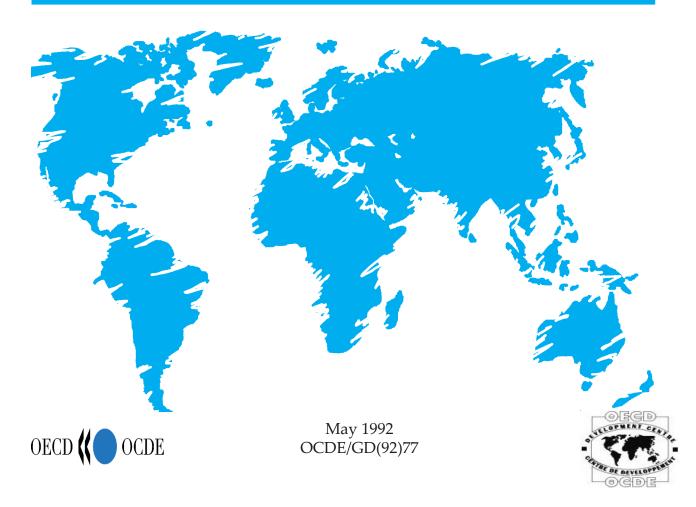# OECD DEVELOPMENT CENTRE

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MEXICAN AGRICULTURE IN THE FREE TRADE AGREEMENT: TRANSITION PROBLEMS IN ECONOMIC REFORM

by

Santiago Levy and Sweder van Wijnbergen

OECD OCDE

PREFACE

In developing countries, structural adjustment and trade liberalisation are matters of immediate and profound concern. Research carried out within the OECD Development Centre's programme on Developing Country Agriculture and International Economic Trends aims to provide fresh perspectives which may facilitate the reform process.

The Centre's research on agriculture incorporates several components: a conceptual component to provide analytical guidance to the broader issues; a global general equilibrium model to analyse the overall trends and policy consequences; country case studies to look at the reform options and their implications for individual representative countries; and a component to analyse the links between economic reform and technological change in agriculture. This paper is an element in the third component: it provides analytical insights into the interactions between trade policy and agricultural reforms in Mexico.

Mexico's bold economic reforms since 1985 have been primarily focused on balancing the budget, reducing protectionism and privatising state companies. The successful experience has set the stage for two even more fundamental reforms; the establishment of a North American free trade agreement and the associated opening up of Mexico's antiquated agricultural sector to market forces.

Almost 27 million people, a third of Mexico's population, live in the countryside, and around 11 million of these rural people are estimated to live in extreme poverty. Subsidies to maize farmers is the government's most significant contribution to alleviate this poverty. This study shows that high maize prices almost certainly contribute to, rather than alleviate rural poverty. Nevertheless, agricultural liberalisation could in the short term further aggravate the already dire rural situation.

The study focuses on the design of appropriate policies for the transition period in order to ensure that liberalisation improves rural welfare. It is unique in its application of state-of-the-art economic analysis of the transition problems. The application of an inter-temporal applied general equilibrium model allows the examination of alternative policies, providing the best-yet basis for the evaluation of the welfare implications of the reform options. The authors show that liberalising agriculture poses serious problems, but that policies can be designed which greatly ease the transition path, raising rural productivity and incomes.

Transition problems, such as those analysed in this paper, currently pose a major challenge to economists. This analysis offers insights drawing on the frontier of economic knowledge. It will be of immediate benefit to Mexican policy makers and provides insights which are of value to a much wider audience.

Louis Emmerij
President, OECD Development Centre
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RÉSUMÉ

L'agriculture mexicaine doit-elle être libéralisée ? Dans l'affirmative, à quel rythme la libéralisation doit-elle être menée et quelles sont les mesures qui doivent être prises pendant la période de transition ? L'exemple de l'agriculture mexicaine est utilisé comme étude de cas pour l'analyse des problèmes provoqués par toute période de transition lors de la plupart des réformes économiques d'importance. L'analyse porte sur les conséquences, pour la mise en place des politiques, de l'absence de marchés de capitaux efficaces ; sur les coûts, pour le bien-être social, d'une réforme graduelle ; sur les problèmes d'incitation créés par les politiques d'ajustement des échanges ; enfin, sur les aspects redistributifs de la réforme de la politique là où il y a des limites sur les instruments de politique existants. L'argument central est que l'ajustement doit s'attacher à l'augmentation de la valeur des avoirs détenus par les groupes concernés et non aux transferts directs des revenus ou aux programmes visant la production ou d'autres éléments contrôlés par les bénéficiaires de tels programmes. L'ajustement doit concerner les biens des personnes et non pas leurs activités.

SUMMARY

Should Mexican agriculture be liberalized? If so, how fast should this be done, and what policies should accompany the transition? We use Mexican agriculture as a case study to analyze the transition problems that arise in most major economic reforms. We 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 policy instruments. Our key point is that adjustment should focus on increasing the value of the assets owned by the groups affected, and not on direct income transfers or programs targeted on output or other characteristics controlled by the beneficiaries. We target adjustment on what people have, as opposed to what people do.

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I. INTRODUCTION

Agriculture contributes less than 9 per cent 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. Distributional concerns thus vastly complicate the process of opening up agriculture to international trade. Further complications arise because, while high maize prices almost certainly contribute to rather than alleviate rural poverty, rapid liberalization would beyond doubt increase poverty on the transition path.

This paper focuses on the distributional effects of liberalizing maize in Mexico, the policies that could 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. In fact, it has always been excluded from GATT until the recent Uruguay round, which then almost broke down on it. In many cases the reasons are related to the problems discussed in this paper. Moreover, transition problems like the ones analyzed here are likely to arise in most major economic reforms.

We show below that maize 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. Further, reducing the value of land lowers the value of the main asset farmers can give as collateral; this can reduce 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, liberalization of maize lowers wage rates across the board.[1] The effects of liberalization thus spill-over to the urban poor.

Lump-sum transfers are not a feasible option in Mexico, so alternative policies to protect the rural poor are needed. Moreover, Mexico's rural poor have limited access to capital markets to smooth consumption over time, and this access may in fact be reduced by the liberalization; therefore these policies should not only focus on steady-state welfare, but also on the transition period. And because the FTA is a permanent change, these policies should not only transfer income, but, if they are not to become open-ended, must also facilitate change towards other activities.

Both in our analysis of maize pricing and of a comprehensive and two-sided liberalization effort, we focus on four sets of issues:

First, the impact of liberalization on the rural labor market and, via migration, the urban labor market. Apart from migration to the US, Mexico has over the past few decades also seen substantial migration to the cities as agriculture lagged behind industry. Without migration, the entire burden of adjustment is likely to fall on rural labor; with migration, some of the incidence is shifted to urban labor. We provide an explicit treatment of labor markets and migration constructing a model that highlights these general equilibrium linkages.

Second, the impact of liberalization on the returns to various types of land (irrigated vs. rain-fed), and on the welfare of different type of land-owners.

Third, the role of government adjustment policies, through transfer schemes and rural infrastructure investments that increase agricultural productivity. We pay attention to the way these programs influence migration incentives. We also evaluate how the welfare of various groups is affected under alternative assumptions about the distribution of infrastructure investments between different types of land-owners.

Fourth, the sequencing and timing of liberalization and adjustment. We construct a dynamic framework where the trade-offs between the speed of liberalization and the size of the efficiency gains can be assessed. We also use this framework to quantify how the welfare of different groups is affected during the transition path.

The paper is organized as follows. Section II provides background on Mexican agriculture. Section II.1 focuses on the relationship between agriculture and poverty; section II.2 discusses the structure of output and protection in agriculture, while section II.3 covers land-tenure regulations that bear upon the adjustment to free trade. Section III presents a first view of the effects of maize price liberalization. We develop a partial equilibrium set-up to identify the mechanisms through which liberalization affects the different groups, paying particular attention to the distinction between net sellers and ney buyers of both goods and labor. Section IV then develops a general equilibrium framework. Section IV.1 presents a static model; sections IV.2 and IV.3 extend this framework to an inter-temporal setting. Section V presents a discussion of data sources (section V.1), and model calibration procedures (section V.2). Section VI contains the core of our results. Section VI.1 begins by studying a growth path where agriculture is kept out of the FTA and current protection levels are continued. Section VI.2 analyzes the efficiency and distributional effects of incorporating agriculture in the FTA under various liberalization speeds. Section VI.3 turns to the adjustment program, while section VI.4 further elaborates on the pace of reform. We summarize our results in section VII.

II. BACKGROUND

1.   *Agriculture and Poverty[2]*

Figure 1 below uses data from the 1984 Income-Expenditure Survey (IES) to classify households by location and income level. In particular, 20 groups of households are constructed in intervals of 5 per cent of the total sample ordered by per capita household income; within each group, households are divided into urban and rural. The figure makes clear that the bulk of the low income population is concentrated in the rural areas.

(Figure 1: Perc. Living in Rural vs Urban Areas)

Income distribution figures by themselves, however, say nothing about poverty. To remedy this situation, we combine the data underlying figure 1 with an exogenous calculation of a line of extreme-poverty, where extreme-poverty is defined with reference to a nutritional level. In particular, the poverty line, denoted by z, is based on the cost of a diet necessary to satisfy a minimum of 2,150 calories and 65 grams of proteins a day per adult-equivalent, as recommended by Coplamar[3]. We use the Foster-Greer-Thorbecke poverty index to incorporate information about the depth and distribution of poverty, and decompose the poverty index into its urban and rural component.[4] These poverty indices are listed in Table 1.

Consider initially the case when a = 0, the simple head-count ratio. We first find that 19.5 per cent of the sample population could be classified as extremely-poor. Next, focusing on the rural-urban split, we find that 37 per cent of the rural population could be classified as extremely-poor, while only 9.9 per cent of the urban population would fall under this category. Given the shares of the rural and urban population in the national total, this implies that in 1984 almost 67 per cent of the extremely-poor were living in the rural areas. When correction is made for the depth of poverty by setting a = 1, the proportion of extreme-poverty accounted for by the rural population increases to 72.8 per cent. Finally, when account is made of the distribution of poverty, a = 2, the proportion of extreme-poverty accounted for by rural groups increases to 76.6 per cent. The fact that the share of rural extreme-poverty increases as we go to higher order indices indicates that *not only is extreme-poverty mostly a rural phenomenon, but the poorest of the extremely-poor are almost all in the rural areas.*

Table 1

Indices of Extreme Poverty

	a = 0		a = 1		a = 2	
	P_j T_j		P_j	T_j	P_j	T_j
Rural	0.372	0.669	0.123 0.728		0.057 0.766	
Urban	0.099	0.331	0.025	0.272	0.009 0.234	
National	0.195	1.000	0.059	1.000	0.026	1.000

Source: Levy (1991)

Next, we use the data from the IES to classify household-heads by occupational characteristics. This shows that the largest number of the poorest heads of household work as self-employed in the rural areas (almost 40 per cent), with the next category being 'jornalero agricola' or landless agricultural worker (21 per cent). Although there is no direct information, self-employed workers in the rural areas are most probably small-scale agricultural producers (though other activities like handicrafts are also included here); hence, *even owners of some land are among the very poor.* Furthermore, if, following table 1, we take the lowest three household groups as constituting the extremely-poor, and assume that self-employed and employers with one to five employees in the rural areas are mostly in small-scale agriculture, and add to this landless agricultural workers, we find that 63 per cent of all extremely-poor household heads are principally engaged in agriculture. In sum, not only are most of Mexico's extremely-poor located in rural areas, but the majority of them are directly engaged in agricultural activities.

2. *Agricultural Output and Protection*

Mexican agriculture consists of an import-substituting sector producing basic grains and oilseeds, and an export sector producing fruits, vegetables, sugar, coffee and similar crops. Table 2, which aggregates all agricultural output into the 4 sectors that we model explicitly below, provides output data for 1989 divided by type of land. Total agricultural output in 1989 was US$ 17.8 billion, of which 22.6 per cent is accounted for by maize and other basic grains. Mexico's GDP in the same year was US$ 207 billion.

Almost one-third of Mexico's labor force, or about six million workers, is classified as rural. Of this amount, more than two-thirds is directly engaged in agriculture, with the remainder allocated to livestock, handicrafts and other activities. Maize accounts for the largest share of employment in rural areas.

Agricultural protection in Mexico has long historical roots. The process of land reform associated with the Revolution of 1917 gave farmers some land, but as the extensive margin was exhausted the quality of the land distributed diminished.[5] Since then, protection has been one of the mechanisms used to enhance the value of the asset distributed.

Most import-substituting crops other than maize receive only moderate protection (at an average nominal rate of 15 per cent in 1991). But maize, the most important crop in terms of acreage and rural employment, and the most costly in terms of fiscal subsidies, is substantially more protected. As shown in table 3, it is subject to a support price 70 per cent above the world price. This support price in turn is maintained through the use of import controls managed by CONASUPO, Mexico's food marketing and distribution agency.

Maize is grown by subsistence farmers, but also by medium and large scale farmers in rain-fed and irrigated lands. But because irrigated lands have substantially higher yields, owners of these lands, who are not among the rural poor, receive large infra-marginal rents.[6] As table 3 shows, of every dollar of subsidy only 0.32 reaches subsistence farmers.

Maize is also the key input into tortillas, Mexico's main staple food. To at least partially offset the tax on consumers implied by maize protection, the government subsidizes tortillas, though it does so differentially in urban and rural areas. Despite these subsidies, tortillas prices are higher than would obtain if maize was traded freely (cf.table 3). Thus, the rural poor (landless rural workers and subsistence maize producers with very marginal lands who are actually net maize buyers) suffer a net income loss from the tax on their main consumption good.[7] In urban areas the tax is partly offset by infra-marginal deliveries of tortillas through the 'tortivale' program.[8] Higher prices also hurt the livestock industry, which uses maize as feed.

Table 2
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.Sunflower Seed	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.Tobacco	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		
2.Strawberries	0	515	613
3.Sunflower	0.7	68	68
4.Tomatoes	0.1	0.7	1.4
5.Avocadoes	151	1 393	1 502
6.Alfalfa	12	194	345
7.Copra	131	2 251	2 263
8.Lemon	159	59	190
9.Apples	80	478	637
10.Oranges	343	322	403
11.Bananas	332	147	490
12.Rest	5 671	156	488
		4 040	9 711

[*] Millions of 1989 pesos; totals may not match due to rounding errors.
 GVS = gross value of supply.

Source: Direction General de Estadistica, SARH.

Table 3
Basic Maize Statistics, 1991

I. Prices[a]

1.	World price of maize[b]	132.50	
2.	Domestic producer price	226.60	
3.	Tortilla production costs with maize protection[c]	0.35	
4.	Tortilla production costs with free trade in maize[c]	0.20	
5.	Average tortilla prices urban areas[d]	0.31	
6.	Average tortilla prices rural areas[e]	0.26	

II. Taxes and Subsidies[f]

1.	Total subsidy to maize producers	1.28	
	of which:		
	a) subsidy to producers in irrigated lands		0.36
	b) subsidy to large producers in rain-fed lands		0.51
	c) subsidy to subsistence producers in rain-fed lands		0.42
2.	Tortilla taxes paid by consumers	0.96	
3.	Fiscal cost of maize and tortilla subsidies	0.32	
4.	Fiscal cost of 'tortivale' program	0.33	

III. Resource Allocation

1.	Share of total irrigated land allocated to maize	0.25	
2.	Share of total rain-fed land allocated to maize	0.48	
3.	Share of total arable land allocated to maize	0.42	
4.	Share of rural employment in maize production	0.29	

a. in US$.
b. CIF; includes a 10 per cent quality differential between yellow and white maize.
c. price per kilo.
d. average of 0.25 in Mexico City and 0.35 in other urban areas.
e. assumes only half of the rural population has access to subsidized stores.
f. US$ billion.

