13/ These barriers are equivalent to a 20% tariff (Feenstra and Rose (1991)). But because the sector labelled here 'fuits and vegetables' includes other crops (cf the data appendix) the tariff is scaled back to 5%. Thus prices faced by Mexican fruit and vegetable exporters increase by 1% during each of the five years of adjustment, and then stay constant at the higher level.

Next, consider the effects of the US liberalization on aggregate efficiency. Table 1 shows that the aggregate efficiency gains in simulation five are slightly lower than in four, which has the same path for maize prices and irrigation investments. This seemingly paradoxical result follows from second-best effects. Because of the urban-rural wage differential, re-allocating labor from rural to urban areas gives, ceteris paribus, efficiency gains. By slowing down migration, the gradual liberalization of the US market diminishes the size of the gains from labor re-allocation into urban areas.

Consider next the fiscal impact of the adjustment program. We focus on the trade-off between fiscal savings from the reduction in maize and tortilla subsidies vs. the fiscal cost of the CNA irrigation program. Figure 9 plots the fiscal impact of maize and tortilla subsidies: (i) the cost of maize production subsidies, (ii) the revenue from tortilla taxes, (iii) the cost of the tortivale program; and, for simulations 3 and 4, (iv) the cost of irrigation investments[14].

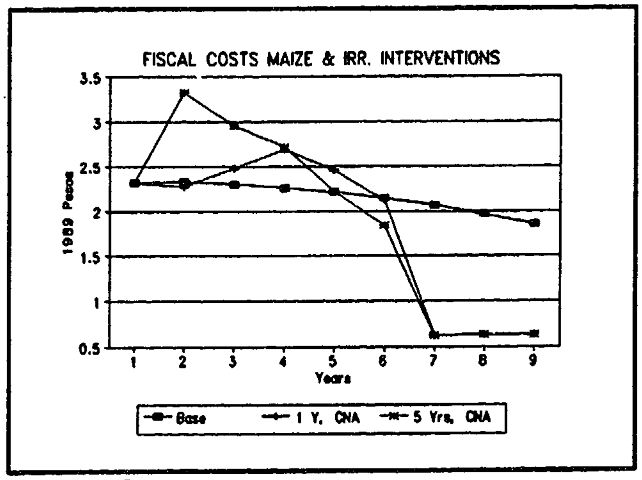

Figure 9

On the reference path the fiscal costs of maize interventions actually decline through time. This is because tortilla consumption, which under current policies is taxed, grows faster than subsidized maize production. When irrigation investments are undertaken, the fiscal position initially deteriorates, but then improves after the fifth or sixth year. With gradual

14/ Investment costs reflect the time-profile of the CNA program and the increased marginal costs of irrigating lower quality lands. The last 150,000 hectares are, on average, 49% more expensive than the first 250,000.

liberalization, this deterioration is initially quite sharp, because only small savings are made each year on the costs of maize interventions. With immediate liberalization, the savings from maize interventions actually dominate the costs of irrigation investments in the first year, and the fiscal costs over the next four years are smaller than in the case of gradual liberalization. After the sixth year, when the irrigation program is complete, both alternatives generate lower costs than current policies[15].

Table 1 indicates the net fiscal impact of each alternative: the net present value of the fiscal surplus in simulation three (four) is 3.5% (3.2%) higher than on the reference path. Current maize policies cost more than the adjustment programs proposed to ease the transition to free trade.

5. On the Pace of Adjustment

Much of the economic literature, and in fact Mexico's own experience, argues for fast-paced reforms. But in this case several points argue for a more gradual approach. First, the impact of speed of reform on labor markets and migration. As shown in figure 2, if maize prices are liberalized instantaneously, around 700,000 workers are predicted to move almost straight away. This implies a migration of between 1 and 5 million people (average family size in rural areas is 7). This would put demands on urban infrastructure and labor markets that would be almost impossible to meet. A more gradual reform leads to the same migration, but spreads it out over most of the coming decade, buying time to set up the infrastructure and training facilities needed to accommodate such a large group of migrants.

15/ The fiscal costs of intervention do not fall to zero because the costs of the tortivale program still have to be covered (though the tortivale program is cheaper because of the lower producer price of maize).

The *second* problem stems from the political dimensions of such a large reform effort. A reform that inflicts substantial losses on particular groups in society may be more difficult to implement, even if the majority benefits. In section 4 we argued that a program focused on improving currently rain-fed land by irrigation and other productivity enhancements intervenes at the right margin; it makes subsistence and rain-fed farmers better off since the value of their land holdings recovers, and also benefits landless rural workers through the labor market impact. But to fully restore land values to pre-liberalization levels requires at least five years, because of technical and engineering constraints on construction. Immediate liberalization of maize, even if accompanied by the irrigation program, would therefore still impose substantial transitory losses: cf Figure 10 for the case of rain-fed farmers.

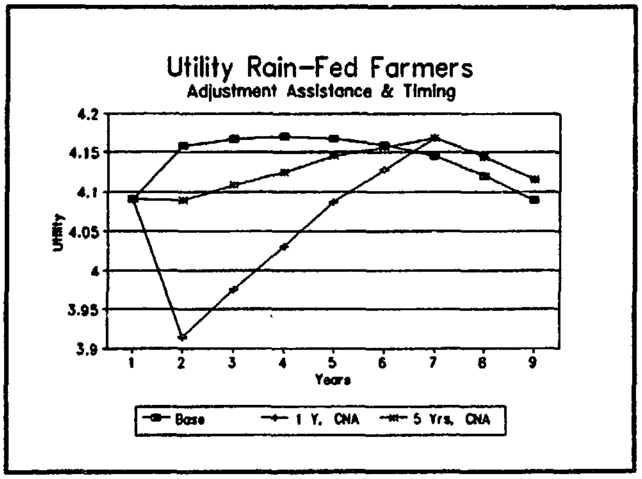

Figure 10

A gradual phasing-out of maize price supports mitigates this problem, although a *relative* decline (compared to the base case) is difficult to avoid for this group. But note that an absolute drop in utility is avoided if the CNA program is accompanied by gradual phasing-out of maize price supports.

A *final* argument concerns *period-to-period* losses. The rural poor have little access to capital markets to help them smooth consumption. Many live in extreme poverty, and may have higher discount rates than assumed here, as survival is at stake. This implies that initial losses, even if the net change in discounted welfare is positive at the discount rate used here, may be particularly costly. But if the adjustment program was such that at no point during the transition utility was less than on the reference path, the reforms would not hurt the rural poor for any discount rate. The government can then argue that they are being made better-off, or at least not losing out, without asking them to wait five years before benefits materialize. Because it is administratively impossible for the government to reach the rural poor directly, and because gradualism may avoid initial losses, this too calls for gradualism as a second best solution.

Simulation 6 explores these issues. We consider the same liberalization of the US market for fruits & vegetables and the same irrigation program, but assume that the liberalization of maize and tortilla prices is spread over six years. Further, we assume that the change in maize and tortilla prices begins one-year after the irrigation program starts. This 'irrigation first' scenario could be interpreted as a signal from the government to farmers of its intentions to help them adjust to free trade in maize: the government invests in productivity improvements before any sacrifice is asked for. This policy insures that all households see their welfare increase vis-a vis the reference path though this comes at an efficiency cost. But this cost is not very large: total efficiency gains are only 4% smaller than the case where maize prices move pari-passu with the irrigation program.

