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Comparative Advantage and Policy Incentives for Wheat Production in Rainfed and irrigated Areas of Mexico

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PREFACE

This is the third study in a series that staff of the CIMMYT Economics Program, in conjunction with national research organizations in selected developing countries, are preparing on the comparative advantage and policy incentives for the production of alternative crops in particular regions. The studies will provide the experience necessary for the preparation of a manual that can be used by colleagues to guide similar work by national programs.

This paper addresses an issue that is important to a number of developing countries - the economics of wheat in irrigated and rainfed or dryland areas. It presents an approach that weighs up, from both the farmer perspective and the national perspective, the profitability of alternative crops in an irrigated region and in a dryland region. This enables more precise judgements to be made about the allocation of research effort between the regions.

If extended to a wider coverage of regions, the information provided is likely to be a very useful tool for research managers. By simple sensitivity analysis of yields, researchers can be provided with a more precise estimate of productivity gains needed to make crops competitive in specific regions.

As well as providing an economic tool for advising research managers, the approach presented in this paper provides considerable information on how farmer incentives are affected by government policies. A better sense of this will help agricultural researchers to understand why adoption rates and increases in production of particular crops are sometimes disappointing.

An initial draft of this paper was prepared in 1983. It was subsequently updated and revised to take account of prices prevailing for the 1984-85 crop cycles. Spreadsheets employed in the analysis, on VISICALC for Apple micro-computers, are retained at CIMMYT's headquarters and can be made available upon request.

This paper could not have been prepared without the active cooperation of many people in Mexico, especially INIA, CIAMEC and CIANO, the private and farming sectors, and CIMMYT's staff based in Mexico.

As with all working papers, we welcome comments, criticisms or counsel so that the paper might be improved.

Robert Tripp
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COMPARATIVE ADVANTAGE AND POLICY INCENTIVES FOR WHEAT PRODUCTION IN RAINFED AND IRRIGATED AREAS OF MEXICO

Executive Summary

Wheat has become an increasingly important food crop in Mexico as consumers with rising incomes, particularly urban consumers, have switched from maize to wheat products. Although wheat production in Mexico has expanded rapidly in the past 25 years, imports of food grains, including wheat, have increased since the early 1970s.

Increasing demand for wheat products and Mexico's trade and financial situation will place additional pressure on expanding domestic wheat production. Expansion in irrigated areas will be limited to yield increases unless wheat substitutes for competing crops. This raises the question of whether research and policy should give more attention to rainfed wheat production.

This study analyzes the comparative advantage of wheat in two contrasting regions of Mexico:

- the Yaqui Valley of the State of Sonora which is the most important wheat growing area of Mexico. An average of over 100,000 ha of irrigated wheat are sown annually with yields now averaging over 5 t/ha.

- the rainfed highland area of the states of Tlaxcala and Hidalgo. Although wheat was traditionally grown in the area, it has been largely replaced by barley. Here, while costs of transportation to major markets are much lower than in Sonora, prices to farmers for their grain are the same. Wheat yields are around 2 t/ha.

This resource cost study on two of Mexico's wheat-producing areas shows the substantial influence of the government in setting output and input prices in the Mexican wheat industry. In general, producers have

been receiving prices below world prices for wheat. This is particularly the case in Tlaxcala which is adjacent to major consuming centers and, hence, has markedly lower transportation costs than alternative sources of supply. Policy has also intervened to change price relationships with other crops. In most cases, farmers have received prices higher than world prices for competing crops, especially maize and oilseeds. At the same time, cotton production was influenced as overvalued exchange rates had the effect of reducing domestic cotton prices in most years of the 1970s and some more recent years.

To some extent, government policy has compensated producers through subsidies on inputs. Subsidies on fertilizer, diesel fuel, credit, seed (in rainfed areas) and water (in irrigated areas) all exceeded 50 percent in the period 1979-82. Since then, credit and water remain the major sources of assistance, as the direct government subsidies have been reduced in relative terms. High level of subsidies, however, have encouraged both intensive use of inputs and high costs in terms of national resources.