Agricultural products account for about nine percent of US exports to Mexico and about ten percent of US imports from Mexico. Table 4 lists the volume of trade and the main trade barriers between the two countries.

Table 4
Mexico-US Agricultural Trade and Barriers

	US	Mexico
Trade	US imports from Mex $2746 m; mainly coffee, shrimp, cattle, fruit and vegetables.	US exports to Mex $2628 m; mainly grains and oilseeds
Barriers NTBs	QRs on dairy products, sugar and sugar products.	QRs on about 60 items, particularly grains and oilseeds.
Tariffs	Generally low high seasonal tariffs on fruit and vegetables.	Higher, some 20 per cent
Other	Marketing orders on fruit, vegetables, and flowers. Health and sanitary requirements.	Health and sanitary reqs.

Trade figures for 1989 from US sources in millions of US dollars.
 Source: USITC Report 2326 and other sources.

Most Mexican fruit & vegetable exports face nominal tariff rates in the US on the order of 10 per cent in addition to NTB's like health and sanitary requirements (Feenstra and Rose (1991)). Although precise estimates of the tariff-equivalent of these NTB's are difficult to obtain, we here interpret these barriers to add an additional 10 per cent to the nominal tariff rates faced by the fruit & vegetables sector.

3   *Land Tenure Regulations*

Mexican agriculture has been strongly influenced by land tenure regulations that have been in place since the Mexican Revolution. In particular:

i   the land tenure system divides agriculture in two separate forms of tenure, private and ejido agriculture[9], and

ii   until very recently, a complex system of regulations applied to the use of land, labor and credit *in both types of agriculture.* In private agriculture there were limitations to the size of land holdings, so that entry was severely restricted; restrictions applied also to the uses of land[10]. In ejido agriculture land could not be sold, mortgaged, or rented; additional restrictions applied to sharecropping and other the uses of land.

A full analysis of how these regulations have affected agriculture is beyond the scope of this paper.[11] Here we simply remark on three mechanisms through which they have deterred private investment, with ensuing income loss and reduced productivity. First, incentives for investment in private agriculture were lower given limits to expansion of land holdings, uncertainty about tenure[12], and restrictions on land use. Second, uncertainty about tenure and restrictions on sale and rental reduced individual ejidatario's incentives to improve their plot of land since such investments could not be recouped[13] through sales of the land. Moreover, even if individual ejidatarios would have been certain about their own property rights, restrictions on sale still deterred investment (particularly for the better-off ejidatarios): the option value of liquid capital (or investment in areas other than agriculture) often, and especially in periods of uncertainty, would exceed the value of investments in a non-marketable asset. This implied that most investments had to be carried out by the public sector (water pumps, irrigation channels, storage facilities, etc.). Third, joint operations between private and ejido agriculture were not allowed[14].

A constitutional reform approved in December of 1991 has substantially altered these regulations. The reforms attempt to increase certainty of land tenure by formally ending the process of land distribution. Although the limits on the size of land-holdings for private agriculture remain, they allow the operation of stock companies through which the holdings of various individuals can be pulled together to exploit economies of scale. In addition, they allow ejidatarios to sell land within the confines of the ejido and, under some circumstances, permit the conversion of ejido land into private. Further, the new regulations allow private-ejido ventures, and permit alternative forms of exploitation of ejido land (like renting and sharecropping).

These changes will greatly increase the attractiveness of private investment in agriculture. They will also make it easier for farmers of all types, but particularly ejidatarios, to have access to private sources of credit. The reforms are thus very welcome, regardless of whether agriculture is liberalized or not. But opening a land market and liberalizing agricultural trade may lead to land concentrations that have nothing to do with technical efficiency. These circumstances require that special attention be paid to rural credit during the transition to free trade. In particular, it is of the essence to insure that small farmers have access to credit during the adjustment to preclude land sales induced only by the lack of short-term liquidity. This is compounded by the fact that, as discussed more fully in section VI, liberalization will tend to reduce land values in some rain-fed areas. The standard difficulties for private credit to reach small farmers (asymmetric information, transaction costs, etc.) have yet to be overcome in Mexico. But in addition over the next few years there may be a period of uncertainty as property rights change. Hence, it will take some time before the currently-being-privatized commercial banks can effectively reach small farmers. In the short to medium term public interventions in the rural credit market will be required. In addition, mechanisms need to be developed for commercial banks to improve their incentives and capacity to serve small viable farmers.

4.   *Main Questions*

Protection to agriculture, and particularly to maize, is a mechanism for supporting wage rates and rental rates on rain-fed land, and has been pursued with the distributional objective of helping the rural poor, particularly the sub-set of them who own land. But pursuing distributional objectives through protection has come at the cost of taxing consumption of the main staple consumed by the very poor that the program was set up to help. In addition, agricultural protection is a major drain on the fiscus, leads to inefficient allocation of land and rural labor, and to significant leakage in the form of infra-marginal rents to relatively better-off producers. What are thus the net effects of agricultural protection? And what instruments other than lump-sum transfers could be used to pursue distributional objectives in rural areas?

The FTA puts into sharp focus the choices faced by policy makers: continue with present policies or include agriculture, and particularly maize, in the FTA. Thus, the FTA will force policy makers to make fundamental decisions about the future of agriculture. Current policies almost certainly would imply rising levels of protection, as faster productivity growth in industry would make it increasingly difficult to maintain some sort of rural urban income parity without steadily increasing the degree of protection. If on the other hand it is decided to include maize in the FTA, the challenge to policy makers will be to design a transition strategy that simultaneously removes protection to maize while it:

i   protects poor rural inhabitants (either subsistence maize producers or landless rural workers) who may be hurt by the removal of protection,

ii   protects the urban poor from the effects of additional rural-to-urban migration, and

iii insures that the agricultural sector develops in a manner that is congruent with Mexico's recent structural changes away from public sector intervention. Put differently, the challenge is to find mechanisms to transfer the efficiency gains from free trade to those that are most needy and will be most negatively affected by a transition to free trade, but to do so in a way that leaves these efficiency gains in tact. This is the core question addressed here.

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III. PARTIAL EQUILIBRIUM ANALYSIS

This section presents a preliminary partial-equilibrium analysis of the effects of maize prices on various groups in society. Issues of inter-sectoral linkages via factor prices and/or non-traded prices are deferred until the next section. Similarly, we defer discussion of complete agricultural liberalization, focusing only on maize. We also ignore any differences in maize prices between urban and rural areas, and/or maize-tortilla substitutions. To both simplify and highlight the issues as sharply as possible, we make strong assumptions about the distribution of land ownership and the possibilites for crop substitutions. These assumptions are relaxed in section IV.

1.   *Direct Price Effects*

We begin by identifying the main groups affected by maize policies. First, **small scale producers or subsistence farmers**, who consist of farmers who own small amounts of (generally low quality) rain-fed land, and derive their income partly from exploiting their own land and partly from participating in the labor market.[15] Subsistence farmers devote part of their maize output to own consumption. Two, **landless rural workers**, who derive their income only from wages, and at times compete with subsistence farmers on the supply side of the rural labor market. Three, **medium and large scale producers**, who are net buyers of labor, and derive their income from producing a wide variety of crops.[16] Four, **urban consumers**, made up of workers and capital owners.

We assume a simple set-up with only three tradeable products: maize, vegetables and manufactures (indexed by m, v and q, respectively)[17]. To sharpen the argument, we also assume that:

i   rain-fed lands can only produce maize, while irrigated lands can also produce vegetables, and
ii all rain-fed (irrigated) lands are owned by subsistence (medium and large scale) producers.

Let p_m, p_v and p_q be the prices of maize, vegetables and manufactures, respectively, and let manufactures be the numeraire, so that $p_q = 1$. Finally, let w_r be the rural wage rate. Consider now the income effects on each of the groups mentioned above of changes in maize prices.

Subsistence Producers. These producers must allocate their total labor, $\bar{L}_p$, between cultivating maize on their rain-fed land, L_{mr}, and participating in the labor market, $(\bar{L}_p - L_{mr})$. Writing Q_{mr} for the quantity of maize produced by them, and $E(.)$ for the expenditure function, their budget constraint is:

$$E(pm, pv, 1, U) = pm.Q_{mr}(L_{mr}) + wr.(\bar{L}_p - L_{mr}) \tag{1}$$

where U is utility level. Differentiating (1) with respect to pm yields:

$$E_{pm}.dpm + E_u.dU = pm.(dQ_{mr}/dpm)dpm + Q_{mr}.dpm + (\bar{L}_p.dwr/dpm - wr.dL_{mr}/dpm$$

$$- L_{mr}.dwr/dpm)dpm \tag{2}$$

where we use the fact that $dpv/dpm = 0$. Noting that E_{pm} is the compensated demand for maize, C_m, that at an optimal labor allocation $pm.\P Q_{mr}/\P L_{mr} = wr$, and that $dQ_{mr}/dpm = (\P Q_{mr}/\P L_{mr}).dL_{mr}/dpm$, we can re-arrange (2) to yield:

$$E_u.dU = (Q_{mr} - C_m).dpm + (\bar{L}_p - L_{mr})(dwr/dpm)dpm \tag{3}$$

Note that E_u is the inverse of the marginal utility of income, so that the left side of (3) provides a 'money' measure of the change in real income associated with a small change in pm. Hence, (3) tells us that changes in the price of maize affect subsistence farmers through two channels, which we label the **direct 'price effect'** and the **indirect 'wage rate effect'** (the first and second terms on the right side of (3), respectively). The direct price effect tells us that, in the absence of changes in the rural wage rate, the impact on the real income of subsistence farmers of changes in pm depends only on their net maize position: *subsistence producers who are net sellers (buyers) lose (gain) with a fall in the price of maize.*

The indirect wage rate effect, on the other hand, depends on whether subsistence farmers are net-sellers or net-buyers of labor, i.e., on whether $(\bar{L}_p - L_{mr}) >/< 0$. If, as is generally the case, subsistence farmers are net sellers of labor, then they will gain (lose) on the amount of their *marketed* labor as the rural wage rate increases (decreases).

Labor allocated by subsistence producers to on-farm maize production is obtained by solving the equation $pm.\P Q_{mr}/\P L_{mr} - wr = 0$. Let the solution be $L_{mr}(wr, pm)$, and note that $\P L_{mr}/\P pm > 0$. Hence, reducing the producer price of maize increases subsistence farmers' participation in the labor market, since the opportunity cost of on-farm labor is now higher. This increase in the rural labor supply causes a change in wr, which in turn affects subsistence farmers by changing the income they receive on their marketed labor.

The term dwr/dpm captures this indirect effect. The direction of change in the rural wage rate, however, also depends on what happens to the demand for rural labor as the price of maize falls. If dwr/dpm > 0:

i   subsistence producers who are net sellers of maize and labor lose both because their marketed maize is worth less and because their marketed labor is worth less, and

ii subsistence producers who are net buyers of maize and net sellers of labor gain from lower maize prices on account of the maize they buy, but lose from lower wages for their labor, so that the impact on their real income is ambiguous.

Conversely, if dwr/dpm < 0:

i   subsistence producers who are net sellers of maize and labor face an ambiguous real income change (losing on their maize sold but gaining on their labor sold), and

ii subsistence producers who are net buyers of maize and net sellers of labor unambiguously gain (paying less for the maize they buy and getting more for the labor they sell).[18]

Landless Rural Workers. Since by definition they own no land, they must market all their labor, L_r, and purchase all the maize they consume. The change in their real income is given by:

$$E_u.dU = - C_m.dpm + L_r.(dwr/dpm).dpm \qquad (4)$$

Clearly, the direct effect of lower maize prices is beneficial to them: an important element of their consumption bundle becomes cheaper. On the other hand, the indirect effect may hurt them if the rural wage rate falls as a result of the increased labor market participation by subsistence producers, and if such fall is large enough to eliminate the gains associated with a lower price for the maize they consume[19].

Medium and large scale farmers. We assume they derive all their income from the (irrigated) land they own. Their problem is to allocate their total land, T, between maize and vegetables (T_{mi} and T_v, respectively), and determine how much labor to employ in each crop (L_{mi} and L_v). Hence, their budget constraint is:

$$E(pm,pv,1,U) = pm.Q_{mi}(T_{mi},L_{mi}) + p_v.Q_v(T_v,L_v) - wr.(L_{mi} + L_v) \qquad (5)$$

where Q_{mi} is maize output in irrigated lands, and Q_v vegetable output. Note that efficient allocation of land requires $dT_v/dpm = - dT_{mi}/dpm$ (given the constraint on total irrigated land $T = T_v + T_{mi}$). Differentiating (5) and using this condition yields:

$$E_u.dU = (Q_{mi} - C_m).dpm - (L_v + L_{mi}).(dwr/dpm).dpm \qquad (6)$$

For these producers own-consumption of maize is certainly lower than production. Hence, when maize prices fall the direct price effect lowers their real income. The indirect wage rate effect again depends on the sign of dwr/dpm. If positive, large scale producers gain because their total wage bill is less. Interestingly, note that if the wage fall is large enough, these gains can off-set the loses on their marketed maize, *implying that large scale farmers may actually benefit from lower maize prices*. Note that this outcome will be more likely the easier it is for these producers to substitute from maize into other crops, and the higher is the share of wage costs on total costs.[20]

Urban consumers. Consider first urban **workers**. The impact on their real income is given by an expression similar to (4), except that the urban wage rate, wu, is the relevant variables in this case. Hence, urban workers are directly affected by changes in the price of maize in proportion to their consumption. If maize prices fall, they receive a direct benefit. On the other hand, urban workers are also affected through the indirect wage rate effect. In particular, if the fall in the price of maize induces rural-to-urban migration there will be an increase in the urban labor supply, thus reducing the urban wage. The net effect on their real income will then depend on the relative size of these two effects.

Urban **capitalists** will also see their real income increase when the price of maize falls through the direct price effect, although its significance is probably minimal since maize is relatively unimportant in their diets. On the other hand, to the extent that the indirect wage rate effect puts downward pressure on the urban wage through migration, the product wage in manufacturing falls, leading to an increase in employment and quasi-rents on the capital stock employed in manufacturing. Thus, this group will gain from maize liberalization, though most of the gains would come from the indirect wage rate effect.

2. *Indirect Wage Rate Effects*

We have shown how lowering the producer price of maize increases subsistence farmers' participation in the rural labor market. But the resulting change in the rural wage also depends on:

i   the change in the demand for rural labor as maize prices fall, and

ii   the change in the size of the rural labor force through migration to urban areas.