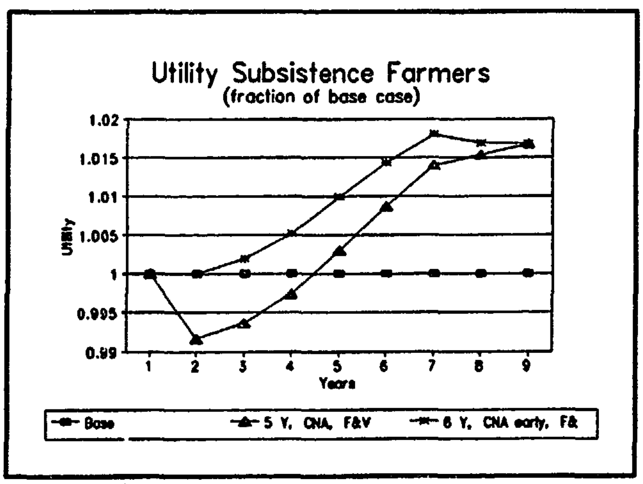

Figure 11

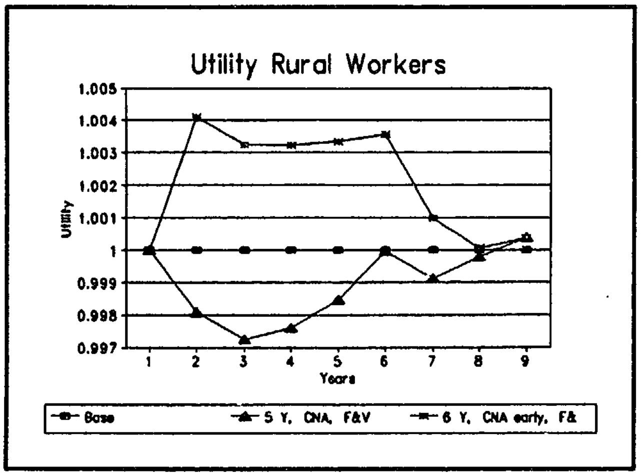

Figure 12

The pay-off to this efficiency cost is shown in Figure 11 and Figure 12: landless rural workers and subsistence farmers are better off at every point in time than under protection. And because spreading the maize pricing over a longer horizon also slows down migration, urban workers also have higher utility at each point in time. Thus, if price reforms and adjustment programs are timed carefully, incorporating maize into the FTA can strengthen poverty alleviation efforts.

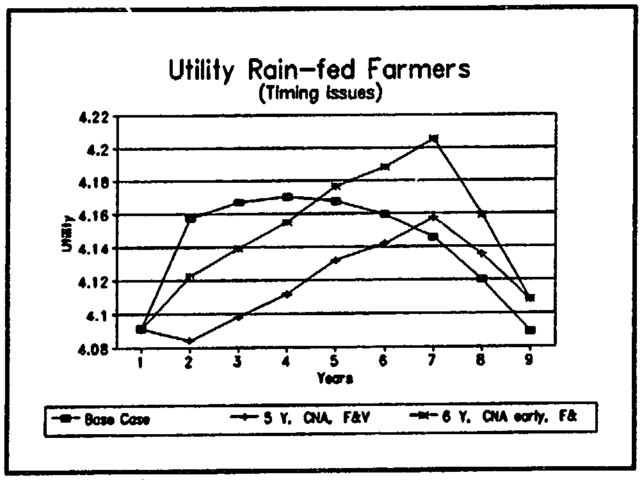

Figure 13

Consider now farmers on rain-fed lands. Despite the timing changes in the irrigation and liberalization program, their utility is still less than the reference case for three years (Figure 13). As discussed, the CNA program tightens the rural labor market. And while higher rural wages improve initial utility of subsistence farmers and landless workers, they also raise wage costs for rain-fed farmers. Thus, because the government can only help the first two groups via higher rural wages, it cannot simultaneously help rain-fed farmers in the initial phase of the reforms. This may call for other instruments to provide transitory support to this group (see below).

Figure 14 shows the fiscal impact of these timing changes. Initially fiscal expenditures increase substantially because there are no savings from reduced maize subsidies while outlays for irrigation are made. But though it takes 5 years for the fiscal costs of interventions to fall below those under protection, table 1 shows that in present value terms this policy is still cheaper than continuing protection forever. The fiscal issue associated with the adjustment program is thus not one of overall costs, but one of transitory financing.

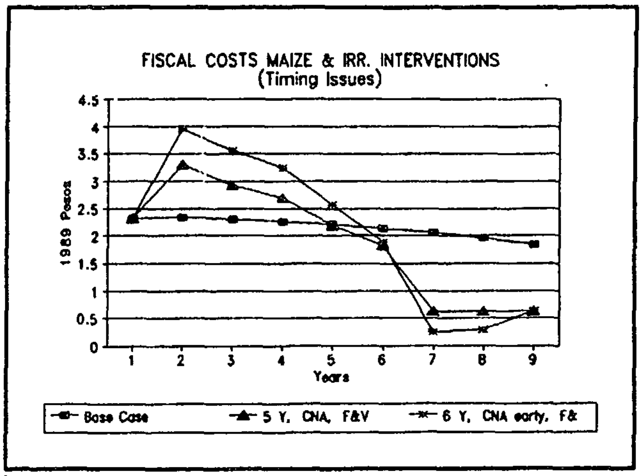

Figure 14

But to label an issue as 'transitory' is not to dismiss it as irrelevant. Fiscal authorities will want to insure that if resources are commited to irrigation investments, maize prices will indeed be freed; adding the costs of irrigation investments to the costs of maize policies would put an undue burden on the fiscal accounts. At the same time, policy makers in charge of agriculture will want to insure that if maize prices are freed, the resources required for irrigation investments will indeed be there; liberalizing agriculture in the absence of resources for adjustment would put an undue strain on the welfare of large numbers of the rural population. Thus the reform process needs a 'commitment technology' to insure that its two components -maize liberalization and the irrigation program- are carried out.

Signing maize price liberalization as part of the FTA solves the first half of the commitment problem. But the second half still needs attention because there are legal impediments to multi-year commitments of fiscal expenditures in Mexico. What guarantees do the rural groups potentially affected by maize liberalization have that the irrigation program will be completed once the FTA negotiations are finished, even if the government 'moves first' with its irrigation investments? What is optimal for the government to promise now may well not be optimal for it to deliver once the FTA has been signed.

The need for transitory financing for the adjustment program provides part of the solution. In particular, a multilateral organization could provide financing during the adjustment process to the FTA. Since the overall fiscal gains are positive in discounted value terms, the loan can be paid back out of the savings made later in time. If such financing is made contingent, not on the price reforms being carried out, but on the irrigation programs promised, it would become expensive to renege. The credibility of the program is then increased by increasing the costs of failing to follow it through.

Recall also that liberalization reduces the value of the main collateral owned by subsistence and rain-fed farmers. These farmers will have better access to credit only if commercial banks are certain that the land improvements that will raise the value of the land available for collateral will indeed incur. A program of public credit guarantees could insure farmers access to credit. But, equally important in our context, by committing itself through credit guarantees, the government not only signals its intent to implement the adjustment program, but also makes it more costly for itself to not implement it: after all, not following through on the irrigation program would reduce the value of the collateral for loans that carry a public guarantee. Again, increasing the expected cost of the guarantee scheme makes reneging on promises to implement the CNA program less attractive.

6. Conclusions

Empirical evidence and theoretical analysis overwhelmingly support the view that liberalizing international trade leads to efficiency gains. Recent forays in the economics of imperfect competition have created some question marks by bringing in rent-shifting and second best aspects, but have not led to any strong presumption against this claim (Krugman and Helpman (1989)). This paper fits the mold by demonstrating that the efficiency gains from liberalizing agricultural trade between the US and Mexico are quite large.