In Sonora, cotton provides higher national economic returns in those years when irrigation water supplies are plentiful and when land is the limiting factor. However, when water is limiting, the case for wheat is made more favorable. This is especially so when allowance is made for the substantial variation in yields and international prices of cotton.

Production of the remaining crops, oilseeds and maize, seems to have no comparative advantage in Sonora. However, in the case of soya beans, often grown in rotation with wheat and cotton (cotton-wheat-soya over 2 years), there is a comparative advantage when the fixed costs of production are not attributed to soya beans as a third crop in the rotation.

Finally, for wheat in Sonora, the major research opportunity posed by this study is to find ways to reduce production costs. With government policy now committed to reducing subsidies there is a need to look for ways to use more effectively water, fuel, credit, and fertilizers.

In Tlaxcala, wheat production also has a comparative advantage relative to other crops, especially maize. This potential for wheat has not yet been realized, partly because price policies have generally not encouraged wheat production and partly because more profitable wheat varieties have still to be developed and/or extended to local farmers. Even with more appropriate varieties, wheat would still be a slightly more risky crop (because of its longer growing cycle) relative to barley.

The analysis of the comparative advantage of wheat production in two regions in Mexico suggests that rainfed wheat in the central highlands may be equally as competitive as irrigated wheat in the north west. This is despite the fact that very little research and extension has been devoted to wheat grown under rainfed conditions in Mexico. The case for allocating research and extension resources to rainfed wheat in Mexico is strengthened by this study.

COMPARATIVE ADVANTAGE AND POLICY INCENTIVES FOR WHEAT PRODUCTION IN RAINFED AND IRRIGATED AREAS OF MEXICO

1.0 Introduction

Agricultural research institutions, both international and national, are under increasing pressure to justify allocation of research resources between crops and between regions. For example, in the case of wheat many national research programs, especially in the tropical countries, are faced with the decision on whether to invest in wheat research and production programs in order to introduce wheat as a new crop (or to expand wheat production from a small base).

An agricultural research program can use many criteria for making decisions on allocation of research resources (see Scobie, 1984). These will often include the objectives of food self-sufficiency to avoid dependence on a fluctuating world market, and more equitable income distribution. But a major criterion in allocating research resources will and should be, the expected economic returns to the investment in research. Some simple rules have been proposed to judge research resource allocation in terms of the economic importance of the crop. The most common is to measure research resources allocated to each crop as a percentage of the gross value of the crop. (See, for example, Daniels and Nestel, 1981). Such a measure is deficient in at least two respects. First, it will seriously underestimate resources allocated to potential crops since their gross value of output is low at the time of the decision. This might then lead to an under-investment in crops that could be important in the future[1/] and an over-investment in crops that are stagnant or declining. Second, gross value of production, current or potential, might be a poor guide to the contribution of that crop to national income. This is in part because high value crops typically also have higher costs of production. More importantly, prices paid and received by farmers are often a poor guide to the value of the

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1/ Examples of recent large scale expansion of new crops are soyabeans in Brazil, sorghum in Mexico and wheat in Bangladesh.

resources when employed in alternative uses. In particular, profitability to farmers of cereal production often reflects the effects of policy interventions such as low producer prices to protect consumers or subsidies on specific inputs as an incentive to producers.

Many research systems now also face conflicting signals emanating from government policies which, on the one hand, seek to achieve food self-sufficiency and, on the other hand, promote export crops in an effort to overcome a burdensome foreign exchange deficit. What is needed to provide a better guide for agricultural research decisions is a means of measuring the costs of these goals in terms of profitability to the nation.

Closely related to the issue of research resource allocation is the extent to which policy incentives on the whole favor or discriminate against a particular crop. Research decision makers and scientists often feel that technologies emerging from the research systems are not adopted because policies, especially price policies, act as a disincentive. In most cases however, these policy effects are measured by very superficial means such as deflation of producer prices by the consumer price index to estimate changes in real producer prices.

The purpose of this paper is to illustrate the methodology of comparative advantage and policy incentives as a means of linking the research decision making to the policy environment in which researchers and farmers make decisions. This methodology emphasizes means for valuing resources and outputs in terms that are meaningful for measuring the present or potential contribution of a crop to national income. The methodology is applied to a particular issue in Mexico: the relative emphasis that should be given to irrigated versus rainfed wheat production in planning future research on wheat.