To gain some insights on the first point, consider the isolated rural labor market described in (7)[21]. The first term on the left side is marketed labor by subsistence farmers; the second is marketed labor by landless rural workers. The right side is the demand for rural labor by medium and large-scale farmers, made up of employment in vegetable and maize production on irrigated lands. We also add a term L_g that represents an exogenous component of rural labor demand (associated, say, with government infrastructure projects). Equilibrium in the rural labor market implies that:

$$[L_p - L_{mr}] + L_r = L_v + L_{mi} + L_g \qquad (7)$$

When maize prices fall, labor supply of subsistence farmers increases, labor demand in irrigated maize falls, and labor demand in vegetables increases. Thus, the pressures on the rural wage rate hinge on:

$$|\frac{\partial \Lambda_{\mu\rho}}{\partial \pi\mu^\rho} + \frac{\partial \Lambda_{\mu\iota}}{\partial \pi\mu^\rho}| \underset{>}{<} \frac{\partial \Lambda_\varpi}{\partial \pi\mu^\rho} \qquad (8)$$

i.e., on whether the additional employment creation in vegetable production can absorb the displaced employment from maize cultivation. Assuming the left side of (8) exceeds the right side, there is a net release of labor[22]. Equilibrium in the rural labor market can be restored through different mechanisms. First, ignoring migration, the rural wage would fall, with employment increasing in both maize and vegetable production until excess labor disappears. Second, still ignoring migration, released labor could be absorbed through direct interventions by the government (increase L_g).

Third, equilibrium can be restored through migration. If the only policy change is a decrease in the price of maize, the labor released from maize would reduce the rural wage and widen the rural-urban wage differential. This would induce rural workers to migrate to urban areas, mitigate the decline in the rural wage, but would lower the urban wage.

Depending on the size of the migration flows, the fall in the urban wage may or may not off-set the gain to urban workers from lower maize prices. But note that the government could also off-set any negative effects on urban workers increasing deliveries of tortillas through the tortivales program. This would imply that while the product wage falls, the consumption wage could actually increase. Thus, policy makers can influence the outcome of maize liberalization on both rural and urban workers through both rural infrastructure investments and the size of programs like the tortivales.

3   *Summing Up*

Three insights follow from the discussion so far. First, the analysis suggests that the effects of maize liberalization on subsistence farmers that are net maize buyers are analogous to those on landless rural workers. The rural labor market is the key channel through which these groups are affected. This is of substantial import, given that *almost two-thirds of all subsistence farmers fall in the category of net maize buyers* (Levy and van Wijnbergen (1991)). As long as measures are taken to off-set any negative effects on rural wages as a result of maize liberalization, these two groups will likely gain from such liberalization.

Second, crop substitution possibilities and labor intensities are the key factors in determining the impact of maize liberalization on those producers that are net sellers of maize and net buyers of labor. These two factors will to a large extent determine the impact of changes in the price of maize on land values. The analysis suggests an assymmetric impact of maize liberalization on different types of land and, in particular, on rain-fed and irrigated land. Finally, the discussion points out that migration is the key link through which urban workers can lose as a result of maize liberalization. Hence, measures that off-set the impact of maize liberalization on rural labor markets will also benefit urban workers.

In sum, the analysis reveals that it is of the essence to incorporate the effects of maize liberalization on factor markets. And, because some of the effects are in principle of ambiguous sign, the analysis also reveals that a quantitative framework is required to assess the magnitude of these effects. Developing a model that can do this is the task of the next section.

IV. GENERAL EQUILIBRIUM ANALYSIS

In this section we develop a general equilibrium model that emphasizes the agricultural sector. The change in approach allows us to incorporate the effects on efficiency and welfare of factor price changes and changes in non-tradeable prices. We begin with the static relations of the model, and for ease of notation omit a time sub-index for all variables (except where strictly necessary).

1. Static Relations

Goods, Factor Endowments and Factor Ownership

Table 5 lists the number of goods produced, as well as their production location. 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 a non-traded pure consumption good, 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.[23]

Table 5
Commodities' Characteristics

Good	Sector	Tradeable	Primary Factors Used
Maize	Rural	Yes	Rural Labor, Land
Basic Grains	Rural	Yes	Rural Labor, Land
Fruits & Veg	Rural	Yes	Rural Labor, Land
Other Agr Prod.	Rural	Yes	Rural Labor, Land
Livestock	Rural	Yes	Rural Labor, Land
Industry	Urban	Yes	Urban Labor, Capital
Services	Urban	No	Urban Labor, Capital

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

Given our distributional focus, we distinguish six types of households, classified by ownership of factors of production. Four are in rural areas:

    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,
    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. Ownership shares are given by matrix $\mathbf{M} = \{m_{hj}\}$ where m_{hj} is household's h share of factor of production j.

Prices

World prices for traded goods, $\mathbf{pw}$[24], are exogenous. The price of services, the non-traded good, is ps. The vector of commodity goods prices is $\mathbf{p} = [\ \mathbf{pw}\ |\ ps]$. Modelling trade interventions as combinations of production and consumption subsidies and taxes, we write producer prices as:

$$\mathbf{pp} = \mathbf{p}.^*(1 + \mathbf{s}) \qquad\qquad (9)$$

where $\mathbf{s}$ 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:

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

$$\mathbf{cp}^u = \mathbf{p}.^*(1 + \mathbf{ct}^u) \qquad\qquad (10)$$

Urban and rural tortilla prices may also differ[25]. Because we assume tortillas are only produced with maize, their price is:

$$pt^r = a_{mt}{}^*\mathbf{pp}_m{}^*(1 - ts^r) = a_{mt}{}^*\mathbf{pw}_m{}^*(1 + \mathbf{s}_m)^*(1 - ts^r)$$

$$pt^u = a_{mt}{}^*\mathbf{pp}_m{}^*(1 - ts^u) = a_{mt}{}^*\mathbf{pw}_m{}^*(1 + \mathbf{s}_m)^*(1 - ts^u) \qquad (11)$$

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 $\mathbf{s}_m$, 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.[26]

Technology

Intermediate inputs are used 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:[27]

$$a_{ml} = t^m.(pa^*/ip^r_m)^m.a^*$$

$$a_{gl} = (1-t)^m.(pa^*/ip^r_g)^m.a^*$$

(12)

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. Using rain-fed land as as example, the relationship between them is:

$$\tilde{T}1_\varphi = \tau 1_\varphi . T1_\varphi^{\phi 1 \varphi} ; \ \tau 1_\varphi > 0, \ 0 < \phi 1_\varphi < 1$$

(13)

where ~ denotes effective land; the subscript j refers to the four agricultural goods. Relation (13) shows that as more rain-fed 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.[28] Similar expressions apply to irrigated land. However, irrigated land is assumed to be better than rain-fed in the following way: **f1 £ f2**, 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.[29] As a result of yield differences, infra-marginal rents accrue to owners of irrigated land in standard Ricardian fashion.

Value Added

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

$$\varsigma A1_\mu = \Lambda P1_\mu^{1-\alpha 1_\mu} \mathcal{T}1_\mu^{\alpha 1_\mu} = \Lambda P1_\mu^{1-\alpha 1_\mu} \tau 1_\mu^{\alpha 1_\mu} T1_\mu^{\phi 1_\mu \alpha 1_\mu}$$

$$\text{(14)}$$

$$= \rho 1_\mu \Lambda P1_\mu^{1-\alpha 1_\mu} T1_\mu^{\lambda 1_\mu}$$

$LR1_m$, $T1_m$ are rural labor and rain-fed lands allocated to maize; $r1_m = t1_m^{a1m}$ and $l1_m = f1_m.a1_m$. Similar functions apply to the other agricultural products in both types of land. Note that since $0 < l < a < 1$, there will be, for given labor intensity, diminishing returns to *physical* land. Thus, for a wide range of prices there need not be full specialization in agriculture.

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 subtracting 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):

$$T1_\mu = \{(1-\alpha 1_\mu)^{1-\alpha 1_\mu} . \rho 1_\mu . \pi v_\mu . \lambda 1_\mu^{\alpha 1_\mu} . \omega^{\rho^{(\alpha 1_\mu - 1)}} . \rho 1^{-\alpha 1_\mu}\}^{1/(\alpha 1_\mu - \lambda 1_\mu)}$$

$$\Lambda P1_\mu = \{(1-\alpha 1_\mu)^{(1-\lambda 1_\mu)(\lambda 1_\mu - \alpha 1_\mu)} \lambda 1_\mu^{-\lambda 1_\mu} \omega^{\rho^{1-\lambda 1_\mu}} . \rho 1^{\lambda 1_\mu} (\rho 1_\mu . \rho v_\mu)^{-1}\}^{1/(\lambda 1_\mu - \alpha 1_\mu)}$$ **(15)**

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 'tortivale' 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 household h, $\mathbf{QT}_h$, depends on household's location. Thus, for example, for urban workers (the fifth household group) we have:

$$\mathbf{vt}_5 = pt^{u}\mathbf{*QT}_5 \qquad (16)$$

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

$$XT = \Re \sum_{\eta=1}^{6} \alpha_{\mu\tau} {*}\pi\pi_{\mu}.\Theta T_{\eta} > \Re \sum_{\eta=1}^{6} \varpi\tau_{\eta}$$

$$(17)$$

Since the government has to purchase maize from producers at prices $\mathbf{pp}_m$ to make tortillas for the tortivale program. 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:

$$\mathbf{Y} = \mathbf{M^*facinc + vt} \qquad (18)$$

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

$$\mathbf{S}_h = \varphi_h . \mathbf{Y}_h \tag{19}$$

($\mathbf{Y}_h$ - $\mathbf{S}_h$) are thus the consumption expenditures for households of type h. We assume a nested, homothetic 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.[30] Solving the utility 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, $\mathbf{c}$.

Because of homotheticity of preferences, the exact price index for each household, CPI_h, depends only on:

    i   the location of the household (given differences in rural, $\mathbf{cp}^r$, and urban, $\mathbf{cp}^u$, consumer prices), and

    ii   the particular parameters of the household's utility function. We use these exact price indices to construct group-specific indices of the real consumption wage for rural and urban workers, Ω^r and Ω^u, separately:

$$\Omega^r = w^r/CPI_2$$
$$\tag{20}$$
$$\Omega^u = w^u/CPI_5$$

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

$$\mathbf{z}_t = (gk_t + gd_t).(KI_t + KS_t).\mathbf{invprop} \tag{21}$$

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

$$\mathbf{I}_t = \mathbf{p}_t.\mathbf{z}_t \tag{22}$$

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. Hence, the total demand for goods and labor required for irrigation investments is:

$$\mathbf{g}_t = RI_t.\mathbf{inputirr}$$
$$\tag{23}$$
$$LRIRR_t = RI_t.lrirr$$

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

$$\mathbf{qd} = A^*\mathbf{qs} + \mathbf{c} + \mathbf{z} + \mathbf{g} \tag{24}$$

Migration

Migration plays an important role in determining the incidence of any policy change with respect to agricultural protection. While migration to the US has attracted most international attention, there is little doubt that rural-urban migration inside Mexico is of more importance quantitatively over the long run. Mexico's very rapid urban growth over the last two decades has been largely fuelled by such migration, and involves numbers far in excess of any available estimate of the number of Mexican migrants currently in the US. This should not come as a surprise; while US wages for unskilled workers are about double the wage for similarly skilled workers in the North of Mexico, there are significant barriers to international migration. Migrating to the US remains illegal for all but a very small group of Mexicans. On the other hand, there are no barriers at all, other than moving costs, informational issues and so on, to internal migration. We therefore focus on internal migration, and ignore considerations of international migration.

Landless rural workers, subsistence farmers and urban workers are allowed to move between rural and urban areas. These three groups own all the labor, and constitute the potential migrant population. In our results migration occurs from rural to urban areas (although one could think of price configurations that yield reverse migration flows). Farmers who only own rain-fed and/or irrigated land, and urban capitalists are assumed to always stay in the same location.

Let H_h be the total number of households of type h. Consumption quantities for each household group are divided by the total number of households in the group to obtain per-household consumptions. Substituting per-household consumptions into the utility function gives per-household utility, U_h. Utility *functions* are identical for all groups, 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-households' utilities across locations.

We assume that migration decisions are based on the comparison of the per-household utilities derived from living in rural vs. urban areas. More particularly, we assume that migration flows for landless rural workers, on the one hand, and subsistence farmers, on the other, are such that the ratio of per household utility differentials between each of these groups and urban workers is kept constant. We model migration decisions separately for landless rural workers and subsistence farmers because the set of opportunities open to each group is different: while both can become urban workers, the latter group also derives income from land. On the other hand, we assume that the land owned by subsistence farmers who migrate to urban areas is kept by those subsistence farmers who remain in the rural areas.[31] Thus, migration by subsistence farmers increases the land/labor ratio for the remaining subsistence farmers.

We focus on utility differentials rather than the more conventional wage differences (as in the Harris-Todaro model) because urban transfer programs like the tortivales further affect migration choices. We capture all such effects by focusing on total utility rather than individual income components. Let L_h^{ru} be the stock of migrants from rural group h (h = landless worker or subsistence farmer), U_u the per capita utility of a worker in the urban areas, and U_{hr} the per capita utility of a rural worker of type h. We can then write the migration equation for each of these two groups as:

$$\Lambda_\eta^{\rho\upsilon} = \kappa_\eta \left(\frac{Y_\upsilon / Y_{\rho\eta}}{Y_\upsilon^0 / Y_{\rho\eta}^0} \right)^{\eta_\eta} - \kappa_\eta \; ; \; \kappa_\eta > 0, \eta_\eta \; 0 \qquad (25)$$

where 0 denotes an initial equilibrium, and h_h is the elasticity of migration of rural group h with respect to the utility differential of that group vs. urban workers. By setting very high values for h_h's this relation insures that enough migrants move in response to any policy change to restore pre-liberalization utility differentials for each of these two groups.[32] Total rural-to-urban migration, L^{ru}, is simply given by adding the migration of the two groups.

We note that (U_u^0 - U_{hr}^0) equals the implicit cost of migration measured in utility terms, which we take to be constant. These costs of migration differ between landless rural workers and subsistence farmers. There is, however, no explicit accounting of the real resource costs of migration. An alternative interpretation of why utility differences persist over time has to do with entry barriers into the urban labor market, and supports the omission of explicit migration costs. The literature on inter-industry wage differentials has attributed such differentials to the presence of industry rents which competition in the labor market fails to fully eliminate (cf. Katz and Summers (1989)). This supports the view taken in this paper that re-allocating workers from low productivity rural to high productivity urban jobs provides national efficiency gains.

Excess Demands

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

$$T1^D(r1) = S\ T1_j$$

$$T2^D(r2) = S\ T2_j \qquad\qquad \textbf{(26)}$$

$$LR^D(w^r) = S\ LR1_j + S\ LR2_j + LR3 + LRIRR$$

$$LU^D(w^u) = LU_i + LU_s$$

Note from (26) that rural labor demand includes the workers employed in constructing irrigation infrastructure (when such investments occur).

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[33], via the excess demand functions in (27):

$$LR^D(P) + L^{ru}(P) - LR^o = 0 \qquad\qquad (27)$$
$$LU^D(P) - L^{ru}(P) - Lu^o = 0$$
$$T1^D(P) - T1 = 0$$
$$T2^D(P) - T2 = 0$$
$$qS_s(P) - qd_s(P) = 0$$

where vector **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), i.e., **P** = [w^r | w^u | r1 | r2 | ps]. 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 between the two areas so that in the base case $L^{ru} = 0$.

Given the value at time t for production and consumption taxes and subsidies, a solution to (27) 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.