But if the gains are so large, why has agriculture turned out to be so hard to open up? Our analysis raises points that are likely to feature in any satisfactory answer to this question. We show, in a realistic analysis of the consequences of including agriculture in the currently-negotiated FTA between Mexico and the US, how efficiency gains fail to filter through to important groups in society. In particular we show that in the absence of adjustment measures all benefits accrue to the richer groups in both rural and urban areas. These effects are dramatically brought out early in the reform process by being capitalized in land values. This is surely a factor in the resistance by farmers against easing protection of agriculture.[16/]

Standard trade theory counters these arguments by pointing out that aggregate efficiency gains imply that winners can compensate losers and still

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16/ Krugman (1982) also links resistance to trade liberalization to factor price effects.

be better off themselves. This paper starts from the premise that instruments to effect such lump-sum transfers are not available. Compensations could also occur, although imperfectly, through indirect taxes and subsidies (Dixit and Norman (1980)), but this would require a degree of differentiation in the tax structure that would itself trigger substantial administrative and incentive problems. In more realistic circumstances specific adjustment programs have to be designed to accompany a major trade reform.

Liberalizing maize in Mexico in the context of a permanent change like the FTA creates two incentive problems. First, it clearly hurts maize growers. But compensating farmers pro rata to their maize production would create an incentive to continue maize production, the opposite of what the reform is designed to achieve to begin with. Second, liberalizing maize has a substantial impact on rural labor markets and migration. Rural employment programs could be used to mitigate large labor dislocations and transfer income to workers. But such a program raises a key issue: how to get out of it as time goes by. If in current circumstances the Government feels compelled to assist, those affected have every incentive not to adjust so as not to lose the transfers by changing the incentive structure the Government itself faces (Tornell (1991)). Temporary adjustment programs need built in incentives for change.

We point out that to avoid these incentive problems adjustment programs should focus not on offsetting the income loss associated with past activities, since that provides an incentive to continue them; instead they should focus on improving the productivity of the assets owned by the groups harmed by the reforms. This solves both incentive problems; by not linking the program to past activities, there is no incentive to continue them; and once the assets of those affected are more productive, other opportunities will be easier to find, reducing pressure on the Government to help out.

This paper argues the need for such a program in the context of opening up Mexican agriculture, and designs one along the lines sketched before.. In the specific circumstances of Mexican agriculture, this translates into investments that increase the productivity of rain-fed land via irrigation and other land improvements. We find that a program that transforms about 8% of the total stock of rain-fed land to irrigated restores the value of the land-holdings of those affected by the liberalization. This restores the collateral value of land, and thus enhance subsistence and rain-fed farmers' access to credit precisely at the time when credit is most needed. In addition, the program helps owners of labor by generating rural employment during the construction period. More fundamentally, it increases the long term demand for rural labor because irrigated land is substantially more labor-intensive than rain-fed. Thus, the program provides workers with alternatives once it ends; its transitory nature is thus credible.

Improving the value of assets people own is like an investment program and thus takes time. In contexts where capital markets are imperfect those affected may not be able to borrow against the value of future assets to smooth consumption overtime. This is particularly important if those affected are, as in Mexico's case, amongst the poorest groups in society. We therefore argue for a gradual pace of reform. We first compute the efficiency gains of trade reforms under different liberalization speeds, and find that gradualism is not too costly: spreading the liberalization over a five year period lowers the present discounted value of the efficiency gains by only 5-6%. We next show that careful timing of both the liberalization and the adjustment program implies that the rural poor have always higher utility along the adjustment path than under the protection path.

Embedding trade liberalization in a Free Trade Agreements is a form of commitment technology to the reform process; thus arguments for 'cold turkey' reforms on the grounds that this is the best form to show commitment to the reforms are less compelling in this case. But there is a different commitment problem, created by the time delays inherent in adjustment programs. How can the potential beneficiaries of adjustment programs be assured that those programs will be implemented once the trade liberalizations have been negotiated in the FTA? We argue that gradualism also contributes to solve this time-consistency problem. Because gradualism gives time to implement the productivity-enhancing programs, the beneficiaries do not have to give anything up before the benefits start coming in. Support by external organizations contingent on the adjustment programs can help in solving such commitment problems.

We hope the principles outlined in this paper for the design of adjustment programs will contribute to find efficient solutions to similar transitional problems. The analysis also suggests, however, that application of these principles requires careful analysis of the specifics of each case, and of the mechanisms through which the different groups are affected. There may be general principles, but there are unlikely to be rigid rules applicable to each and every reform program.

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TRANSITION PROBLEMS IN ECONOMIC REFORM: AGRICULTURE IN THE MEXICO-US FREE TRADE AGREEMENT

APPENDIX

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Appendix: Model Structure, Data and Calibration

I. Model Structure

I.1 Static Relations

We begin with the static relationships of the model before turning to the inter-temporal aspects. For ease of notation we omit a time sub-index for all variables (except where strictly necessary).

Goods, Factor Endowments and Factor Ownership

The economy produces seven goods: maize, m; basic grains, g; vegetables, v; other agriculture, o; livestock, l; industry, i; and services, s. The first five goods are produced in the rural areas; the last two in the urban areas. Goods are produced by seven factors of production: rural labor, LR, urban labor, LU, rain-fed land, T1, irrigated land, T2, livestock land, T3, industry capital, KI, and services capital, KS.[17]

We distinguish between maize and tortillas, but model tortilla production in a very stylized fashion. Tortillas are obtained from maize via a Leontief transformation that, for simplicity, requires no primary factors. Tortillas are assumed to be non-traded, with their price being a function only of the tax/subsidy-inclusive producer price of maize, and any direct government taxes or subsidies to tortillas.

Factors of production are owned by six types of households: (i) landless rural workers, (ii) subsistence farmers, who each own two hectares of rain-fed land, and who allocate their labor between producing on their own land and participating in the rural labor market[18], (iii) "rain-fed" farmers, who own the remainder of the rain-fed land and half of the land devoted to livestock and, (iv) "irrigated" farmers, who own all the irrigated land, and the other half of livestock land. For both rain-fed and irrigated farmers, land ownership is the only source of income.

Urban households consist of workers, who own all urban labor, and capitalists, who own the capital stock in industry and services. There are H_h of each type of households ($h = 1,2,..,6$). Ownership shares are given by matrix $M = (m_{hj})$ where m_{hj} is household's h share of factor of production j.

17/ We separate land devoted to livestock from land devoted to agriculture because Mexican land tenure regulations preclude the use of agricultural land for livestock activities (see Heath (1990)).

18/ Data on the distribution of ownership of land in Mexico are scarce. Various studies refer to the class of 'subsistence farmers', who are owners of such small quantities of land that they must also participate in the labor market (see Masera (1990) and Salinas (1990)). In this paper we define a 'typical' subsistence farmer as one who owns two hectares of rain-fed land. Of course, in reality there is a continuum of ownership.

__Prices__

World prices for traded goods, **pw**[19], are exogenous. The price of services, the non-traded good, is ps. The vector of commodity goods prices is **p** = [**pw** | ps]. Modelling trade interventions as combinations of production and consumption subsidies and taxes we write producer prices as:

(I.1) $\mathbf{pp} = \mathbf{p}.*(1 + \mathbf{s})$

where **s** is the vector of producer subsidies(+)/taxes(-), and .* denotes an element-by-element multiplication.