The methodology presented here is not new. It has been recently applied in a number of agricultural situations (e.g. Pearson et al, 1981). It has not, however, been utilized in research decision making. Nor have results been analyzed and presented in a way that they can be readily understood by the non-economist.

This paper is organized as follows. First, we present the methodology using a simplified example to show the basic steps. (A more formal treatment is given in Appendix A). We then discuss the broad issues of food policy in Mexico as it relates to agricultural research decisions and specifically those related to wheat. This leads to a detailed analysis of policy incentives for wheat production in Mexico that measures the effect of government interventions in product and input markets. Finally we estimate the profitability of wheat in an irrigated area (the State of Sonora) and a rainfed area (the States of Tlaxcala and Hidalgo) in relation to other crops. Two sets of calculations are made - first, using actual farm prices and, second, adjusting prices for the effects of government taxes and subsidies. The presentation is purposefully detailed to enable the reader (including the non-economist) to follow the methodology and to appreciate the decisions that were taken at each step in the analysis.

2.0 Methodology for Measuring Comparative Advantage and Policy Incentives

2.1 The Resource Cost Ratio

Comparative advantage is an expression of the efficiency of using resources to produce a particular product when measured against the possibilities of international trade. In a very simple example, assume that one hectare of land and a given amount of other inputs can be used to grow cotton or wheat. If the yield of cotton is 1 ton/ha, then at recent international prices this cotton, when exported, will purchase about 10 tons of wheat. Thus, the country gains relatively more by producing and exporting cotton and importing wheat, since wheat is unlikely to yield 10 tons/ha. Of course, this simple example ignores a number of issues such as the fact that cotton may require more imported inputs for its production.

A more useful measure of resource use efficiency is provided by the resource cost ratio (RCR). Assume that country A, where wheat is grown only on a small scale, is importing substantial quantities of wheat. Consequently it is considering a major investment in a wheat research and production campaign to substitute for imports. For simplicity assume the following:

a) The government has set the price of wheat at $300/ton.
b) The major purchased input for wheat production will be fertilizer which costs the farmer $50/ha.
c) The farmers' land, labor and capital used in wheat production are costed at $150/ha at market prices.

Clearly if the current yield is 1.3 tons/ha it is quite profitable for farmers to grow wheat. Profits = (1.3x300)-150-50 = $190 or a 95% return on an outlay of $200(=150+50).

However from the national viewpoint the resources used in growing wheat may not be profitably employed. Assume that wheat can be imported to the capital city, the major consumer of wheat, for $200/ton, that it costs $20 to transport domestic wheat to the capital and that fertilizer is subsidized by the government by 33 percent. In this case the national value of the wheat produced is $180/ha (the cost of imports less local transport costs) and the value of the fertilizer employed is $75/ha when the subsidy is subtracted. Assuming as before the market value of the farmers' land and labour resources of $150/ha, wheat production is marginally profitable (1.3 x 180-150-75 = 9 or a return on investment of less than 5 percent). This calculation which considers the true costs and returns to the country we call the national profitability, as distinct from farmer profitability.

The final step in this calculation of national profitability is to take into account the opportunity cost of the farmers' resources of land, labor, capital and irrigation water in other uses. In some cases the market value of these resources may adequately reflect these costs. In most cases, policy measures distort market values as a good measure of their value in alternative uses. Assume that the alternative use of the farmers' resources is in the production of cotton for the export market. To the farmer. the value of his resources in cotton is $150, i.e. the value at market prices. However, because of export taxes imposed on cotton the country actually earns a net value of $200/ha in foreign exchange from growing cotton (i.e. the foreign exchange value of the cotton less the cost of inputs used in producing cotton). Hence, national profitability of wheat production is negative (1.3 x 180-200-75 = $-41/ton) and in fact there is a net loss of foreign exchange from wheat production. This contrasts with the government's objectives to save foreign exchange through local wheat production.