2.   *Inter-Temporal Relations*

Accumulation Equations

At each period of time the economy is described by the excess demand functions in (27). 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[34],
    ii   Hicks-neutral technical change in urban and rural sectors,
    iii growth of the capital stock in industry and services[35],
    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 three policy-induced changes to alter the economy's growth path: trade policy, agriculture investments, and urban transfer schemes. 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, the key issues are the size and time-profile of investments in irrigation. Within transfer schemes we focus on the effects of the urban tortivale program on rural-urban utility differentials and migration.

Investments in irrigation infrastructure change the total endowments of irrigated and rain-fed land. Recalling that T1 and T2 denote rain-fed and irrigated land, respectively, we have:

$$T1_\tau = T1_{\tau-1} - PI_{\tau-1}$$

$$(28)$$

$$T2_\tau = T2_{\tau-1} + PI_{\tau-1}$$

where RI is the number of hectares of rain-fed land that are transformed to irrigated via investments in period t-1. (We assume a one-period gestation lag.) The number of hectares of land devoted to livestock, on the other hand, is assumed constant throughout.[36]

We consider two alternative scenarios for distributing the rain-fed land that is transformed to irrigated between the owners of rain-fed land (subsistence and rain-fed farmers). In the first scenario we assume that the location of the land owned by both groups is such that they are equally well placed to benefit from irrigation investments. As a result, both groups benefit from irrigation investments in proportion to the initial share of rain-fed land held by each group. Thus, as irrigation investments take place, the share of total rain-fed land owned by each of these groups is constant, while at the same time they increase their ownership share of irrigated land (so that both groups hold a mix of rain-fed and irrigated land).

In the second scenario we make a more pessimistic assumption: only the rain-fed land that is owned by rain-fed farmers can be improved by irrigation investments.[37] This would reflect the fact that the rain-fed land owned by rain-fed farmers is better located than that of subsistence farmers in terms of proximity to water resources (or, alternatively, is less steep, etc.). In this scenario, as irrigation investments proceed the share of total rain-fed land owned by subsistence farmers increases while that of rain-fed farmers decreases. In turn, in this scenario only rain-fed farmers hold a mix of rain-fed and irrigated land. Note that in both scenarios the share of total irrigated land owned by irrigated farmers decreases (although of course the absolute amount of land that they own is constant). In the simulations, the matrix of ownership shares, $\mathbf{M}_t$, is up-dated at each period to reflect how as irrigation investments proceed the increase (decrease) in the endowments of irrigated (rain-fed) land is distributed between the different groups according to the case being analyzed.

Irrigation investments are paid for by the government.[38] The real resource costs of irrigation are modelled as 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.). This yields:

$$\Theta_\tau = \theta \left(\frac{\Re_{t=0}^{\tau-1} T2_t}{T2_0} \right)^\gamma \; ; \; \theta > 0 \; ; \; \gamma > 1 \qquad (29)$$

where Q_t is an index of marginal costs applied to the vector of inputs (goods, **inputirr**, and labor, lrirr) required for irrigation investments.

Note that while the rates of growth of labor are exogenous, migration responds to endogenously determined utility differentials, implying in turn that the urban and rural labor force are determined endogenously by:

$$\Lambda P_\tau = (\Lambda P_{\tau-1} - \Lambda_{\tau-1}^{pv})(1 + \gamma\lambda_{\tau-1})$$

$$(30)$$

$$\Lambda Y_\tau = (\Lambda Y_{\tau-1} + \Lambda_{\tau-1}^{pv})(1 + \gamma\lambda_{\tau-1})$$

where gl_t is the growth rate of labor in period t. Thus, the urban-rural distribution of the labor force responds to alternative liberalization paths. On the other hand, the number of rain-fed farmers, irrigated farmers and urban capitalists grows according to:

$$H_t = H_{t-1}(1 + gp_{t-1}) \tag{31}$$

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

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

$$KI_t = KI_{t-1}.(1+gk_{t-1})$$

$$(32)$$

$$KS_t = KS_{t-1}.(1+gk_{t-1})$$

The Transition Path and the Steady-State

We take as starting point for our analysis a particular date (t_1), and divide the future into a transition path and a steady-state. The transition path lasts (at most) 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. These changes take the form of various paths to remove tariffs and subsidies, different investment programs in irrigation, and possibly different sizes for the tortivale program. During this period the rate of growth of labor also converges to that of the population. In the steady-state, on the other hand, there are no policy changes, 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,¥). 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 scale factor (growth rate) for all quantities. The aggregation process therefore only affects the discount factors between T-1 and T; these are much larger than those between earlier periods to account for the fact that this period is replicated an infinite number of times (again, up to a uniform scale factor for all quantities).

If we label the common and constant post-T growth rate g, and the real world interest rate r^w, this process works as follows. Define $d=1/(1+r^w)$, and $d_a=(1+g)/(1+r^w)$, where d_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, d(i):

$$\delta(\iota) = \delta^{\iota-1} \qquad \phi o \rho \ \iota < T$$

$$\delta(T) = \Re_T^\infty \delta^{\iota-1} \qquad \phi o \rho \ \iota = T \qquad (33)$$

$$= \delta^{T-1} \Re_0^\infty \delta^\iota = \frac{\delta^{T-1}}{1-\delta}$$

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

$$N\Pi\varsigma_{\psi} = \mathfrak{R}_1^{\infty}\psi_{\tau}.\delta^{\tau-1} = \mathfrak{R}_1^{T-1}\psi_{\tau}.\delta^{\tau-1} + \delta^{T-1}.\mathfrak{R}_T^{\infty}\psi_T.(1+\gamma)^{\tau-T}\delta^{\tau-T}$$

(34)

$$= \mathfrak{R}_1^{T-1}\psi_{\tau}.\delta^{\tau-1} + \delta^{T-1}\mathfrak{R}_T^{\infty}\psi_T.\delta_{\alpha}^{\tau-T} = \mathfrak{R}_1^{T-1}\psi_{\tau}.\delta^{\tau-1} + \frac{\delta^{T-1}}{1-\delta_{\alpha}}.\psi_T$$

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

$$\delta(T) = \frac{\delta^{T-1}}{1-\delta_{\alpha}}$$

(35)

3.   *Budget Constraints and Welfare Measures*

We assume that only urban capitalists save and invest.[39] Private investment is driven by the exogenously given growth of the capital stock in industry and services. Private savings is a constant proportion of urban capitalist's disposable income. This proportion is exogenous during the transition period. 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 across 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,¥), urban capitalists will exactly satisfy their intertemporal budget constraint.   This means that over the interval [1,¥), 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:

$$N\Pi\varsigma_\xi(T) = \Re_T^\infty \xi_T \cdot \frac{(1+\gamma)^{\tau-T}}{(1+\rho^\omega)^{\tau-T}}$$

(36)

$$= \frac{\xi_T}{1-\delta_\alpha}$$

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

$$\frac{\xi_T}{1-\delta_\alpha} = \Delta_{T-1}.(1+\rho^\omega)$$

$$-\varphi_T \frac{\xi_T}{\psi_T}$$

(37)

$$= \frac{\Delta_{T-1}}{\psi_T}.\frac{1-\delta_\alpha}{\delta}$$

To make welfare comparisons across different scenarios 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, $\{U^h_0....U^h_{T-1};U^h_T\}$, will cross between simulations, 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 (26) for the interval [T,¥). The reason is, that per-household consumption grows at the rate gc[40], 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:

$$\hat{Y}_\eta = (1/\sigma)\hat{\gamma\chi}$$

(38)

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:

$$\Omega_\eta = \Re_1^\infty \frac{\upsilon_\eta(\chi_\tau)}{(1+\rho)^\tau} = \Re_1^{T-1}\upsilon_\eta(\chi_\tau).\delta_{\pi\rho\epsilon\phi}^\tau + \frac{\upsilon_\eta(\chi_T)}{(1+\rho)^T}\Re_T^\infty\frac{(1+\sigma^{-1}.\gamma\chi)^{\tau-T}}{(1+\rho)^{\tau-T}}$$

$$= \Re_1^{T-1}\upsilon_\eta(\chi_\tau).\delta_{\pi\rho\epsilon\phi}^\tau + \frac{\upsilon_\eta(\chi_T).\delta_{\pi\rho\epsilon\phi}^T}{1-\delta_{\pi\rho\epsilon\phi A}}$$

(39)

$$\omega\eta\epsilon\rho\epsilon\, \delta_{\pi\rho\epsilon\phi} = \frac{1}{1+\rho} \quad \alpha\nu\delta \quad \delta_{\pi\rho\epsilon\phi A} = \frac{1+\sigma^{-1}.\gamma\chi}{1+\rho}$$

where ρ is the rate of time-preference, assumed equal for all households.

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^o, and any B generated by an alternative path, and interpret the difference as the change in available resources generated by the policy change.

For each alternative path we calculate the lump-sum transfers (or taxes) required so that each household in each period has the same current utility as that obtained 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.

V. DATA

1.   *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.   On agriculture, 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 per cent 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 per cent of output, though we do have the totals for all the variables concerned.   Table 2 in section II 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.[41]

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

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: 6 and 15.9 million workers, respectively. 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. These are listed in table 6 below.

Table 6
Land - Labor Ratios[*]

	Maize	Other Grains	Fruits & Vegetables	Other Agriculture
Irrigated	51.5	25	l65	23
Rain-fed	18.4	9	58	18

* number of man-days employed per year per hectare of land.
 Source: Constructed from data in Norton and Solis (1983).

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 per cent), 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.

Data on the distribution of factor ownership by various groups is unavailable. To compute matrix **M**, the matrix of ownership shares, we proceed as follows. First, various sources refer to a population of landless rural workers of approximately 3 million (cf. Masera (1990), Salinas (1990)). Since the initial rural labor force is 6 million workers, we assume the remaining 3 million workers are subsistence farmers. Second, as discussed in section III, we impute 2 hectares of rain-fed land to each subsistence farmer, implying that 6 out of the 13.2 million hectares of rain-fed land (or 45 per cent) belong to this group, with the remaining belonging to rain-fed farmers. Irrigated farmers are assumed to own all the initial stock of irrigated land, while the land devoted to livestock is evenly divided between rain-fed and irrigated farmers. Finally, we assume urban capitalists own all the capital stock in industry and services, while urban workers own all urban labor. Table 7 below summarizes the initial matrix of ownership shares.

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Our model requires information on the parameters for the 'land transformation functions' [**t1** , **f1**] and [**t2** , **f2**]. Given our production technology the price elasticity of supply for any crop (in any given type of land) is:

$$e_s = 1/(a - af) \tag{40}$$

Given the shares of land in value added[42], a, we selected values for f 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, 1991). Lack of previously estimated elasticities made this procedure impractical for other crops. In these cases given the values for a we simply choose values for f such that:

i   f1 $\leq$ f2 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 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, 1991) 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 per cent. VAT rates for industry and services, as well as direct tax rates on factors and households were derived from our SAM. For simplicity, we assumed that only urban capitalists pay direct income taxes.

Table 7
Initial Ownership Shares

	Rural Labor	Urban Labor	Rain-fed Land	Irrigated Land	Livestock Land	Urban Capital
Subsistence Farmers	0.500	0.000	0.450	0.000	0.000	0.000
Landless Rural Worker	0.500	0.000	0.000	0.000	0.000	0.000
Rain-fed Farmer	0.000	0.000	0.550	0.000	0.500	0.000
Irrigated Farmer	0.000	0.000	0.000	1.000	0.500	0.000
Urban Worker	0.000	1.000	0.000	0.000	0.000	0.000
Urban Capitalist	0.000	0.000	0.000	0.000	0.000	1.000

We list now our assumptions concerning the parameters that determine the growth path of the economy:

    i   rate of time preference, 7 per cent;
    ii inter-temporal elasticity of substitution, 2;
    iii world rate of interest, 7 per cent;
    iv rate of growth of the capital stock in industry and services and non-irrigation real government expenditures, 4 per cent;
    v   rate of growth of population, 2 per cent;
    vi productivity growth in the urban sector, 2 per cent;
    vii productivity growth in rain-fed and irrigated agriculture, 0.5 and 1.5 per cent, respectively. In addition, to reflect Mexico's demographic transition, we assume that the initial rate of growth of the labor force is 3 per cent, and that it linearly converges to the rate of growth of population, 2 per cent, over a 10-year period.

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, re-habilitation of existing ones and projects for drainage in rain-fed lands. The data included average costs, internal rate of return and labor requirements per hectare for each project. All projects with an internal rate of return of 8 per cent 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, and obtained an estimate for lrirr in (15). A simple OLS regression for (21) yields for γ :

$$ \ln C_i = \ln \theta + \gamma \ln \Re \sum_{\iota=1}^{\nu} RI_\iota = \varepsilon_\iota \qquad (41) $$

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). Table 8 lists the number of projects with an economic rate of return of 8 per cent or more by state, identifying the number of hectares that can be newly irrigated, re-habilitated or subject to drainage and other improvements.

Finally, we also gathered data on the regional distribution of arable land by state, as well as on the share of maize output in the total value of agricultural output of each state. This is listed in table 9, and will be used later on, together with the data in table 8, to assess the regional impact of changes in maize protection. We make three remarks on table 9. First, in 1989 20 per cent of the total irrigated land and 42 per cent of total rain-fed land was allocated to maize. However, there are wide regional variations across this average. In some states (e.g., Guerrero and Jalisco), over 50 per cent of the irrigated land is allocated to maize, while in other states (e.g. Baja California Norte, Nayarit) this share is less than 10 per cent. Second, the data also shows wide differences in yields, both in irrigated and rain-fed lands. Third, there is wide variation in the share of maize in the gross value of agricultural output of each state. In some states like Chiapas, Guerrero and Jalisco maize accounts for around 50 per cent of the state's agricultural output, while in other states like Hidalgo, Morelos and Tabasco its share is less than 10 per cent. At this level of disaggregation no clear geographical pattern is apparent (Chiapas and Tabasco are both states in the South of Mexico, while Jalisco is in the Mid-West). As discussed further in section VI, however, the large variations in the share of maize in each state's output imply that the effects of maize liberalization will be concentrated in a few states.

<div align="center">**Table 8**: Potential for Land Improvements by State</div>

State	Number of Projects	Total Hectares		
		New Irrigation	Renovation Irrigated	Renovation Rain-fed
Aguascalientes	3	439	2 201	0
Baja Calif. N.	1	0	207 180	0
Baja Calif. S.	0	0	0	0
Campeche	12	113 115	0	1 250
Chiapas	18	2 500	0	549 487
Chihuahua	24	20 805	184 560	0
Coahuila	26	8 798	33 909	0
Colima	3	10 855	20 807	0
DF	0	0	0	0
Durango	11	6 391	2 703	195 085
Guanajuato	4	2 706	0	0
Guerrero	8	19 275	570	0
Hidalgo	14	25 167	33 607	0
Jalisco	6	13 129	12 862	0
Mexico	9	914	6 891	0
Michoacan	6	41 349	66 842	0
Morelos	4	5 000	2 040	0
Nayarit	8	22 421	4 347	13 400
Nuevo Leon	4	474	1 065	344 075
Oaxaca	11	13 009	43	110 396
Puebla	1	200	0	0
Queretaro	0	0	0	0
Quintana Roo	10	7 950	0	3 974
Sn Luis Potosi	6	7 406	66 821	110 631
Sinaloa	23	183 662	442 300	0
Sonora	6	3 348	234 150	0
Tabasco	13	1 000	0	418 731
Tamaulipas	9	12 941	81 669	0
Tlaxcala	0	0	0	0
Veracruz	8	8 360	18 765	138 431
Yucatan	3	250	0	2 033
Zacatecas	23	12 255	4 610	802 000
TOTAL	274	543 719	1 427 942	2 689 493

Source: Comision Nacional del Agua.