Consumer prices differ between rural and urban households, so we introduce separate vectors of consumer taxes(+) or subsidies(-), $\mathbf{ct}^r$ and $\mathbf{ct}^u$, for rural and urban areas, respectively:

(I.2) $\mathbf{cp}^r = \mathbf{p}.*(1 + \mathbf{ct}^r)$

(I.3) $\mathbf{cp}^u = \mathbf{p}.*(1 + \mathbf{ct}^u)$

Urban and rural tortilla prices may also differ[20]. Because tortillas are only produced with maize, their price is:

(I.4) $pt^r = a_{mt}*pp_m*(1 - ts^r) = a_{mt}*pw_m*(1 + s_m)*(1 - ts^r)$

(I.5) $pt^u = a_{mt}*pp_m*(1 - ts^u) = a_{mt}*pw_m*(1 + s_m)*(1 - ts^u)$

where a_{mt} is maize input per unit of tortillas, and ts^r/ts^u are rural/urban tortilla subsidies. Note that as long as ts^r (ts^u) is less than s_m, rural (urban) tortilla consumers pay a net tax, despite the fact that tortillas are 'subsidized'.

Intermediate input prices depend on production location (e.g., maize sold as input into livestock in rural areas vs. maize sold as input into industry in urban areas). Vectors $\mathbf{it}^r$ and $\mathbf{it}^u$ contain ad valorem taxes/subsidies on intermediate inputs for rural and urban areas respectively. Thus the vectors $\mathbf{ip}^r$ and $\mathbf{ip}^u$ of intermediate prices to producers in rural and urban areas, respectively, are in general different.

Finally, we denote by w^r and w^u the rural and urban wage rates, and by r1 and r2 the rental rates on rain-fed and irrigated lands, respectively.[21]

19/ All price vectors are defined as row vectors, and all quantity vectors as column vectors. All vectors are in bold.

20/ The government attempts to stop arbitrage on maize and tortillas via controls on maize distribution to tortilla mills and to other users of maize.

21/ In what follows the labels 1/2 on any variable refer to the rain-fed/irrigated distinction.

Technology

Intermediate inputs are used in in fixed proportions; primary inputs produce value added. Except for Hicks-neutral technical change, technology is constant through time. Matrix A contains intermediate input/output coefficients, with most elements exogenously given. However, we do allow substitution between maize and basic grains (mainly sorghum) as inputs into livestock. With a CES structure, the cost-minimizing I/O coefficients of maize and basic grains into livestock, a_{ml} and a_{gl}, are:22/

(I.6) $a_{ml} = \tau^{\mu}.(pa^{*}/ip^{r}_{m})^{\mu}.a^{*}$

(I.7) $a_{gl} = (1-\tau)^{\mu}.(pa^{*}/ip^{r}_{g})^{\mu}.a^{*}$

Land Use

Land allocated to any given crop is subject to diminishing returns. To capture this, we make a difference between effective land, $\tilde{T}$, and physical land, T. The latter refers to the actual hectares allocated to a crop; the former to the amount of land that is usable for producing that crop. The relationship between them is given by:

(I.8) $\tilde{T} = \tau.T^{\phi}$ $\quad \tau > 0 \quad ; \quad 0 < \phi < 1,$

so that as more (rain-fed or irrigated) physical land is applied to a crop, the amount of effective land grows less than proportionately. This captures incentives for crop rotation and other agricultural practices that result in crop diversification. Irrigated land is assumed to be better than rain-fed in the following way: $\phi 1 \leq \phi 2$, i.e., as more irrigated land is allocated to a given crop, diminishing returns obtain more slowly than in rain-fed lands. Hence, for the same price change the supply response in irrigated lands is stronger. As a result of yield differences, infra-marginal rents accrue to owners of irrigated land in standard Ricardian fashion.

Value Added

Production functions are Cobb-Douglas with constant returns to scale to labor and capital in the urban goods, and to labor and effective land in the

---

22/ Let a^{*} be the exogenously given fixed quantity of feed per unit of livestock, given by:

$a^{*} = [\tau.a_{ml}{}^{\mu-1/\mu} + (1-\tau).a_{gl}{}^{\mu-1/\mu}]^{\mu/(\ \mu)} \quad \mu > 0,\ \mu \neq 1,\ \tau \in (0,1)$

Given intermediate input prices an exact price index for a^{*} is:

$pa^{*} = [\tau^{\mu}.ip^{r}{}_{m}{}^{1-\mu} + (1-\tau)^{\mu}.ip^{r}{}_{g}{}^{1-\mu}]^{1/(1-\mu)}$

Substituting pa^{*} in (I.6) and (I.7) gives matrix A(p).

rural goods. For example, value added on maize cultivated in rain-fed lands is:

$$(I.9)\quad VA1_m = LR1_m^{(1-\alpha 1_m)} . \tilde{T}1_m^{\alpha 1_m} = LR1_m^{(1-\alpha 1_m)} . \tau 1_m^{\alpha 1_m} . T1_m^{\phi 1_m . \alpha 1_m}$$

$$= \rho 1_m . LR1_m^{(1-\alpha 1_m)} . T1_m^{\lambda 1_m}$$

where $LR1_m$, $T1_m$ are rural labor and rain-fed lands allocated to maize production, $\rho 1_m = \tau 1_m^{\alpha 1m}$ and $\lambda 1_m = \phi 1_m . \alpha 1_m$. Note that $0 < \lambda 1_m < \alpha 1_m < 1$, implying that (I.9) exhibits decreasing returns to scale between rural labor and physical land. As a result, although the number of agricultural goods exceeds the number of rural factors of production, there need not be full specialization.

Technical Change

Technical change is assumed to be Hicks-neutral in all sectors. A time-dependent constant pre-multiplies the Cobb-Douglas value added function in all sectors. The rate of technical change in rain-fed land (equal to the rate of technical change in livestock) is less than in irrigated land. Rates of technical change in industry and services are assumed to be equal.

Goods Supply

Output vectors in rain-fed and irrigated lands are q1 and q2, respectively. Output of livestock is denoted q3, while the output vector in the urban sector is qu. Hence, the vector of gross supplies is: qs = [(q1 + q2) | q3 | qu]. All sectors are perfectly competitive. Let pn be the vector of 'net' or value added prices, obtained by substracting from producer prices intermediate input costs. The derived demands for labor and land in agricultural production are (again using maize in rain-fed lands as example):

$$T1_m = \left((1-\alpha 1_m)^{1-\alpha 1_m} . \rho 1_m . pn_m . \lambda 1_m^{\alpha 1_m} . w^{r\,(\alpha 1_m - 1)} . r1^{-\alpha 1_m} \right)^{1/(\alpha 1_m - \lambda 1_m)}$$

(I.10)

$$LR1_m = \left((1-\alpha 1_m)^{(1-\lambda 1_m)(\lambda 1_m - \alpha 1_m)} \lambda 1_m^{-\lambda 1_m} . w^{r\,1-\lambda 1_m} . r1^{\lambda 1_m} (\rho 1_m . pn_m)^{-1} \right)^{1/(\lambda 1_m - \alpha 1_m)}$$

Similar equations follow for other crops. In industry and services capital is sector-specific, as is land in livestock, so that only demands for rural labor in livestock, LR3, and for urban labor in industry, LU_i, and services, LU_s, are derived. Goods supply follow from substituting optimal factor demands into the Cobb-Douglas production functions.

Household Incomes, Consumption and Savings

Production generates factor incomes: rural and urban wages, rents to rain-fed, irrigated and livestock land, and quasi-rents to capital in industry and services. M, the matrix of ownership shares, maps factor incomes facinc into household incomes.