The resource cost ratio is a measure of the total cost of production when prices are adjusted for taxes and subsidies and resources are valued in alternative uses. It is calculated by dividing inputs and outputs used in production into "tradeables" and "non-tradeables" as follows:

a) Tradeables are commodities which are imported or exported, such as wheat and fertilizer in the above example.

b) Non-tradeables are resouces such as land or labor that do not usually enter international trade.

c) All tradeable commodities are valued at their world price equivalent. This is the price at which the commodity can be imported (or exported), adjusted for transport costs and exchange rate anomalies. In order to compare import prices it is necessary to establish a common location, usually the place of consumption of the commodity.

d) Inputs which are partly tradeable and partly domestic (e.g. transport with tradeable fuel and spare parts, but non-tradeable labor) are divided into their tradeable and domestic components.

e) Non-tradeables are valued at their returns in alternative opportunities (again valued at world prices).

The Resource Cost Ratio (RCR) is then calculated as:

$$\text{RCR} = \frac{\text{Returns to non-tradeable domestic resources in the next best alternative use (valued at world price equivalent)}}{\text{Value added to tradeables (valued at world price equivalent) = Value of tradeable outputs - value of tradeable inputs}}$$

In the above example,

$$\text{RCR} = \frac{200}{(1.3\text{x}180)-75} = 1.26$$

A ratio above one implies that the value of the domestic resources employed is greater than the value of the foreign exchange saved or earned. In the example, it costs $1.3 in domestic resources to save one unit of foreign exchange. Thus, in this case the crop is unprofitable to the nation, and no comparative advantage exists in devoting resources to it.

This example shows a situation where policy measures make wheat production of a crop profitable to farmers, although it is not an efficient use of resources from the national perspective since it decreases national income. There are, of course, many situations where the opposite situation prevails where it would be efficient to produce a crop, but policy measures such as low producer prices or tariffs on inputs make it unprofitable for farmers to produce that crop.

2.1.1 Influence of Production Technique on the Resource Cost Ratio

It is a common mistake to assume that there is a unique comparative advantage over the whole country. In fact, in most cases a country has several different actual or potential production regions for a crop with different technologies, yield potentials, and competing crops. Hence, the resource cost ratio is likely to vary from region to region. This in itself, is important information because it establishes the efficiency of resource use between regions. If wheat can be produced in both irrigated or rainfed areas there are clearly two quite different strategies available for expanding domestic wheat production. Likewise in a given region different techniques may be available such as large mechanized farms and small farms depending on animal and manual power. Each technique will have a different resource cost ratio.

The range of techniques included in the calculation of RCRs can also include potential techniques. This can be used as a guide to investment in research. If in the above example researchers believe yields can be increased to 1.6 tons/ha through additional expenditures of $10/ha of local resources in developing an earlier variety and better land preparation techniques, then

$$RCR = \frac{210}{(1.6 \times 130)-75} = .99,$$

and wheat is now marginally efficient. If in the future there is the possibility of a heat tolerant variety that will yield 2 t/ha then wheat is a potentially efficient crop that justifies further investment in research on that crop.

2.1.2 Influence of Transportation Costs on Comparative Advantage

The choice of consumption point and the cost of transportation are also important when analysing comparative advantage. Returning to the above example, assume that wheat production is possible in an inland area which is 1,000 km from the capital city and main port - a not uncommon situation in many developing countries. If the cost of transportation from the producing regions to the capital is $50/ton then we can calculate the resource cost ratio under two assumptions; a) the wheat is consumed in the producing region and hence competes with imported wheat that must be transported from the port (i.e. capital city) and b) the wheat is consumed in the capital city and hence the value of domestic wheat must be adjusted for transportation costs. Table 2.1 shows the resource cost ratios for each consumption point assuming two different transport costs. Clearly at the low transport cost, wheat production is only marginally efficient if it is consumed at the producing point. However, for the high transport cost wheat production becomes efficient at the producing point but highly inefficient when calculated for the capital city. In general resource cost ratios are quite sensitive to the cost of both international and domestic transport and the choice of consumption point.