Table 9: Land Allocation and Maize Output by State, 1989

STATE	Total Hectares Cultivated		Hectares Allocated to Maize		Share of Maize in Value of Ag. Output		
	Irrigated	Rain-fed	Irrigated	Rain-fed	Irrigated	Rain-fed	Total
Aguascalientes	21 070	79 200	9 662	64 967	0.124	0.052	0.176
Baja Calif. N.	184 730	3 960	1 995	92	0.003	0	0.003
Baja Calif. S.	33 810	0	3 421	0	0.035	0	0.035
Campeche	15 190	80 520	1 276	32 586	0.012	0.142	0.154
Chiapas	24 010	850 080	7 311	583 494	0.008	0.530	0.539
Chihuahua	267 050	300 960	41 873	178 439	0.058	0.068	0.127
Coahuila	120 540	42 240	11 101	22 306	0.015	0.007	0.022
Colima	41 650	35 640	7 967	22 264	0.224	0.052	0.075
DF	0	50 160	0	9 089	0	0.262	0.262
Durango	107 800	339 240	33 579	152 386	0.070	0.104	0.174
Guanajuato	396 900	492 360	39 174	285 174	0.046	0.076	0.123
Guerrero	43 120	547 800	22 409	405 810	0.036	0.519	0.555
Hidalgo	159 740	772 200	57 298	190 887	0.045	0.037	0.082
Jalisco	144 060	831 600	28 783	548 689	0.032	0.423	0.455
Mexico	169 050	1 184 040	95 581	459 052	0.024	0.089	0.113
Michoacan	273 910	600 600	68 395	273 813	0.054	0.127	0.181
Morelos	38 710	102 960	11 551	30 064	0.035	0.057	0.092
Nayarit	94 080	186 120	5 560	50 419	0.016	0.109	0.124
Nuevo Leon	60 760	104 280	15 688	58 803	0.110	0.078	0.188

Table 9. (continued)

Oaxaca	32 830	567 600	18 690	341 638	0.023	0.231	0.260
Puebla	189 140	951 720	44 448	426 275	0.044	0.166	0.210
Queretaro	47 530	67 320	13 460	52 428	0.082	0.082	0.164
Quintana Roo	2 940	68 640	155	49 516	0.002	0.072	0.074
Sn Luis Potosi	67 130	304 920	27 013	146 849	0.044	0.059	0.108
Sinaloa	923 160	472 560	99 147	71 498	0.0388	0.009	0.049
Sonora	669 830	0	67 384	0	0.064	0	0.064
Tabasco	490	182 160	0	39 583	0	0.077	0.077
Tamaulipas	392 490	599 280	125 753	47 163	0.127	0.030	0.158
Tlaxcala	28 420	360 360	13 957	104 144	0.064	0.361	0.425
Veracruz	46 060	1 845 360	11 855	433 475	0.007	0.132	0.139
Yucatan	231 770	319 440	2 063	115 382	0.014	0.240	0.255
Zacatecas	71 050	855 360	25 272	329 399	0.062	0.234	0.296
TOTAL	4 899 020	13 198 680	911 831	5 525 698			

2.   *Model Calibration*

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. Tables 10 and 11, available upon request from the authors, display the differences between actual and simulated values for the main macreconomic aggregates and sectoral values for production, allocation of each type of land across crops, and yields. These tables show that the performance of the model in replicating original values is very satisfactory.

Significant changes occurred in agricultural policies between 1989 and 1991:

    i   protection to maize was increased from 47 per cent to 70 per cent,

    ii tortilla subsidies were reduced substantially, particularly in urban areas, and

    iii protection to other basic grains increased on average from 10 to 15 per cent. 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.

Using the trade and subsidy information for 1991 as departure point, we computed a 10 year reference path for the economy, where 9 years are the adjustment period and, as described above, the tenth period corresponds to the steady-state.

VI. ADJUSTING TO FREE TRADE

1.   *The Reference Path*

We use the model developed in section IV to study the efficiency gains of moving to free trade in agriculture. Because of its key importance, we focus the discussion on maize. In particular, 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; the reference path is also one with no investments in irrigation infrastructure, and no changes in the size of the urban tortivale program. In addition, on the reference path we also assume that US protection stays at its present level, implying no change in the world prices received for Mexico's agricultural exports (mostly fruits & vegetables).[43]

We highlight some key features of the reference path. We first focus in figure 2 on the path of utility that would be observed for the three groups in the rural areas who own land. What is interesting to contrast is the pattern observed for subsistence and rain-fed farmers. Both farm rain-fed land, but differ in the fact that the former are net sellers of labor and can migrate to urban areas, while the latter are net buyers of labor and, in our set-up, do not have the possibility of migration. With the capital stock in industry and services growing at 4 per cent a year there is substantial labor absorption in the urban areas (see below). This, together with the slowdown in the rate of growth of the labor force, contributes to a tightening of the urban labor market and to the trend for higher urban real wages. But through migration owners of rural labor are also able to benefit. Thus, over the nine year span the model predicts an increase in subsistence farmers utility of about 16 per cent (with a similar result for landless rural workers).

(Figure 2: Base Case Utility)

But for rain-fed farmers the situation is quite different. For them higher rural wages as a result of rural-to-urban migration and slower labor force growth translate into higher costs. If product prices are fixed over the relevant horizon, higher wage costs can only be off-set by higher productivity. But productivity growth in rain-fed is assumed to only grow at 0.5 per cent annually, and overtime cannot offset the effects of increased rural wages. The result is a trend of absolute declines in per capita utility for rain-fed farmers.[44] Differently put, for groups that *only* own rain-fed land a growing economy is, paradoxically, an undesirable trend.

The key role played by productivity growth is highlighted contrasting the behavior of per-capita utility between irrigated and rain-fed farmers. Both groups are buyers of labor and only derive their income from land. Thus, as the economy grows they are affected by the same trends as rain-fed farmers, with one key difference: productivity growth in irrigated land is higher: 1.5 per cent vs. 0.5 per cent annually. Despite the fact that irrigated land is more labor-intensive, higher productivity growth allows them to off-set the effects of higher wage costs and, overtime, to keep per-capita utility constant.

We turn now to the behavior of migration under the reference case, depicted in figure 3. Three points merit attention. The first point concerns aggregate rural to urban migration. 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 aabout 1.1 million workers over the next decade. While specific numbers are obviously open to discussion, the sheer order of magnitude suggests that maize pricing as a rural employment policy is likely to fail increasingly or, alternatively, to become much more expensive than it already is.

(Figure 3: Base Case Migration)

The second point concerns the composition of migration between landless workers and subsistence farmers. Figure 3 also shows that about two-thirds of the total migration is accounted by subsistence farmers. This group devotes part of their labor time to farming their own land. But increasing urban wages resulting from a growing economy raises subsistence farmers' opportunity cost of allocating their labor to their own lands. As a result, overtime these farmers alter their labor allocation in favor of increased off-farm work.

The last point concerns the composition of the rural labor force. While subsistence farmers are better-off over time, they are also contracting in size. In the first year the total rural labor force is evenly divided between 3 million subsistence farmers and 3 milllion landless workers. But faster migration by subsistence farmers implies that after nine years the total number of subsistence farmers falls to 2.8 million, while that of landless workers increases to 3.35 million.[45] Of course, the reduction in the number of subsistence farmers has a counterpart in the consolidation of plot sizes. Because the total land owned by subsistence farmers does not change (6 million hectares), migration implies that over the decade the average plot size increases by about 7.5 per cent, from 2 to 2.15 hectares.

The trends predicted here depend quite crucially on our assumptions concerning productivity growth and capital formation in the urban areas. An economy that grows at 5 per cent a year has a strong motor to pull up urban wages and, via migration, the earnings of landless rural workers and subsistence farmers. Given the results of the macroeconomic stabilization program and the structural reforms put in place over the last few years, these assumptions seem reasonable. But for groups that derive their income mainly from land, and for rain-fed farmers in particular, this process is not so beneficial. The trends in per-capita utility show clearly that over time these groups will be relatively worse-off than the rest of the population. Unless other changes are instituted to increase the productivity of the land owned by these farmers, it is clear that the political pressures for higher output prices, i.e., increased protection, will be very strong indeed.

2.   *The Impact of Free Trade*

We turn to study the implications of liberalizing maize, analyzing both the case of unilateral liberalization and of liberalization within the conntext of the FTA. Table 10 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 that the government can deliver lump-sum transfers (and, in some cases, impose lump-sum levies) such that every household has the same utility at each point in time as in the reference path. The welfare change reported for each household, on the other hand, measures the impact of various alternative adjustments, but excludes the effects of such lump-sum transfers or levies.

In this sub-section we only focus on the first three columns, where we evaluate the effects of maize and tortilla price liberalization **without** any adjustment policies. The first column shows the impact of an immediate elimination of all maize taxes and subsidies under the assumption that migration flows do **not** respond to the liberalization. Thus, the levels of migration in this case are assumed to be the same as those observed in the reference path. The second column also shows the impact of immediate liberalization, but allows migration by landless rural workers and subsistence farmers to occur such that at each point in time utility differentials vis-a-vis urban workers are, for each group, equal to the base levels. Thus, a comparison of the first two columns shows the differential effects of migration on efficiency and welfare. The third column shows the effects of a gradual change where maize moves linearly to world prices over 5 years. In this and all further scenarios migration flows respond to the liberalization.

Consider first the impact of instantaneous liberalization. In the case where migration flows do not respond to the policy change the **PDV** of the efficiency gains equal US$ 19.78 billion. With a growth-adjusted discount rate of about 3 per cent[46], these efficiency gains can sustain US$ 573 million of additional consumption *per annum*. When migration is allowed to respond to the policy change, the **PDV** of the efficiency gains increases to US$ 44.66 billion. Using the same growth-adjusted discount rate, this translates into 0.6 per cent of 1989 GDP (US$ 1.3 billion in that year). This is a very significant number, particularly if one considers that these are the gains from removing taxes and subsidies to only two commodities: maize and tortillas.

The difference between the with and without migration estimates derives from an interesting second-best effect. The reference path is characterized by a positive urban-rural wage differential, implying an inefficient allocation of rural and urban labor. Liberalizing maize, by inducing migration out of the low productivity rural sector, further strengthens the efficiency gains by more than a factor of two.[47]

Table 10
Welfare and Efficiency Effects

	Maize 1Y, no CNA, no F&V, no migration (1)	Maize 1Y, no CNA, no F&V (2)	Maize 5Y, no CNA, no F&V (3)	Maize 1Y, CNA(A), no F&V (4)	Maize 1Y, CNA(B), no F&V (5)	Maize 5Y, CNA(A), no F&V (6)	Maize 5Y, CNA(A), F&V (7)	Maize 6Y, CNA(A) early, F&V (8)
Subsistence Farmer[a]	0.876	0.984	0.986	0.993	0.993	0.994	1.000	1.002
Landless Rural Worker[a]	0.893	0.983	0.985	0.992	0.992	0.994	1.000	1.002
Rain-Fed Farmer[a]	0.963	0.943	0.949	1.046	0.995	1.052	1.053	1.055
Irrigated Farmer[a]	1.047	1.028	1.024	1.019	1.019	1.014	1.027	1.024
Urban Worker[a]	1.016	0.984	0.985	0.993	0.993	0.994	1.000	1.002
Urban Capitalist[a]	1.001	1.018	1.016	1.013	1.013	1.012	1.007	1.006
Efficiency Gains[b]	19.78	44.66	42.89	55.64	50.82	54.05	49.84	47.78
Cumulated Fiscal Gain[a]	1.020	1.045	1.042	1.035	1.035	1.032	1.026	1.020

CNA(A) = Additional irrigated land goes to rain-fed farmers only.
CNA(B) = Additional irrigated land goes to subsistence and rain-fed farmers.
a/Measured as a percentage of the reference case.
b/1989 US$ billion; Mexico's GDP was 207 billion in 1989.

Consider now the effects of gradual liberalization. As expected, the efficiency gains are less, at US$ 42.89 billion, because the price distortions are extended for a longer time-period (although at declining rates). But the efficiency gains are actually not much lower. Distributing the adjustment over a five year period reduces the PDV of the efficiency gains by only 4 per cent. Thus the efficiency costs of waiting do **not** seem large when compared to the benefits that maize liberalization eventually leads to.

But the aggregate efficiency gains have substantial distributional effects, a not-so-surprising result given the importance of maize in Mexican agriculture. Assessing these effects is not straightforward, because there is no one-to-one link between factors of production and the various groups in society.

(Figure 4: Rural Product Wages)

To understand how different groups are affected by the policy change, it helps to first look at what happens to the prices of the factors of production they own.

Consider first the impact of liberalization on the returns to labor. Figure 4 shows that rural product wages are clearly 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 (cf. table 6). Figure 4 also shows that when additional migration is ruled out the wage fall is quite large. Compared to the reference case rural wages are, on average, about 13 per cent lower hroughout the whole path. But with migration the gap between the reference and the liberalization wage paths narrows considerably, to about 4 per cent.

These results indicate that migration plays a key role in mitigating the impact of the liberalization on rural workers (although, as shown below, with an offsetting effect on urban workers). Of course, migration may not respond to exactly restore utility differentials, as we have assumed, or, alternatively, it may do so with a lag.[48] Thus, while the path without any additional migration is unlikely to be an equilibrium response to the trade liberalization, the path with immediate migration probably under estimates the short-run downward pressure on rural wages.

Table 11: Land Values and Land-Holdings[a/]

	Rain-fed Land	Irrigated Land	Land-holdings of Subsistence farmers	Land-holdings of Rain-fed farmers	Land-holdings of Irrigated farmers
Reference Case	12.067	40.172	12.067	12.067	40.172
Case 1: Maize 1Y, no CNA, no F&V, no migration	9.660	41.937	9.660	9.660	41.937
Case 2: Maize 1Y, no CNA, no F&V	9.233	40.803	9.233	9.233	40.803
Case 3: Maize 5Y, no CNA, no F&V	9.445	40.732	9.445	9.445	40.732
Case 4: Maize 1Y, CNA(A), no F&V	9.180	40.668	9.180	13.421	40.668
Case 5: Maize 1Y, CNA(B), no F&V	9.182	40.674	11.502	11.502	40.674
Case 6: Maize 5Y, CNA(A), no F&V	9.389	40.594	9.389	13.618	40.594
Case 7: Maize 5Y, CNA(A), F&V	9.608	42.174	9.608	14.036	42.174
Case 8: Maize 6Y, CNA(A) early, F&V	9.719	42.112	9.719	14.132	42.112

CNA(A) = Additional irrigated land goes to rain-fed farmers only.
CNA(B) = Additional irrigated land goes to rain-fed and subsistence farmers.
a/ million pesos of 1989 per hectare

Turn now to the impact of liberalization on land values. Table 11 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 per cent under immediate liberalization, clearly a very significant capital loss. This reflects the fact that most maize is grown in rain-fed areas, and that substitution possibilities towards other crops are much more limited than on irrigated land. Interestingly, 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.