In addition, households receive government transfers through the 'tortivales' program, with a market value of vt. But since urban and rural tortilla prices differ, the market value of a given quantity of freely distributed tortillas to households of type h, QT_h, depends on households' location. Thus, for example, for urban workers (the fifth household group) we have:

$$(I.11)\ vt_5 = pt^u * QT_5$$

The fiscal cost of the 'tortivale' program, CT, is given by:

$$(I.12)\ CT = \sum_{h=1}^{6} a_{mt} * pp_m . QT_h > \sum_{h=1}^{6} vt_h$$

since the government has to purchase maize from producers at prices pp_m to make tortillas for the tortivales. But because tortillas are subsidized, the value of the transfer to households is less than the fiscal cost of the transfer to the government. The difference is an 'implicit' subsidy to maize producers.

Collecting terms (and ignoring household's income taxes) we obtain Y, households' disposable income:

$$(I.13)\ Y = M * facinc + vt$$

Households save a constant proportion of their disposable income, φ_h, so that savings for each household are:

$$(I.14)\ S_h = \varphi_h . Y_h$$

$(Y_h - S_h)$ are consumption expenditures for households of type h. We assume a nested Cobb-Douglas/CES/CES utility function. The outer Cobb-Douglas nest allocates expenditures between three goods: industry, services and a composite agricultural good. The next CES nest aggregates the five rural goods into a composite rural good. Finally, the last CES nest distributes maize consumption between raw maize and tortillas.23/ Solving the utility

23/ Urban inhabitants consume maize mostly in the form of tortillas. In the rural areas the government purchases maize from producers at the price pp_m, but sells maize flour to consumers at the price pt^r because there are fewer tortilla distribution outlets in rural areas. (This is why the 'tortivale' program does not operate in rural areas.) Our model ignores the opportunity cost of time to rural households of making tortillas from maize flour, but allows for maize to be consumed either as raw maize or as tortillas.

maximization problem for each household we obtain consumption demands for tortillas, maize, the remaining agricultural goods, as well as livestock, industry and services. Demand for tortillas is then translated into maize demand given the input/output coefficient a_{mt}. This gives us the vector of total household consumption, c.

Given the homotheticity of preferences we can construct an exact price index for each household, CPI_h, that depends on the location of the household (given differences in rural, cp^r, and urban, cp^u, consumer prices), as well as on the particular parameters of its utility function. Given these indices, we compute an index of the real consumption wage to rural and urban workers, Ω^r and Ω^u, respectively, as:

(I.15a) $\Omega^r = w^r/CPI_2$ (I.15b) $\Omega^u = w^u/CPI_5$

where we use the preferences of landless rural workers and urban workers (household groups 2 and 5, respectively) for computing the relebant CPIs.

Investment and Total Demand

Private investment only takes place in industry and services. We take the rate of growth of the capital stock in industry and services in period t, gk_t, as exogenous. Let **invprop** be the vector of goods required to produce one unit of capital, and assume that capital produced for industry and services has the same composition. The vector of private investment demands, **z**, is then given by:

(I.16) $\mathbf{z}_t = (gk_t+gd_t).(KI_t + KS_t).\mathbf{invprop}$

where gd_t is the depreciation rate. Then total value of private investment is:

(I.17) $I_t = \mathbf{p}_t.\mathbf{z}_t$

We only consider public investment in irrigation infrastructure. Let RI_t be the number of hectares of rain-fed land that is transformed to irrigated in period t. Irrigation construction is assumed to require rural labor and intermediate inputs, given at the unit level by vector **inputirr** for goods, and by lrirr for labor. The real resource costs of irrigation are assume to be an increasing function of the stock of irrigated land, reflecting the fact that as these investments increase lands of poorer-quality are encountered (greater distance from water resources, steeper lands, etc.). We write:

(I.18) $$Q_t = q.\left(\sum_{t=0}^{t-1} T2_t / T2_0\right)^{\gamma} \quad ; \quad q > 0, \quad \gamma > 1$$

where Q_t is an index of marginal costs applied to **inputirr** and lrirr, and $T2_0$ is the initial stock of irrigated land. Hence, the total demand for goods and labor required for irrigation investments is:

(I.19a) $g_t = Q_t.RI_t.inputirr$

(I.19b) $LRIRR_t = Q_t.RI_t.lrirr$

Ignoring other components of government expenditures, the vector of total goods' demand is:

(I.20) $qd = A*qs + c + z + g$

<u>Migration</u>

Let H_h be the total number of households of type h. Consumption quantities are divided by the total number of households of each type to obtain per-capita consumptions. Substituting per-capita consumptions into the utility function gives per-household utility for each type of household, U_h.

Utility <u>functions</u> are identical, but parameters differ between urban workers, landless rural workers and subsistence farmers, on the one hand, and rain-fed and irrigated land-owners and urban capitalists, on the other. The first group allocates a larger share of expenditure to rural goods compared to the second. Thus, changes in maize and tortilla prices have a larger impact on the first group. All members of the potential migrant population have the same utility function, so we can compare per-capita workers' utilities across locations.

Migration incentives result from rural-urban differences in consumption wages, Ω^r and Ω^u, and from differences in benefits derived from living in a given area (like the urban 'tortivale' program). Letting L^{ru} be the stock of migrants that move from the rural to the urban areas, U_r and U_u the (per capita) utility of a worker in the rural and urban areas, respectively, and the superscript 0 an initial equilibrium, we write:

(I.21) $L^{ru} = k[(U_u^0/U_r^0)/(U_u/U_r)]^{\eta} - k \quad ; \quad k > 0, \quad \eta \geq 0$

where k is a constant and η the elasticity of migration to urban-rural utility differentials. Note that $\eta = 0$ completely segments the urban and rural labor markets.

<u>Excess Demands</u>

At each period of time total demands for land and labor are:

(I.22a) $T1^D(r1) = \Sigma\, T1_j$

(I.22b) $T2^D(r2) = \Sigma\, T2_j$ for $j = m,g,v,o$.

(I.22c) $LR^D(w^r) = \Sigma\, LR1_j + \Sigma\, LR2_j + LR3 + LRIRR$

(I.22d) $LU^D(w^u) = LU_i + LU_s$

Note from (I.22c) that rural labor demand includes the workers employed in constructing irrigation.

Given taxes and subsidies domestic prices for tradeable goods follow from world prices, with net exports bringing tradeables supply and demand into balance. The same is not true of services. This market, jointly with the markets for rural and urban labor, and rain-fed and irrigated land, is cleared by prices. Our model thus determines factor prices and the real exchange rate.24/ Let P contain these prices, i.e., $P = [\ w^r \mid w^u \mid r1 \mid r2 \mid ps]$. Excess demand functions to determine P are:

(I.23a) $LR^D(P) + L^{ru}(P) - LR^0 = 0$

(I.23b) $LU^D(P) - L^{ru}(P) - LU^0 = 0$

(I.23c) $T1^D(P) - T1 = 0$

(I.23d) $T2^D(P) - T2 = 0$

(I.23e) $qs_s(P) - qd_s(P) = 0$

By construction, at the initial values for the exogenous variables $L^{ru} = 0$.

Given the value at time t for production and consumption taxes and subsidies, a solution to (I.23) provides allocations of rain-fed and irrigated land to each crop, a division of the total labor force between urban and rural areas as well as its allocation across goods, factor prices and the real exchange rate, and a utility level for each household.