It is also worthwhile noting three additional assumptions that are implicit in the above calculations. First, if wheat is to be consumed at the producing point some provision will usually have to be made for local milling. Most milling facilities in wheat importing countries are established at the port. Clearly, consumption of locally produced wheat looses its advantage if wheat must be transported to the port for milling and the flour transported back again. Second, transport costs themselves are subject to considerable policy intervention. In particular, governments often subsidize public transportation such as railways or provide subsidies on transport inputs such as fuel. These distortions of transport costs should be removed when calculating resource cost ratios. Finally, input costs are also sensitive to transport costs. If fertilizer is imported and shipped inland then its price in the producing region should be adjusted for the higher transport cost.

Table 2.1. Resource Cost Ratios Calculated under Varying Assumptions about Transport Costs and the Consumption Point.

	Transport Cost from Producing Region to Capital City-Port	
	$20/ton	$50/ton
	Value of RCR	
Wheat consumed in the producing region [a/]	.95	.80
Wheat consumed in the capital city-port	1.26	1.67

a/ In this case, transport costs are added to the CIF Price. That is for transport costs of $20/ton, RCR = 200/[(1.3 x(200+20))-75]

2.1.3 Uses of Domestic Resource Cost Analysis in Allocating Research Resources.

The resource cost ratio is a measure of comparative advantage and can be used for a number of purposes.

a) To help decide on investment in a production program. Given current technological coefficients and world prices the domestic production of wheat in the above example is an inefficient use of resources although the government might still procede on the basis of other criteria such as food security.

b) To help decide on investment in research. Other things being equal researchers will want to allocate research resources to crops, techniques and regions which seem to be efficient users of resources when measured from the national point of view. Several types of decision situations are possible.

  i) Allocation of research resources to a specific crop in a given region. The resource cost ratios of potential techniques, as in the above example, will be a basis for such a decision.

ii) Allocation of research resources to a specific crop across regions. If the resource cost ratio of rainfed wheat regions is less than that for irrigated wheat regions, research on improved technology for rainfed wheat will encourage expansion in regions where wheat has its comparative advantage.

iii) Allocation of research resources across crops in a specific region. Again a ranking of crops by their resource cost ratio provides a measure of their underlying competitiveness.

It should always be kept in mind that measures of comparative advantage are a measure of the efficiency of resource use. Governments have other objectives in resource allocation besides efficiency, especially income distribution objectives. Nonetheless, the efficiency of resource use is important and any measure which enables decision makers to quantify the cost of pursuing other objectives will provide considerably more information than is currently available.

2.2 Measuring Policy Incentives

Closely related to measures of comparative advantage are measures of policy incentives. The divergence between national profitability and private profitability is a measure of policy effects induced by a) taxes and subsidies, b) import and exchange rate policies, c) price policies, and d) market impefections such as monopolies.

A simple measure of policy incentives is provided by the ratio of domestic prices to world prices (adjusted for transportation charges). This is the "nominal protection coefficient" defined for producers as

$$NPC = \frac{\text{domestic producer price}}{\text{world price equivalent x official exchange rate}}$$

In the earlier example, $NPC = \frac{300}{200 - 20} = 1.7$

where transportation charges from the producer to the city are $20[1/]. This rate of protection indicates that policy measures such as tariffs or other import restrictions strongly protect local wheat producers.

Since official exchange rates are often a poor guide to the real value of foreign exchange (i.e. the exchange rate is overvalued), it is often useful to also calculate the nominal protection coefficient with a "corrected" exchange rate to convert world prices to local prices. The difficulty with this approach is of course the problem of choosing a realistic exchange rate.

A better measure of policy incentives also takes into account effects of policies on input prices such as a subsidy on fertilizer which increases the incentives for local production. This measure is defined as the "effective protection coefficient", EPC, which is expressed as

$$EPC = \frac{\text{Value of output at domestic prices} - \text{Value of traded inputs per unit of output at domestic prices}}{\text{Value of output at world prices converted at the official exchange rate} - \text{Value of traded inputs per unit of output at world prices converted at the official exchange rate}}$$

In the example,

$$EPC = \frac{300 - (50/1.3)}{180 - (75/1.3)} = 2.1$$

The EPC is higher than the NPC in this case, since there is a subsidy on fertilizer. In general the EPC is a summary of the incentives or disincentives created by government price policy interventions in input and output markets. An EPC less than one indicates that policy is a potential disincentive to production. However, the incentive provided by pricing policy on a particular crop must be measured against incentives provided to other crops. For example, if the EPC for wheat is 1.3 this might not be a particularly strong incentive to produce wheat

[1/] NPCs can be measured at either the producing point or the consuming point. In this paper we use the producing point so that the denominator is the farm gate equivalent of the world price. That is, in a free trade situation, the farmer would receive the world price less the cost of transportation. At the consuming point, the NPC is equal to (300+20)/200 = 1.6.

if the EPC for a competing crop is 1.6.