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. As just seen, a large part of the impact on rural labor can be shifted to urban workers through migration. But even without additional migration, prices of rain-fed fall more than rural wages, because rural labor is also used in irrigated lands, and can be more easily re-allocated towards other crops.
(Figure 5: Cumulative Migration)

Turn now to migration. Figure 5 shows that immediate liberalization would have a large impact, adding about 700,00 workers to the reference level of migration in a *single* year. Gradual liberalization, on the other hand, also increases migration over the reference case, but does so at a slower pace. Note, however, that after the adjustment is over (from year 7 onwards) the cumulative amount of migration is the same.

But regardless of whether the adjustment is gradual or immediate, liberalization contracts substantially the size of the rural labor force. As noted before, without liberalization the rural labor force would have increased from 6 to 6.15 million workers over the nine year horizon. With liberalization the rural labor force actually falls to 5.3 million workers by the end of the ninth year.

What do all these factor price developments imply for the welfare of the various groups identified before? Table 10 provides the answer. Rural landless workers only own labor and hence lose out unambiguously as rural wage rates fall. But note that their welfare drops less in percentage terms than rural product wages do, because they are also consumers of maize and as such profit from
lower maize and tortilla prices. As Figure 6 shows, the drop in the rural consumption wage is less than the fall in the rural product wage.

(Figure 6: Consumption & Product Wages)

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 per cent, and their labor income declines in line with the drop in rural wages (although they also benefit from lower consumer prices). Hence, their migration response is stronger than that of landless rural workers. Indeed, most of the additional rural to urban migration (over the reference level) is accounted for by subsistence farmers.
The differential migration response is, in turn, reflected in the composition of the rural labor force. By then end of the ninth year landless rural workers would account for 59 per cent of the total rural labor force of 5.3 million. The absolute number of subsistence farmers would decline by one-third, from 3 to 2 million. Differently put, maize liberalization accounts not only for an absolute reduction of the total rural labor force, but also for a relatively faster contraction of the group of subsistence farmers.[49]

The situation is somewhat 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 11: rain-fed farmers lose substantially, while irrigated farmers experience a small gain. Note from table 11 that under gradual liberalization values of rain-fed land fall less than under immediate, reflecting the fact that protection-induced rents can be reaped for five additional years.

Figure 7 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 produces no further gain once the transition is over.

(Figure 7: Cold Turkey vs Gradualism)

Consider now the effects on urban groups. As analyzed, increased migration slows the drop in rural wages at the cost of increased downward pressure on urban wages. This produces opposite effects on the welfare of urban groups.
 Figure 8 shows the impact of this on urban consumption wages. Note first that when there is no migration by rural workers, urban workers are better-off because of lower maize and tortilla prices. Indeed, the direct effect of lower maize and tortilla prices is equivalent to a 2 per cent real wage increase. But these gains are eroded when migration increases the supply of urban labor. Despite lower consumer prices for maize and tortillas, urban workers' real consumption wages fall by about 2 per cent with respect to the base case, regardless of the pace of adjustment. Thus, the indirect effect via migration on its own accounts for an urban wage drop of about 5 per cent. And with the marginal product of capital increasing as a result of higher urban employment, urban capitalists are slightly better off (cf. table 10).

(Figure 8: Urban consumption Wages)

To sum up: the efficiency gains of liberalization in the absence of adjustment policies are substantial, but unevenly distributed. The gains are large even when migration is ruled out, but migration increases the size of the gains. Immediate liberalization produces larger gains, but gradualism is not very costly; the aggregate efficiency gains foregone during the 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. If no other measures accompany the transition, the time gained by gradualism generates no lasting gain. How this can be done is the subject of the next section.

3. *What Type of Trade Adjustment?*

Most adjustment programs help farmers survive *temporary* misfortunes. Successful programs maintain peasants' purchasing power until their economic fortunes take a turn for the better. Such programs may be part of a larger poverty alleviation strategy, but may lead to welfare dependency when used after a *permanent* adverse shock, since the turn for the better will not come in such cases. An adjustment program that contemplates the need for permanent subsidies is not focusing on the right objectives.

By its very nature, incorporating maize into the FTA constitutes a permanent shock. A program designed for such a permanent change needs to not only transfer purchasing power to the poor that are adversely affected, but also to help them find alternative sources of income. The major problem in the design of such a program is that the first objective usually conflicts with the second.

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 graft; the number of 'registered' maize producers would soon exceed the rural population. This is particularly important in Mexico's agricultural setting, where administrative capacity is weak, as are records of farm size and output. But, more fundamentally, a program focused on transferring 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 VI.2 indicates that in Mexico's case this translates into programs that can increase land values and stimulate the permanent demand for rural labor.

An implication of table 11 is that at free trade prices the average rental rate on irrigated land is four times that of rain-fed land. This suggests that a program of investments in irrigation has a substantial potential for increasing land productivity. 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.[50] 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.[51] By supporting the rural wage rate during the construction period it eases the transition towards free trade in maize for landless rural workers and subsistence farmers; and by slowing down migration it helps insulate urban workers from the policy change. And, more fundamentally, 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 finished it still provides employment opportunities in the rural areas.

But the program also increases the value of the land owned by subsistence and rain-fed farmers (though, as stressed below, this depends on how the improved land is distributed between rain-fed and subsistence farmers). As some of their land is improved with irrigation and drainage, the capital loss suffered from the removal of protection is compensated; this 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 while crop choice is augmented. This facilitates a permanent adjustment away from maize cultivation.

Simulations four, five and six explore the impact of such a program. In all these simulations we assume that 1.1 million hectares of land are transformed from rain-fed to irrigated, with investments beginning in the second year and lasting a total of five years[52]; in simulation four maize and tortilla prices are liberalized immediately, as is the case of simulation five. The differences between these two scenarios center on who benefits from the improved land. In simulation four we consider the case where **none** of the land owned by subsistence farmers can be improved by irrigation, so that all the benefits of the irrigation investments accrue to rain-fed farmers. This would reflect the fact that the land owned by rain-fed farmers is better located than that of subsistence farmers in terms of proximity to water resources (or, alternatively, is less steep, etc.). In simulation five, on the other hand, we assume that both rain-fed and subsistence farmers benefit from the irrigation investments in proportion to the initial onwership share that each group has in the total endowment of rain-fed land. This would be the case if the land owned by each group is equally well placed to benefit from irrigation investments.[53]   In simulation six, finally, we consider a pari-passu five year adjustment path for price liberalization and the irrigation investments, and assume that all the improved land accrues to rain-fed farmers only.

Table 10 measures the impact of this adjustment program. Notice first that the aggregate efficiency gains of immediate maize liberalization accompanied by irrigation investments are between 15 to 25 per cent higher than in the absence of irrigation. (The differences between these two estimates reflects differences in the migration behavior of subsistence farmers as a function of the amount of their own land that is improved with irrigation investments; see below.) Note also that, as before, the efficiency costs of gradualism are not very large: removing price distortions gradually as irrigation investments take place reduces the aggregate efficiency gains by only 4 per cent. More importantly, note that the efficiency gains of *gradual* liberalization with the adjustment program exceed by over 20 per cent the gains from *immediate* liberalization without the adjustment program.

These results highlight the fact that there indeed is a large outstanding stock of socially profitable land improvement projects. The results indicate that the potential gains from irrigation investments are very 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. Not surprisingly, these effects depend on how the expansion of irrigated land is distributed between subsistence and rain-fed farmers. As table 11 shows, when only the land owned by rain-fed farmers is improved with irrigation the value of their land-holdings increases by 11.3 per cent compared to the **protection** situation. As a result, their welfare under liberalization-with-adjustment is 5 per cent higher than under protection (cf. table 10). On the other hand, when rain-fed farmers only appropriate part of the benefits of irrigation, the value of their land-holdings increases by a smaller amount. As a result, their welfare is slightly below the level attained under the reference situation. But regardless of the distribution of land improvements, it is clear that rain-fed farmers are substantially helped by these investments.

Consider now the impact on subsistence farmers. As can be seen from table 11, when some of their land is improved with irrigation investments the value of their land-holdings is almost restored to the protection level. Conversely, when none of their land is improved, they suffer the full capital loss of the removal of protection. But note from table 10 that under either of these two cases their welfare is the same. Two factors

(Figure 9: Cumulative Migration)

account for this result: first, as opposed to rain-fed farmers, subsistence farmers only derive 20 per cent of their total earnings from land. As a result, the increased income that they derive from improvements on a part of their land is not as significant. Second, and more importantly, with or without irrigation investments, subsistence farmers still have the option to migrate. As a result, as figure 9 shows, when none of the land owned by subsistence farmers can be improved, they respond with higher migration to maintain their utility.

Thus, while the irrigation investments slow down total migration (see figure 12 below), the composition of migration depends on the distribution of the improved land between rain-fed and subsistence farmers. When none of the improved land goes to subsistence farmers they are the ones who, at the margin, migrate the most. And, as before, this would have implications for the composition of the rural labor force and the absolute number of each type of worker. By the end of the ninth year there would be 5.5 million rural workers, out of which 3.35 million would be landless. Thus, compared to the reference case the group of subsistence farmers would fall by 22 per cent, from 2.76 to 2.14 million.[54]

Figure 10 shows the impact of the irrigation program on the rural labor market. Rural consumption wage rates are higher when *gradual* 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. Further, note that the higher wage rates persist after the sixth year, when the irrigation program comes to an end. As a consequence, the welfare of landless rural workers and urban workers is almost restored to the protection level (cf. table 10). 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 10 Rural Consumption Wages)

Turn now to figure 11 where we depict the time-path of utility for rain-fed farmers, and focus on the gradual liberalization paths with and without the CNA program. What is interesting to note is that even if we assume that all the benefits of the irrigation program accrue to rain-fed farmers, this group is initially worse-off, reflecting the interaction between the rural labor market and the gestation period of irrigation investments.

(Figure 11: Utility Rain-Fed Farmers)

From the point of view of rain-fed farmers, 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 lower maize prices. This interaction between the path of price declines, on the one hand, and the timing of irrigation investments, on the other, determines *when* the different groups receive the benefits of the adjustment program. And while all this is masked by the discounted value of utility, such timing issues can be particularly important for the political economy aspects of the reform (of which more below).

The scenarios presented so far have ignored any change in US protection towards Mexico's export crops. Simulation seven remedies this situation by considering a scenario where the liberalization of the Mexican maize market is carried out in the context of a FTA with the United States. We consider the scenario where a gradual Mexican liberalization is accompanied by a 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[55]. We assume that this simultaneous trade liberalization is accompanied by the same five year CNA program considered before (with all land improvements accruing to rain-fed farmers only).

Consider first the distributional effects of improved market access to the US fruit & vegetable market. The first point to make is that 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 (cf. table 10).

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, and higher urban wages. As Figure 12 shows, the FTA would reduce cumulative migration by around 200,000 workers. 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 associated with higher prices for fruits & vegetables: as table 10 shows, their welfare increases. And because the irrigation program improves the land of rain-fed farmers, the benefits of the FTA also spill-over to this group. Differently put, the adjustment program creates a mechanism by which rain-fed farmers, the group of producers most dependent on the price of maize, can also benefit from the trade liberalization.

(Figure 12: Cumulative Migration)

Next, consider the effects of the US liberalization on aggregate efficiency. Table 10 shows that the aggregate efficiency gains in simulation seven are slightly lower than in six, 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.

We turn now to the fiscal impact of the adjustment program (and, for simplicity, ignore the effects of the US liberalization of fruits & vegetables). We focus on the trade-off between fiscal savings from the reduction in maize and tortilla subsidies vs. the fiscal cost of the CNA program. Figure 13 plots the fiscal resources devoted to maize and tortilla subsidies under the reference path, made up from three components:

    i   the cost of maize production subsidies,
    ii the revenue from tortilla taxes, and
    iii the cost of the tortivale program; for simulations 4 and 6 we add,
    iv the cost of irrigation investments[56].

Note first that 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. Second, note that when irrigation investments are undertaken, the fiscal position initially deteriorates, but then improves substantially after the fifth or sixth year. When gradual liberalization is undertaken this deterioration is initially quite sharp, because only small savings are made each year on the costs of maize interventions. The net effect is four years of increasing fiscal costs. With immediate liberalization the path is different. In the first year the savings from maize interventions actually dominate the costs of irrigation investments, and the additional 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[57].

(Figure 13: Fiscal costs maize & CAN program)

What is the net fiscal impact of each alternative? Table 10 provides an unambiguous answer: the net present value of the fiscal surplus in simulation four (six) is 3.5 per cent (3.2 per cent) higher than on the reference path. Current maize policies thus cost **more** than the adjustment programs proposed to ease the transition to free trade.

We end this section with a brief discussion of the regional impact of the adjustment program. We use the data from tables 8 and 9 to evaluate the match between those states that would be most affected by the maize liberalization and those states where land improvements projects can be carried out. Table 12 groups states into five categories given by the share of the value of maize output in rain-fed land in total agricultural output of the state. States in group one are therefore the most vulnerable to maize liberalization, while states in group five are the least affected. The first column gives the total hectares of rain-fed land allocated to maize in the respective group of states, while the second column gives the total number of hectares of land that can be improved given the CNA's portfolio of projects.

The table shows that production of maize in rain-fed areas is concentrated in a few states. Further, the table shows that for states in group 1, those most likely to be affected by the liberalization, there are in the aggregate sufficient projects to improve over 30 per cent of the rain-fed land currently devoted to maize. The same is not true, unfortunately, for the state of Tlaxcala, the only state in group 2. This state would also be affected by maize liberalization, but shows no potential for any land improvements. Although the state is small, it serves to highlight the fact that there will be a number of farmers for which liberalization will imply a capital loss. Of course, further disaggregation is required to assess more carefully those regions that cannot be compensated from the effects of maize liberalization via land improvements.[58]

Table 12
Regional Distribution of Maize Output and Land Improvements

Share of Rain-fed Maize in Output	Rain-fed Hectares in Maize	Hectares Subject to Improvement	States in Group
Group 1: 40 per cent or more	1 537 993	598 262	Chiapas, Guerrero, Jalisco
Group 2: 30 to 40 per cent	104 144	0	Tlaxcala
Group 3: 20 to 30 per cent	795 508	944 596	Oaxaca, Yucatan, Zacatecas
Group 4: 10 to 20 per cent	1 368 954	632 659	Campeche, Durango, Michoacan, Nayarit, Puebla, Veracruz
Group 5: 10 per cent or less	1 719 085	2 485 637	Aguascalientes, B. California, Chihuahua, Coahuila, Colima, Guanajuato, Hidalgo, Mexico, Morelos, Nuevo Leon, Queretaro, Quintana Roo, S. Luis Potosi, Sinaloa, Sonora, Tabasco, Tamaulipas
TOTAL	5 525 698	4 661 154	

In assessing the problems derived from the inability to reach *all* areas via land improvements it is useful to focus on how the different groups will be affected. And here the key point is to note that because landless rural workers and subsistence farmers can and do engage in substantial *rural-to-rural* migration, the exact location of the land improvement projects is, from their point of view, not as essential. These two groups, the core of the rural poor, will benefit from any invesments that stimulate the rural demand for labor, regardless of its location.[59]

For owners of rain-fed land, on the other hand, regional imbalances are central. The analysis reveals that there is a problem with a sub-set of regions, although this problem is, by national standards, not very large. Alternative programs focused on facilitating adjustment to these sub-set of farmers are required. Following the discussion for far, the challenge is to design alternative adjustment programs for these regions, insuring these programs increase efficiency and provide the incentives for change.[60]

4.   *The Pace of Adjustment*

Much of the economic literature, and in fact Mexico's own experience, argues for fast-paced reforms. But in the case of maize pricing several points argue for a more gradual approach. **First,** the impact of speed of reform on labor markets and migration. As shown in figure 5, if maize prices are liberalized instantaneously, around 800,000 workers are predicted to move almost straight away. Clearly, this would put demands on urban infrastructure and labor markets that would be almost impossible to meet. A more gradual reform program leads to the same migration as time goes by but spreads it out over most of the coming decade. This gives time to set up the infrastructure, training facilities and job placement centers needed to accommodate such a large group of migrants in an acceptable manner.