I.2 Inter-Temporal Relationships

Accumulation Equations

At each period of time the economy is described by the solution to (I.23). But from one period to the next the economy changes as a result of exogenous and policy-induced changes. The exogenous changes are: (i) growth of labor and population25/, (ii) Hicks-neutral technical change in urban and rural sectors, (iii) growth of the capital stock in industry and services26/, (iv) government spending in non-agriculture items, and (v) the path of world prices. Policy-induced changes center on the path of taxes and subsidies, irrigation investments and government transfer policies.

24/ Recall that capital in industry and services (as well as land in livestock) are fixed. Thus, these factors just earn quasi-rents.

25/ To reflect Mexico's demographic transition the rate of growth of labor, 3%, is set higher than the rate of growth of population, 2%. During the transition period, see below, the rate of growth of labor slowly declines until in the steady-state it equals that of population. Thus, households who own labor initially grow faster than households who own only land or capital.

26/ In a fuller model of the impact of the FTA investment rates in industry and services would clearly be endogenous. Here, however, we are interested in the effects of changes in agricultural liberalization only.

The endowments of land evolve if there are irrigation programs transforming rain-fed land into irrigated land:

$$(I.24a)\ T1_t = T1_{t-1} - RI_{t-1} \quad ; \quad (I.24b)\ T2_t = T2_{t-1} + RI_{t-1}$$

Note that we assume a one-period gestation lag. All owners of rain-fed land (subsistence peasants and rain-fed farmers) are assumed to benefit from irrigation investments in proportion to the initial share of rain-fed land held by each group. The matrix of ownership shares, M_t, is therefore up-dated at each period to reflect the fact that when irrigation investments take place the increase in the endowments of irrigated land belongs to subsistence farmers and rain-fed farmers.

The number of households of each type also changes through time. Landless rural workers, subsistence farmers and urban workers grow at the rate of growth of the labor force, gl_t, so that the urban and rural allocation of labor evolves according to:

$$(I.25a)\ LR_t = (LR_{t-1} - L^{ru}{}_{t-1})(1 + gl_{t-1})$$

$$(I.25b)\ LU_t = (LU_{t-1} + L^{ru}{}_{t-1})(1 + gl_{t-1})$$

On the other hand, the number of rain-fed farmers, irrigated farmers and urban capitalists grows according to:

$$(I.26)\ H_t = H_{t-1}(1 + gp_{t-1})$$

where gp_t is the growth rate of population in period t.

Finally, the capital stock in industry and services evolves according to:

$$(I.27a)\ KI_t = KI_{t-1}.(1+gk_{t-1}); \quad (I.27b)\ KS_t = KS_{t-1}.(1+gk_{t-1})$$

<u>The Transition Path and the Steady-State</u>

We take as starting point for our analysis a particular date (t_0=1 for convenience), and divide the future into a transition path and a steady-state. The transition path lasts (at most) T-1 > t_0 years; the steady-state obtains in all periods from T onwards. All policy changes occur during the transition period. By assumption, static and intertemporal relative prices remain unchanged over the interval $[T,\infty)$. This allows us to Hicks-aggregate all of the steady-state path of the economy. It then suffices to simply calculate period T values, since all future periods will be identical up to a uniform scalefactor (growth rate) for all quantities. The aggregation process therefore only affects the discount factors, which is much larger for the T period to account for the fact that this 'period' is replicated (again, up to a uniform scale factor for all quantities) an infinite number of years.

If we label the common and constant post-T growth rate g, and the real interest rate r^w, this process works as follows. Define $\delta=1/(1+r^w)$, and $\delta_a=(1+g)/(1+r^w)$, where δ_a is the period-to-period growth adjusted discount factor. Then the following expressions obtain for the back-to-period-1 discount factors $\delta(i)$:

$$
\begin{aligned}
\delta(i) &= \delta^{i-1} \quad for\ i < T \\
&= \sum_T^\infty \delta^{i-1}\ for\ i \geq T \qquad (I.28) \\
&= \frac{\delta^{T-1}}{1-\delta}
\end{aligned}
$$

Consider now the Net Present Value, NPV_y, of (y_t), where $y_t = y_{t-1}(1+g)$ for all $t > T$:

$$
\begin{aligned}
NPV_y &= \sum_1^\infty y_t.\delta^{t-1} \\
&= \sum_1^{T-1} y_t.\delta^{t-1} + \delta^{T-1}.\sum_T^\infty y_T.(1+g)^{t-T}\delta^{t-T} \\
&= \sum_1^{T-1} y_t.\delta^{t-1} + \delta^{T-1}\sum_T^\infty y_T.\delta_a^{t-T} \qquad (I.29) \\
&= \sum_1^{T-1} y_t.\delta^{t-1} + \frac{\delta^{T-1}}{1-\delta_a}.y_T
\end{aligned}
$$

Thus the infinite horizon modeled can be captured by calculating period T only (out of all $[T,\infty)$ periods), but adjusting the period T discount factor to equal:

$$\delta(T) = \frac{\delta^{T-1}}{1-\delta_a} \qquad (I.30)$$

Intertemporal Budget Constraints

With the exception of urban capitalists, we assume that private households do not save or invest. Thus, in each period their consumption equals their income. Thus, since they satisfy their period-by-period budget constraint, they will automatically satisfy their inter-temporal budget constraint.

Private investment by urban capitalists is given by (I.27), and private savings, all done by urban capitalists, by (I.14). Their savings rate, φ_t, is assumed to be exogenously given during the transition period. Thus, urban capitalists are assumed to have access to the world capital market, where they can lend or borrow as required at the world real interest rate r^w. However, this convention cannot be maintained in the steady state. If the savings rate would mechanically be extended through the steady state period, there would be no guarantee that urban capitalists would remain within their budget constraint, or, alternatively, exhaust all resources available to them. In both cases, welfare comparisons accross different simulation experiments would be illegitimate, since their opportunity set would in effect be varied arbitrarily.

To solve this problem we endogenise the period T savings rate in such a way that, if maintained over the interval $[T,\infty)$, urban capitalists will exactly satisfy their intertemporal budget constraint. This means that over the interval $[1,\infty)$, the discounted value of their consumption expenditure equals the discounted value of their after-tax income net of investment expenditure. In particular, if during the transition period urban capitalists accumulated debt, the steady-state savings rate is increased so that the discounted value at time T of future savings over investment equals the current value of the debt accumulated up through period T-1. The converse holds if during the transition period urban capitalists accumulated assets. Formally this can be represented as follows. Define after-tax savings net of private investment, all in period i, as x_i and income net of taxes and investment expenditure as y_i. Then $NPV_x(T)$ equals:

$$NPV_x(T) = \sum_T^{\infty} x_T \cdot \frac{(1+g)^{t-T}}{(1+r^*)^{t-T}} = \frac{x_T}{1-\delta_a} \qquad (I.31)$$

Define debt accumulated through period T-1 as D_{T-1}. To satisfy the intertemporal budget constraint, x_T needs to satisfy:

$$\frac{x_T}{1-\delta_a} = D_{T-1} \cdot (1+r^*)$$
$$\Rightarrow \varphi_T \equiv \frac{x_T}{y_T} = \frac{D_{T-1}}{y_T} \cdot \frac{1-\delta_a}{\delta} \qquad (I.32)$$

Welfare Measures

To make welfare comparisons accross experiments it is not enough just to make sure that all groups satisfy their intertemporal budget constraints. In many cases, the time paths of period-by-period utility of a particular household accross two simulations will cross, making period-by-period comparisons difficult. The solution is to calculate net discounted utility, or welfare, using the rate of time preference to discount future welfare back to today. That procedure presents no problems for the interval [1,T-1]. However one cannot simply copy the procedure followed for NPV measures in equation (9), (13) for the interval [T,∞). The reason is, that per-household consumption grows at the rate gc[27], but because of declining marginal utility, per-household utility U_h will grow at a lower rate than gc. Since we use a constant relative risk aversion (CRRA) utility function to aggregate utility over time, the following relation between the two growth rates holds:

27/Note that gc < g because it is a per-household measure. If gp is the rate of population growth, g, gc and gp are linked as follows:

$$(1+g) = (1+gc).(1+gp)$$

$$\hat{U}_h = (1/\sigma)\,\hat{c} \quad (I.33)$$

where σ is the intertemporal substitution elasticity, and a hat over a variable denotes the rate of growth. This leads to the following expression for welfare, W_h, the net discounted utility for household h:

$$\begin{aligned} W_h &= \sum_1^{\infty} \frac{u_h(c_t)}{(1+\rho)^t} \\ &= \sum_1^{T-1} u_h(c_t)\,.\,\delta_{pref}^t + \frac{u_h(c_T)}{(1+\rho)^T} \sum_T^{\infty} \frac{(1+\sigma^{-1}.gc)^{t-T}}{(1+\rho)^{t-T}} \qquad (I.34) \\ &= \sum_1^{T-1} u_h(c_t)\,.\,\delta_{pref}^t + \frac{u_h(c_T)\,.\,\delta_{pref}^T}{1-\delta_{prefA}} \end{aligned}$$

$$\text{where } \delta_{pref} = \frac{1}{1+\rho} \quad \text{and} \quad \delta_{prefA} = \frac{1+\sigma^{-1}.gc}{1+\rho}$$

II. Data Sources

We constructed a Social Accounting Matrix (SAM) for 1989, the last year for which information was available for all the variables required for the model.

Our departure point was data provided by the Ministry of Agriculture (SARH) on value of gross output, physical output and areas harvested (and thus yields) in rain-fed and irrigated lands in 1989 for 26 individual agricultural products. These products account for 68.3% of the value of output in agriculture in that year; unfortunately, no information was individually available for the other products that account for the remaining 31.7% of output, though we do have the totals for all the variables concerned. Table II.1 lists the products for which information was available and maps them into the four agricultural sectors included in our model. We interpret the physical totals (in hectares) of harvested rain-fed and irrigated lands in 1989 as the endowments of these two factors of production. SARH also provided us with value of output in livestock industry, as well as with cost data to divide, at the level of each of the five rural sectors, the value of total gross supply into: wages, aggregate rents (but not its division between rain-fed and irrigated lands), and a seven sector disaggregation of intermediate input costs.[28/]

From the Sistema de Cuentas Nacionales de Mexico we obtain the 1989 totals for all the macroeconomic aggregates: national income, private

28/ Unfortunately, these data did not permit disaggregation of intermediate input costs between rain-fed and irrigated lands, forcing us to assume the same input structure in each case.

investment, private consumption, direct taxes (on households and factors), indirect taxes, total government spending, private savings, the trade balance, as well as gross value of demand and value added in industry and services. Data from Cuentas Nacionales was then combined with data from Banco de Mexico. This allowed us to disaggregate the trade balance (at world prices) into the seven sector aggregation used in our model. Substracting sectoral net exports from sectoral gross demands gave us sectoral domestic demand, which we proceeded to divide between private consumption, private investment and government demand using information from the 1985 I/O table, but insuring that the totals coincided with the 1989 National Accounts totals. With the information just described we pieced together a consistent Social Accounting Matrix (SAM) for 1989.

Table A.1: AGRICULTURAL OUTPUT, 1989

Sector/product	GVS Rain-fed	GVS Irrigated	GVS Total*
I Maize	3,610	1,180	4,790
II Basic Grains	1,437	3,711	5,149
1.Rice	175	186	362
2.Wheat	119	1,585	1,704
3.Sorghum	805	904	1,710
4.Barley	155	41	196
5.Soy-Beans	89	885	974
6.Cartamo	57	89	146
7.Sesame Seed	35	19	54
III Key Products	2,363	1,609	3,972
1.Beans	455	292	748
2.Cotton	59	124	184
3.Sugar Cane	1,396	1,071	2,467
4.Coffee	264	0	264
5.Tabbaco	0	121	121
6.Cacao	149	0	149
7.Henequen	37	0	37
IV Fruits, Veg. And Rest	7,089	9,626	16,715
1.Chile	98	515	613
2.Strawberries	0	68	68
3.Sunflower	0.7	0.7	1.4
4.Tomatoes	0.1	1,393	1,502
5.Avocadoes	151	194	345
6.Alfalfa	12	2,251	2,263
7.Copra	131	59	190
8.Lemon	159	478	637
9.Apples	30	322	403
10.Oranges	343	147	490
11.Bananas	332	156	488
12.Rest	5,671	4,040	9,711

* Millions of 1989 pesos; totals may not match due to rounding errors; GVS = gross value of supply.
Source: Direccion General de Estadistica, SARH.

The Sistema de Cuentas Nacionales also had data on the totals of employment in agriculture (including livestock), industry and services. We interpret total agricultural employment as the initial rural labor force, and total services and industry employment as the initial urban labor force. Employment figures are measured as number of workers. Data on the division of employment among the various crops (in each type of land) was unavailable; to remedy this situation we proceed in three steps. First, we use technological information contained in Norton and Solis (1983) to construct approximate labor/land ratios in rain-fed and irrigated lands for our model's crop aggregation. Second, we use the SARH 1989 data on rain-fed and irrigated land allocated to each crop to calculate the employment 'implied' by the observed land allocation. Third, because the total agricultural employment implied by these calculations fell short of the total employment registered in the National Accounts (by a factor of 27%), we augmented all labor/land ratios so that the calculated employment in fact matched the observed 1989 total. Note that since all labor/land ratios were augmented by the same factor, relative labor intensities are equal to those implied in Norton and Solis (1983).

Our model requires information on the parameters for the 'land transformation functions' [$\tau 1$, $\phi 1$] and [$\tau 2$, $\phi 2$]. Given our production technology the price elasticity of supply for any crop (in any given type of land) is:

(II.1) $e_s = 1/(\alpha - \alpha\phi)$

Given the shares of land in value added[29/], α, we selected values for ϕ in each type of land such that the aggregate supply elasticity (a production-weighted average of the supply elasticity in rain-fed and irrigated lands) matched, for the case of maize, estimated elasticities (see Levy and Van Winjbergen, 1991a). Lack of previously estimated elasticities made this procedure impractical for other crops. In these cases given the values for α we simply choose values for ϕ such that: (i) $\phi 1 \leq \phi 2$ and, (ii) the associated division of output between rain-fed and irrigated lands matched the SARH data.

To obtain parameters for the utility functions we used the 1984 Income-Expenditure Survey (IES) to compute expenditure shares for rural and urban households for each income decile. Unfortunately, however, our model's aggregation pattern was difficult to match with the IES expenditure classification. In particular, expenditures on food are not equal to expenditures on our composite rural good, since part of the output of rural goods is sold as input to industry, which in turn produces food (e.g., wheat into bread). To remedy this situation it would be necessary to dis-aggregate the industry sector into a food producing sector and a 'rest of industry' sector. Unfortunately, there was no 1989 data to carry this out. Hence, we arbitrarily re-allocated the IES expenditure shares between the composite rural good, industry and services. Such re-allocation insured that: first, the households that could potentially migrate (subsistence farmers, landless rural workers and urban workers) all had the same expenditure shares and

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29/ As mentioned earlier, the SARH data did not divide total rents to land between rain-fed and irrigated. We carried out this division assuming that the share of rents accruing to rain-fed land was, in each crop, equal to the share of gross value of rain-fed output in total output.

substitution elasticities. Second, all non-migrant households had equal shares and elasticities. Third, the aggregate consumption of each good resulting from the different household preferences and incomes matched the sectoral consumption totals registered in the SAM.