A **second** problem has to do with 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 VI.3 we argued that a program focused on improving currently rain-fed land by irrigation and other productivity enhancements intervenes at just the right margin; it makes rain-fed farmers better off since the value of their land holdings recovers, and also benefits subsistence farmers and landless rural workers by stimulating the permanent demand for rural labor.

But to fully restore land values to pre-liberalization levels requires at least five years, if only because of technical and engineering constraints on construction. Immediate liberalization of maize, even if accompanied by the irrigation program, would still impose substantial transitory losses, as is illustrated in Figure 14 for the case of rain-fed farmers. Even if all the benefits of the irrigation program accrue to this group, when liberalization is immediate there are three years during which their utility is lower than under the reference case. 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 that only improves their land is accompanied by gradual phasing-out of maize price supports.

(Figure 14: Utility Rain-Fed Farmers)

A *final* argument concerns *period-to-period* losses. Mexico's rural poor - landless workers and subsistence farmers- have little access to capital markets to help them smooth consumption. As discussed in section II.1, many of these individuals live close to, or below, the level of extreme-poverty, and may have substantially higher discount rates than assumed in this paper. 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 at any discount rate. The government can argue that they are being made better-off, or at least not losing out, without asking these groups to look five years ahead before benefits materialize. Because it is almost certainly administratively impossible for the government to reach them directly, this too calls for gradualism as a second-best solution.

Simulation 8 explores an adjustment program that incorporates 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 a **six** year period. Further, we assume that the change in maize and tortilla prices begins one-year **after** the irrigation program starts. Note that 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 devotes resources to agricultural productivity improvements *before* any sacrifice is asked for. We also incorporate in this simulation an expansion of the tortivale program for urban workers. In particular, note that if the size of the tortivale program is kept constant in the face of increased migration, the amount of tortillas distributed per-urban worker declines. To avoid this implied reduction in transfer, we increase the amount of tortillas distributed through the tortivales to keep the per-worker amount constant at the level of the initial year (one kilo per day).

As table 10 shows, this policy combination insures that *all* households experience a welfare increase vis-a-vis the reference path though it comes, as expected, at an efficiency cost. But this cost is not very large: total efficiency gains are only 4 per cent smaller than the case where maize prices move pari-passu with the irrigation program.

(Figure 15: Utility Subsistence Farmers)

The payoff to this efficiency cost, on the other hand, is shown in Figure 15 for the case of subsistence farmers. The key point is that under this situation these farmers are better-off at every point in time than under protection.[61] The same holds for landless rural workers. 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. Differently put, with the appropriate timing of price reforms and adjustment programs, *incorporating maize into the FTA can be made compatible with current efforts at poverty alleviation.* Note, moreover, that these results are obtained assuming that all the benefits of the irrigation program accrue to rain-fed farmers.

Consider now rain-fed farmers Figure 16 shows that despite the timing changes in the irrigation and liberalization program they still experience two years during which utility is less than the reference case, even under the assumption that the CNA program only improves their land.

(Figure 16: Utility Rain-Fed Farmers)

Because of gestation lags, the first effect of the irrigation program is to tighten the rural labor market.
And while higher rural wages improve initial utility of subsistence farmers and landless workers, they also cause higher wage costs and therefore lower initial utility 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 phases of the CNA program.

Spreading the price reforms over a longer horizon and investing first in irrigation has a counterpart in the fiscal accounts. As Figure 17 shows, in the second year fiscal expenditures increase substantially because there are no savings from reduced maize subsidies while outlays for irrigation are made. And though it takes 5 years for the fiscal costs of interventions to be less than under protection, table 10 shows that in present value terms this policy is still cheaper than keeping maize and tortilla subsidies forever.[62] The fiscal issue associated with the adjustment program is thus not one of overall costs, but one of transitory financing.

But to label an issue as 'transitory' is not to dismiss it as irrelevant. Policy makers in charge of the fiscal accounts will want to insure that if resources are committed to irrigation investments, liberalization of maize prices will indeed occur; adding the costs of irrigation investments to the costs of maize policies would put an undue burden on the fiscal accounts. On the other hand, policy makers in charge of agricultural policies will want to insure that if maize prices are liberalized, 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 members of the rural population.

What is needed is a 'commitment technology' to insure that both elements of the reform process -maize liberalization and the irrigation program- are indeed carried out.

(Figure 17: Fiscal Costs Maize & CAN Program)

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 allocations of fiscal expenditures in Mexico. What guarantees do the rural groups potentially affected by maize liberalization have that the adjustment 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. We end this section suggesting how this time consistency problem can be made less serious, if maybe not solved altogether.

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

Further strengthening of the commitment can be achieved by recalling that liberalization reduces the value of the main collateral that subsistence and rain-fed farmers can offer. 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. This increases the expected cost of the guarantee scheme, and makes reneging on promises to implement the CNA program correspondingly less attractive.

Reduced credit from a multilateral institution combined with costlier public credit guarantees may make it to the government's own advantage to complete the adjustment program after the FTA is signed. A quantitative analysis of a time-consistent trade liberalization and adjustment path like this is left for further research.

VII. CONCLUDING OBSERVATIONS

Agricultural protection in Mexico, and particularly the policy of maize 'self-sufficiency', introduces significant distortions, has large fiscal costs, and mostly gives substantial infra-marginal rents to already better-off agricultural producers. Our analysis quantifies these arguments: there **are** large efficiency gains to be had from agricultural liberalization. These gains equal 0.6 per cent of GDP when liberalization is immediate, though rural to urban migration increases by about 700,000 workers in a single year. Gradual liberalization over a five year period reduces these gains by only 4 per cent, and spreads the migration response over a longer horizon.

But our analysis shows that in the absence of government interventions the gains will be unevenly distributed. Despite the rents, consumer taxes and production distortions associated with agricultural protection, current policies do serve to both sustain the rural wage rate and increase the rents derived from rain-fed land, the two main assets owned by the rural poor. There are substantive reasons for concern about the distributional impact of agricultural liberalization in the absence of proper adjustment policies.

Our analysis also shows, however, that a package of interventions can fully protect the losers while simultaneously facilitating change towards the free trade output composition. These interventions, moreover, can be fully paid for with the resources liberated by eliminating protection to agriculture, while still leaving a remnant. Our key point is the adjustment program to free trade should focus on increasing the value of the assets owned by the groups affected, and not through direct income transfers or programs targeted on output or any other characteristic controlled by the beneficiaries.

To design this program, we exploit two facts: first, that in Mexico irrigated land is more productive than rain-fed and, second, that for a variety of reasons the potential for profitable irrigation investments has remained unexploited. We show that a program that transforms about 1.1 million hectares of land from rain-fed to irrigated restores the value of the land-holdings of those affected by the liberalization. The size of this program, moreover, is manageable: improving only 8 per cent of the current endowment of rain-fed land. A five year, 220,000 hectares per annum program can be achieved judging by Mexico's past performance in this area, and by the portfolio of irrigation and other projects to improve land currently available.

Land improvements have other advantages. Improved irrigation and related infrastructure increase the collateral value of land, and thus are likely to enhance subsistence and rain-fed farmers' access to credit precisely at the time when credit is most needed. Moreover, since irrigated land allows for more variety in crop choice, farmers' ability to deal with risk is improved.

The adjustment 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. The fact that most workers can be absorbed in agriculture once the program is over means that this "public works for private productivity" program is truly self-eliminating, thereby obviating the most serious objection against temporary adjustment programs: that they rarely stay temporary once put in place. The program provides workers with alternatives once it ends; its transitory nature is thus credible.

Our analysis highlights an important second-best aspect of liberalization: because previous measures have deterred agricultural investments (particularly uncertainty about land tenure and budgetary restrictions), increasing irrigation investments at the same time that maize liberalization takes place actually augments the magnitude of the efficiency gains. This permits to compensate the loss in the value of land associated with liberalization while at the same time increasing efficiency. In fact, when agricultural liberalization is accompanied by the investment-focused adjustment package, the efficiency gains are 20 per cent higher than when such an adjustment package is not undertaken. Thus, our results indicate that much can be gained by changing the way in which the Mexican government channels resources to rural areas: eliminating price subsidies and using the resources to invest in rural infrastructure. These investments increase efficiency *and* improve everybody's welfare.

We consider as well the question of whether there are benefits to including maize liberalization in a wider Free Trade Agreement (FTA) with Mexico's main trading partner, the US. While we show that unilateral liberalization *is* desirable, we also find that transitional problems are eased significantly if liberalization is part of a comprehensive FTA with the United States. In particular, the distributional shocks that liberalizing trade in maize would lead to are softened when access to US markets is gained as part of a comprehensive FTA. The reason for this finding derives from the fact that the major adjustment problems arise in Mexico's rural labor markets. But because Mexico's main export crops, fruits and vegetables, are more labor-intensive than its import crops, improved access to foreign markets shifts out the demand for rural labor. If this happens at the very time that demand for rural labor is reduced because of lower maize prices, the adjustment problems caused by the latter change are correspondingly diminished.

Our analysis indicates that appropriate timing of the liberalization and the adjustment program further eases the transition to the rural poor. We show that if irrigation investments precede trade liberalization, landless rural workers and subsistence farmers have at every point in time higher utility than under protection. Hence, this transition path is fully consistent with, and in fact contributes to, current efforts at poverty alleviation. On the other hand, such a path cannot be found for rain-fed farmers, since gestation lags imply that the initial impact of the irrigation program is to increase wage costs. Although their ultimate (and present discounted value) welfare is higher, utility is lower for the first two years of the adjustment program.

The adjustment program proposed faces two difficulties. The first one is of a fiscal nature. Although in present value terms liberalization-cum-adjustment is less costly then protection, it initially requires larger expenditures. The second difficulty derives from the need to make the government's commitment to the adjustment program time-consistent. This is a serious problem: what guarantee do farmers have that the adjustment programs will in fact be implemented once they have agreed to lifting trade barriers?

Funds provided by a multilateral agency can actually contribute to solving both problems. First, such loans can solve the transitional financial needs by providing resources in the shortage periods which only need to be repaid in the future, surplus years. Second, and possibly of more importance, such funds can be made contingent on the implementation of the adjustment program itself, rather than on the trade reforms; this will make it more costly for the Government to renege on its promises, which in turn makes the Government's commitment to implement the program more credible. We suggest that the commitment to the program can be further strengthened by having the government provide guarantees to commercial banks on loans given to those farmers that are expected to benefit from the irrigation program. These programs clearly increase the value of the collateral once they are in place, but the very fact that the Government could renege will limit the opportunity they give to farmers to access credit markets. But with Government guarantees, defaulting on the irrigation program while the trade reforms continue would then impose a cost on the government, by having to face increased default rates on its guaranteed loans. Thus such guarantees would in fact act as a signal from the government to farmers that it does indeed intend to fully implement the adjustment program.

Uncertainty about property rights and limitations to land use have had a depressing effect on agricultural output and investment. But a major constitutional reform has recently eliminated the source of most of the uncertainty problems: the clause in Mexico's constitution committing the government to a continuous process of land distribution has been eliminated. Furthermore, restrictions on tenancy arrangements (sharecropping, renting-out, joint ventures) in ejido lands have been removed. This breakthrough in the regulatory environment is likely to substantially speed up adjustment to a post-liberalization incentive structure. As the economy moves towards free trade in maize, ejidatarios are now free to engage in whatever crop combination, commercial venture and on/off-farm labor allocation that yields the highest returns, without risks of losing their land or their access to credit. This is important if we recall that 73.5 per cent of all maize producers are ejidatarios, and that maize is the most protected crop. But it is also important because a regulatory structure that minimizes uncertainty and clarifies property rights in both ejido and private agriculture is necessary for sustained and significant increases in private investment in the rural areas. The reforms have removed a major obstacle to this process, and have therefore laid the foundations to fully exploit the benefits of trade liberalization.

It is perhaps useful to conclude with a broader view. The structure of protection has been altered in Mexico: agriculture, and particularly maize, is now more protected than industry. This process will be further strengthened if agriculture is kept out of the FTA. Such an 'inversion' in the pattern of protection, although recent in Mexico, is not unique. Many developed countries (e.g., Japan), and some developing countries (e.g., Korea) have witnessed the same process (cf. Anderson and Hayami (1986)). Their experience in this regard is illuminating: to keep the income gaps between agriculture and industry from widening, agricultural protection has continuously increased. In some cases domestic prices for agricultural products are above the respective world prices by a factor of three or four. Protection to agriculture is accompanied by costly subsidies and elaborate systems of controls on trade, quantities grown, etc. This creates well known incentives for rent-seeking, together with strong agricultural lobbies who take a life of their own and make it very difficult to change the system (as the European Common Agricultural Policy can attest).

The recuperation of macroeconomic stability, the FTA and the other structural reforms that Mexico has put in place over the last few years highlight the need for a policy change. We have shown how as services and manufacturing grow, urban real wages increase. We have also shown how, via migration, this improves the lot of rural workers. But we have also shown that this process will not increase the income of land-owners, particularly owners of rain-fed land. Present policies have no mechanism, bar increasing protection, to keep farmers' income increasing pari passu with urban incomes. But this set up implies increasing distortions in the allocation of labor and land, higher maize prices for landless rural workers, larger rents for large scale farmers, and increasing fiscal costs.

Mexican agriculture is now at the crossroads. The FTA has put into sharp focus the choices faced by policy makers; it can also serve as a catalyst to make fundamental decisions about the future of agriculture. Mexico can follow the route of agricultural policies in other countries, and put its rural population on the operational equivalent of a permanent welfare program. But, as opposed to other countries that have also been unwilling to recognize that as their economies develop they have lost their comparative advantage in traditional agricultural products, it has a much lower income per capita to be able to afford the costs of protective practices[63].

But the country can also use the FTA as an opportunity for a change in course. If this opportunity is taken, Mexico can avoid the need to increase protection to agriculture as real incomes increase in the rest of the economy. This is not to say that liberalization is a panacea. Liberalizing agriculture poses serious challenges to policy makers. Investments in irrigation infrastructure need to be accompanied by changes in water pricing; significant improvements in the functioning of rural credit markets are required; mechanims need to be developed to cope with the instability derived from fluctuations in international prices. Yet, the history of agricultural protection shows convincingly that channeling resources to rural areas via price protection fails to generate a mechanism through which rural productivity can increase over time. By channeling resources to rural areas through productivity-enhancing investments instead of through protection, the government can protect all households and reap efficiency gains for all.

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NOTES AND REFERENCES

1. Feltenstein (1991) and Stark and Taylor (1991) present evidence that migration in Mexico is strongly responsive to income differentials.

2. This sub-section draws from Levy (1991).

3. See Coordinacion General del Plan Nacional de Zonas Deprimidas y Grupos Marginados, Coplamar (1985).

4. The Foster-Greer-Thorbecke poverty index, $P(\alpha,z)$, is given by:

    $\Pi(\alpha,\zeta)=(1/\nu)\Re_{t=1}^{\theta}(\gamma_{1}/\zeta)^{\alpha}$; α 0   where $g_i = $ max $[(z-y_i),0]$, y_i is the income of the ith individual, q is the number of individuals for which $g_i > 0$, and n is the total population. The parameter α measures societies' aversion to poverty: as it increases greater weight is attached to the poverty gap, g_i, of the poorest individuals. This poverty index can be additively decomposed into a weighted average of regional poverty indices, with population shares as weights. These are the rural and poverty indices $P_j(.)$ in table 1. The values of T_j are then given by $(n_j/n)*P_j(.)/P(.)$, where $P(.)$ is the national poverty index, and n_j the population in region j. T_j is thus the contribution of region j to total poverty.

5. Salinas (1990, p. 821) states that out of the 43 million hectares distributed between 1958 and 1976, 91 per cent were 'agostadero, monte, cerril y otras calidades' (roughly: hillside, mountainous terrain and other qualities), 8.4 per cent were rain-fed lands, and only 0.4 per cent were irrigated lands.

6. The production-weighted mean of yields in irrigated lands is 2.94 tons/hectare, with a standard deviation of 0.59; the figures for rain-fed land are 1.48 and 0.73. Note that the dispersion in yields is significantly higher in rain-fed lands, indicating greater variations in land quality.

7. In Levy and van Wijnbergen (1991) we present data that indicate that only about 35 per cent of the two million maize producers in Mexico are net sellers.

8. The 'tortivale' program delivers one kilo of tortillas per day free to any urban family who earns less than two minimum wages. According to the 1984 Income-Expenditure Survey, low income urban families consume over two kilos of tortillas per day. Hence, consumption of tortillas through tortivales is infra-marginal. In 1990 approximately 2 million families benefited from this program, receiving a total of 730 tons of tortilla per year.

9. The ejido is a form of land tenure where a grouping of rural producers labelled ejidatarios have collective property rights over some parts of the ejido, and individual rights over the remaining parts of the ejido. However, ejidatarios are not allowed to sell, mortgage or rent their individual plots of land; see Yates (1981) for further description.

10. For example, private farmers may own a maximum of 100 hectares of irrigated land, but up to 150 if they grow cotton, and up to 300 if the land is used for coffee, sugarcane, grapes and other fruit trees. They may own more land if it is not irrigated, or if it is used for cattle-grazing.

11. Levy (1991) presents a discussion of these issues.

12. "Vagueness and contradictions in the law create a climate of uncertainty that may discourage on-farm investment by both ejidatarios and private farmers" (Heath, 1990, p. ii).

13. Ejidatarios could in principle be evicted from the ejido if they failed to exploit the land, rented it, or engaged in sharecropping. In addition, since many ejidatarios had parcels that were smaller than the legally prescribed minimum (20 hectares of rain-fed land), they faced some uncertainty about their own tenure. (In 1981 the average size of ejido parcels was 7 hectares.)

14. "Ejidos can form their own enterprises, but (the) legal framework prevents them from forming cooperative ventures with domestic and foreign companies who could provide technology and market access." (World Bank, 1989, Vol. I, p. 55).

15. Data on the distribution of ownership of land in Mexico are scarce. Subsistence farmers are generally classified as those who own up to five hectares of rain-fed land (e.g. Masera (1990), Salinas (1990)). But much of the land owned by these farmers is of very poor quality. In this paper we *define* a 'typical' subsistence farmer as one who owns two hectares of rain-fed land of the *average* quality of rain-fed land. Thus, maize yields for subsistence farmers are assumed to be the same as for other farmers in rain-fed land.

16. Medium and large scale farmers own both irrigated and rain-fed land, and are also engaged in livestock activities. In section IV we make a distinction between these two groups and the various type of land they own. Here there is no harm in treating them as an aggregate group.

17. Section IV enlarges the number of goods and considers also the complications brought in by the presence of non-tradeables. Note that vegetables should not be interpreted strictu sensu, but as a proxy for all other agricultural products.

18. We ignore the case where subsistence farmers are net buyers of labor. Most of these farmers own little land and/or land of poor quality that precludes double-cropping, use of pesticides and other labor-intensive practices. (One could in fact define subsistence farmers as those who, regardless of their land-holdings, are net sellers of labor. Here, however, we follow standard practice and define them in terms of the amounts of land they own.)

19. When pm falls the wage rate measured in terms of maize increases, but if dwr/dpm > 0 the wage rate in terms of manufactures decreases.

20. This suggests spliting medium and large-scale farmers into those that own rain-fed land and those that own irrigated land, since both labor intensities and crop substitution possibilities are lower in rain-fed lands. This division is further pursued in section IV, where we show that it is of substantial import for our results.

21. The effects of migration on the urban labor market is left to section IV.

22. In principle the inequality could go either way. But as we show in section VI, the relevant case for Mexico is the one discussed in the text.

23. Goods are classified according to the location of the primary factors required for production. But because tortillas do not require primary factors, it is unnecessary to specify their production location.

24. All price vectors are defined as row vectors, and all quantity vectors as column vectors. All vectors are in **bold**.

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

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

27. Let a^* be the exogenously given fixed quantity of feed per unit of livestock, given by:

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

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

$$pa^* = [\tau^{\mu}.ip_m^{r\,1-\mu} + (1-\tau)^{\mu}.ip_g^{r\,1-\mu}]^{1/(1-\mu)}$$

Substituting pa^* in (12) gives matrix **A**(**p**).

28. Crop diversification also results from risk considerations. We do not model risk at all in this paper, although for numerical purposes relation (5) will provide a similar result.

29. Differently put, there are two transformation surfaces, one for irrigated land and one for rain-fed land, with the former flatter than the latter.

30. Urban inhabitants consume maize mostly in the form of tortillas. In the rural

areas the government purchases maize from producers at the price $\mathbf{pp}_m$, 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.

31.   The assumption here is that a subsistence farmer sells his land to another subsistence farmer, but not to any other group. This implies that the total land owned by subsistence farmers is constant. This simplifies the model since both the payments made for the land and the proceeds of the land sale are all transactions that take place within the group of subsistence farmers, and thus do not need to be followed explicitly.

32.   Note that by setting both η_j's to zero we completely segment the rural and urban labor markets.

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

34.   To reflect Mexico's demographic transition, the rate of growth of labor, 3 per cent, is set higher than the rate of growth of population, 2 per cent. 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.

35.   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.

36.   Some low-quality rain-fed lands currently devoted to agriculture could be switched to livestock under the relative prices implied by liberalization. We have no data on quality differences between rain-fed lands to be able to assess this, and hence simply keep the amount of land in livestock constant. The livestock sector, however, is assumed to experience Hicks-neutral technical change at the same rate as rain-fed agriculture.

37.   A third scenario would have all the additional irrigated land going to subsistence farmers, and none to rain-fed farmers. These three alternatives would then bracket the benefits that either group could obtain from irrigation investments. Henceforth, however, we ignore this third alternative. Subsistence farmers are at subsistence level most likely because the land they own is of very poor quality.

38.   Mexican regulations give the government control over water resources and

restrict private sector involvement in water extraction and distribution. In June of 1991 a new law was introduced to allow the government to recover the capital cost of irrigation investments. In principle this would allow some sharing of investment costs. However, there may be problems with implementation, and so we restrict our attention to the case where the government pays all the costs. Note that there are still issues associated with the fact that water is not priced at marginal cost (see Sanchez Ugarte (1991) for an evaluation of water's regulatory regime in Mexico).

39.   This assumption is made for convenience only. We could assume also that the other groups with similar utility functions, irrigated and rain-fed farmers, have similar savings behavior. But to do this would also require assigning a share of the quasi-rents on the capital stock to these groups, something we prefer to avoid given the lack of data. Moreover, since we are not optimizing savings behavior in the model, it does not matter much what share of total private savings is carried out by each group.

40.   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:

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

41.   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.

42.   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.

43.   We do, however, assume that protection to all other agricultural sectors, and basic grains in particular, is removed during a five year horizon in the reference path, beginning in period two. This procedure allows us to focus exclusively on the question of whether to include maize in the FTA or not, and if so, what kind of supporting policies are advisable. We emphasize that 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 and fruits & vegetables in the FTA. As a result, they underestimate the total gains from agricultural liberalization.

44.   We do not model any process by which these farmers can migrate to urban areas and/or engage in other activities. Clearly, a response of this nature is to be expected, with the number of rain-fed farmers declining in an attempt to mitigate the fall in per-capita utility.

45. The urban labor force, on the other hand, increases from 15.9 to 20.7 million.

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

47. We make no distinction between skilled and unskilled labor. Allowing for different labor skills would lower the wage differential to that between rural workers and unskilled urban workers, reducing the efficiency gains derived from migration.

48. Recall from equation (25) that we have assumed that migration responds to *current* period utility differentials.

49. In our model *all* subsistence farmers are net sellers of maize in the reference case. Hence, liberalization hurts them through both the 'direct price effect' and the 'indirect wage rate effect' (cf. section III.1). While we have assumed that subsistence farmers only own two hectares of rain-fed land, we have ignored differences in the qualities of rain-fed land (so that all subsistence farmers obtain the same yields as rain-fed farmers). As a result, we probably over-estimate the impact of liberalization on subsistence farmers and, therefore, the share of total migration accounted for by these farmers. In reality many subsistence farmers have much lower yields and are net maize buyers. For this sub-set of subsistence farmers the impact of liberalization is similar to the case of landless workers.

50. As discussed in section V.1, the Comision Nacional del Agua (CNA) has a large portfolio of projects to either rehabilitate irrigation districts and/or develop new ones and/or drain and improve rain-fed areas. Executing only projects with an internal rate of return of 8 per cent or more would rehabilitate a total of 1.4 million hectares, incorporate to irrigation 544,000 new hectares and drain 2.7 million hectares (cf. table 8). (These numbers can be put in perspective noting that 4.9 million irrigated hectares and 13.3 million rain-fed hectares were cultivated in 1989.)

51. 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. Our framework does not allow a detailed modelling of these different forms of increasing land productivity. We model land improvements as an increase in the total endowment of irrigated land, and a corresponding decrease in the total endowment of rain-fed land. (cf. equation (28). We do not model any changes in the productivity of a given type of land (beyond Hicks-neutral technical change). Thus, one could argue that our results understate the potential gains from investments in land improvements.

52. The irrigation program, also referred to below as 'the CNA 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. A faster program would be difficult to implement both for technical and administrative reasons. A program of this size approximately restores the value of the land-holdings of subsistence and rain-fed farmers to pre-liberalization levels. But no claim is made that this specific irrigation program follows from an optimal allocation of public expenditures across all sectors.

53. We refer to these two alternative distributions of the CNA program as CNA(A) and CNA(B), respectively.

54. Because we ignore risk considerations these results may over estimate migration by subsistence farmers. If these farmers are risk-averse, and if they perceive that participation in the labor market is risky, they may still prefer to remain in rural areas and carry out some on-farm work. This is one way to diversify their portfolio of earnings, and may be the best available if there are no alternative insurance arrangements.

55. As discussed in section II.2, these barriers are modelled as an initial 20 per cent tariff. But given that the sector labelled here 'fruits and vegetables' includes other crops (see table 2), the tariff is scaled back to 5 per cent. Hence we assume that prices faced by Mexican fruit and vegetable exporters increase by about 1 per cent during each of the five years of adjustment, and then stay constant at the higher level. Note that we ignore changes in protection to sugar, a sector where US trade barriers are significant. Thus, our results underestimate the gains to Mexico from the FTA.

56. Investment costs reflect the time-profile of the CNA program and the increased marginal costs of irrigating lower quality lands (cf. equation (29)). Thus, even though the program slows down as of the fourth year, costs do not fall pari passu. The last 150,000 hectares are, on average, 49 per cent more expensive than the first 250,000.

57. The fiscal costs of interventions do not fall to zero because the cost of the tortivale program still has to be covered (though the tortivale program is cheaper because of the lower producer price of maize; see eq. (17)).

58. Tables 8 and 9 in section V.1 provide state-by-state data to carry this out. We have disaggregated further the analysis with data at the level of Rural Development District, RDD, (not included here for reasons of space). The key finding is that maize accounts for more than 40 per cent of the value of agricultural output in only 37 out of 193 RDDs in which the country is divided. These districts have 39 per cent of the total rain-fed hectares devoted to maize, and are mostly concentrated in the states of Chiapas, Guerrero,

Jalisco, Michoacan, Oaxaca and Puebla. Further, in 15 out of these 37 RDDs, there are profitable land improvement projects. Differently put, there are 22 RDDs where maize liberalization will have a strong effect that cannot be *directly* offset by the adjustment program discussed here. These RDDs constitute the core of the regional problem that must look for alternative forms of adjustment.

59. This provides a strong rational to carry out the most efficient land improvements projects, regardless of their location. Consider, for instance, the state of Sinaloa in the North-West of Mexico. Table 8 reveals that the state has the largest potential for new irrigation. Further analysis of cost data also shows that many of the projects in this state are among the cheapest. Table 9, on the other hand, shows that the value of maize grown in rain-fed areas in that state is almost insignificant. If irrigation investments are seen only from the point of view of compensating land-owners for the capital loss induced by liberalization, there would be no case for further investments in this state. But if investments are also seen from the point of view of compensating rural workers by stimulating the demand for rural labor, there would be a strong case for these investments.

60. The details of such a program are beyond the scope of this paper. But the possibilities of promoting livestock-related or forestry-related industries could be explored.

61. The dip in utility in period 7 is explained by the fact that the CNA program comes to an end (thus laying off rural workers), while the last hectares under improvement have not yet come on stream.

62. Note, moreover, that there is a fiscal gain despite the fact that the size of the tortivale program has increased by 35 per cent by the end of the ninth year, in tandem with the increase in the urban labor force. Interestingly, despite the increased size of the program, the fiscal cost of the tortivales actually declines by 15 per cent. The reason is clear: with liberalization the maize required to make tortillas is purchased by the government from domestic producers at the world price.

63. Anderson and Hayami, 1986, p. 117, note that: "A number of implications for less developed countries can be drawn from East Asia's experience. The first and most obvious one is that newly industrializing economies should be aware of the huge cost of embarking on protectionism, as compared with more efficient strategies for solving the problems of rural-urban income disparity and perceived food insecurity. Second, they should be aware that, if their agricultural comparative advantage continues to decline, protection can only achieve its objectives if it is increased continually overtime. Third, and perhaps most importantly, they need to be aware of the extreme political difficulty associated with trying to reverse a protectionist policy once it has

been introduced.   This is because the value of protection becomes incorporated into the capital value of sector-specific assets such as land, farm buildings and the specific skills of farm workers."