We turn to the tax and subsidy information. Elsewhere (Levy and Van Wijnbergen, 1991a) we calculated the implied urban and rural prices of maize for 1989 given that year's policy configuration. In addition, with the SARH and Banco de Mexico data mentioned above, we calculated the production-weighted tariff for basic grains, the other sector of agriculture with significant protection in 1989. For industry, on the other hand, we assume an average tariff rate of 5%. VAT rates for industry and services, as well as direct tax rates on factors and households were derived from our constructed SAM. For simplicity, we assumed that only urban capitalists pay direct income taxes.

Next, we discuss sources of data for the irrigation program. We obtained the complete portfolio of existing investment projects from the Comision Nacional del Agua (CNA) for both development of new irrigation districts and re-habilitation of existing ones. The data included average costs, internal rate of return and labor requirements per hectare renovated and/or irrigated for each project. All projects with an internal rate of return of 8% or more were ranked in order of increasing per-unit cost of renovated/irrigated hectares. For this sub-set of projects we computed average labor requirements for irrigation, and obtained an estimate for lrirr in (I.19b). We also ran a simple OLS regression for relation (I.18) to obtain estimates of γ. The regression took the form:

$$(II.2)\quad \ln C_i = \ln q + \gamma \ln \sum_{i=1}^{n} RI_i + \varepsilon_i$$

where C_i is the average cost of renovating and/or irrigating RI_i hectares with project i, and n is the total number of projects (ordered by increasing C_i). The regression had a very good fit, with (corrected) R^2 of 0.8630, and an estimated value for γ of 2.2118 (with a t-statistic of 36.895).

Finally, we assumed the following values for the other key parameters: (i) rate of time preference, 7%; (ii) the inter-temporal elasticity of substitution, 2; (iii) the world rate of interest, 7%; (iv) the rate of growth population, 2%. In addition, we assume that initial rate of growth of the labor force is 3%, and that it linearly converges to the rate of growth of population, 2%, over a 10-year period. Lastly, we assume that the capital stock in industry and services and non-irrigation real government expenditures all grow at 4%.

III. Model Calibration

Calibration for 1989

We combine the various sources of information described above to compute an initial solution to the excess demand equations. The initial solution only computes a one-period equilibrium. For convenience we set world prices, pw, equal to unity, and choose units such that in the initial solution p = [pw | ps] is the unit vector. The numeraire is a bundle of domestic goods with the composition observed in 1989. By construction the real exchange rate is unity in the base solution.

Table II.2 displays the difference between simulated and actual values for the main macroeconomic aggregates. Table II.3 shows results at the sectoral level for agriculture. Three comments are relevant. First, the performance of the model at the macro level is quite satisfactory: the difference between estimated and actual values being in most cases smaller than 1%. Second, the model is able to reproduce almost exactly the pattern of output in agriculture, as well as the composition of the balance of trade. Note that for maize and vegetables in particular, the differences between actual and simulated values are almost negligible.

A third significant aspect of the base solution is that the division of the total output of each agricultural commodity between output obtained in rain-fed and irrigated lands mirrors the actual one. In addition, note that the estimated land allocations also match the actual ones, implying in turn that estimated yields are very close to observed yields. Unfortunately, as mentioned above, there is no original data against which the calculated allocations of labor to each crop can be contrasted which, although the relative labor intensities calculated are similar to the data in Norton and Solis (1983).

Calibration for 1991

Significant changes occurred in agricultural policies between 1989 and 1991: (i) protection to maize was increased from 47% to 70%, (ii) tortilla subsidies were reduced substantially, particularly in urban areas, and (iii) protection to other basic grains increased on average from 10 to 15%.

We re-calibrated the model to reflect these changes. Starting from the 1989 base the changes just mentioned were incorporated into the model, and the resulting equilibrium was considered as a benchmark 1991 equilibrium. This procedure has significant drawbacks in that the calculated 1991 equilibrium cannot at this point be contrasted with actual values. Nevertheless, we pursued this route because the changes are significant, and because we believe this provides a more accurate estimate of the effects of the FTA.

We computed a 10 year reference path for the economy, where 9 years are the adjustment period and, as described above, the tenth period summarizes the steady-state. The reference path assumes that world prices are constant, but incorporates Hicks-neutral technical change and the growth of capital, labor, population and real government spending at the rates mentioned above. To focus on the effects of excluding/including maize in the FTA, the reference path incorporates a five-year liberalization of the sector basic grains, beginning in the second period. On the other hand, we assume that no investments in irrigation take place.

TABLE A.2: MODEL PERFORMANCE, MACRO

Variable	Observed Value	Calibrated Value	% Difference (absolute value)
Gross National Expenditure[a]	511.53	511.12	0.0008
1. Consumption	334.84	334.58	0.0007
2. Investment	117.81	117.82	0.0000
3. Government	54.45	54.47	0.0003
4. Trade Balance	4.41	4.24	0.0040
Gross National Income[a]	511.53	511.12	0.0008
1. Wages	131.96	136.30	0.0328
2. Rents	26.78	22.89	0.1699
3. Profits	304.97	303.56	0.0046
4. Indirect Taxes	47.79	48.36	0.0119
Employment[b]	21.88	21.88	0.0000
1. Rural	6.00	6.00	0.0000
2. Urban	15.88	15.88	0.0000

a/ millions of millions of pesos of 1989; b/ millions of workers.

TABLE A.3: MODEL PERFORMANCE, SECTORAL

Agricultural Sector	Observed Values	Calibrated Values	% Difference (absolute value)
I Maize			
GVS Rain-fed[a]	3,610	3,601	0.002
GVS Irrigated[a]	1,180	1,192	0.010
Rain-fed Land[b]	5,553	5,517	0.006
Irrigated Land[b]	915	902	0.014
Yields Rain-fed[c]	1.485	1.491	0.004
Yields Irrigated[c]	2.947	3.021	0.025
Net Exports[a]	-1083.7	-1077.7	0.005
II Basic Grains			
GVS Rain-fed	1,437	1,474	0.025
GVS Irrigated	3,711	3,713	0.000
Rain-fed Land	1,834	2,040	0.112
Irrigated Land	2,045	2,016	0.014
Yields Rain-fed	1.846	1.702	0.084
Yields Irrigated	3.925	3.983	0.014
Net Exports	-1754.1	-2165.4	0.234
III Key Products			
GVS Rain-fed	2,363	2,383	0.008
GVS Irrigated	1,609	1,584	0.015
Rain-fed Land	2,012	2,148	0.063
Irrigated Land	563	481	0.170
Yields Rain-fed	7.502	7.088	0.058
Yields Irrigated	20.190	23.242	0.151
Net Exports	1305.9	1469.4	0.125
IV Fr, Veg & Other			
GVS Rain-fed	7,089	7,069	0.002
GVS Irrigated	9,626	9,620	0.000
Rain-fed Land	3,865	3,557	0.086
Irrigated Land	1,393	1,515	0.080
Yields Rain-fed	5.906	6.399	0.083
Yields Irrigated	23.709	21.783	0.088
Net Exports	745.7	751.9	0.008

a/thousands of millions of pesos of 1989; b/thousands of harvested hectares; c/tons per hectare.

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