These measures of policy incentives may be useful in understanding trends in wheat production in a given country. For example, stagnant production might be related to a deteriorating measure of policy incentives provided to producers. Or measures of policy incentives might be compared across regions to assess to what extent changes in policy have favored particular regions.

2.3 The Overall Measure of Subsidies

The effective protection coefficient only takes account of distortions in prices of outputs and inputs that are traded on the international market. Governments commonly also influence prices for resources used in agricultural production by providing subsidies, especially for credit and water. In a situation where the EPC is less than one it is useful to know if the effects of these subsidies on resources is sufficient to compensate farmers for the tax implicit in the low producer price.

The effective subsidy coefficient is a measure of the overall effect of government intervention in product, input and resource markets. In the example above, let us assume that farmers receive $150/ton for wheat. The effective protection coefficient is then:

$$EPC = \frac{150-(50/1.3)}{180-(75/1.3)} = 0.88$$

That is farmers receive a price below the world price for wheat (NPC = 150/180 = .83) and the subsidy on fertilizer is not sufficient to compensate farmers for the low producer price. Take the case where farmers receive subsidized credit (i.e. low interest rate loans) through a government program and that subsidy (i.e. government costs less income from the program) amounts to $10/ton of wheat produced. The effective subsidy coefficient is then calculated as:

$$ESC = \frac{(150-180) + ((75-50)/1.3) + 10}{180} = \frac{-30 + 19 + 10}{180} = 0$$

The first term of the numerator is the difference between farmer and world prices (at the farm gate), the second term the difference between input costs to the farmer and equivalent world prices for inputs and the third term the credit subsidy. The denominator is the world price for wheat (at the farmgate). In this case the combined effect of a government subsidy on fertilizer and credit compensates for the low price received for wheat.

The effective subsidy coefficient, the overall measure of policy incentives, and the resource cost ratio, the measure of comparative advantage, are closely related. It can be shown algebraically that if ESC is greater than zero (i.e. positive policy incentives for a crop) and RCR is less than one (i.e. the crop has a comparative advantage), then the crop is also profitable to farmers (and vice versa).

Table 2.2 shows four possible outcomes of the resource cost ratio and the effective subsidy coefficient and their interpretation. The most common situations are represented by cases where both are less than unity or where both are greater than unity. In the first case, governments are using the comparative advantage of the industry to keep prices low. This sometimes happens in the case of basic food crops. In the second case, the industry is able to survive only because of the incentives provided by government pricing policy.

2.4 Data Sources and Analysis

It is clear that data will be needed from a wide range of sources in order to calculate measures of comparative advantage and policy incentives. One of the most important needs is reliable information at the farm level on technical coefficients such as input levels and yields as well as prices paid and received by farmers. In our case we used data from farm level surveys which had been conducted over a number of years in the two selected wheat growing areas. This was supplemented by a mini-survey of machinery owners to provide a more detailed breakdown of machinery costs such as depreciation, fuel and operator labor.

Table 2.2 Interpretation of Possible Results of the Resource Cost Ratio and the Effective Protection Coefficient

Effective Protection Coefficient	Resource Cost Ratio	
	Less than one	Greater than one
Less than 1	Industry is efficient and is not protected. Government policy exploits industry comparative advantage by keeping prices low.	Industry is not efficient and is not protected. Likely to be a stagnant or declining industry.
Greater than 1	Industry is efficient and at the same time protected. Will usually have strong incentives to produce.	Industry is not efficient but favorable price policy allows domestic production.

Data on transportation costs were obtained through phone interviews with the major trucking companies and through published annual reports of the railways. The border prices of outputs and inputs were mostly estimated from published sources. Two very useful publications in this regard are the Monthly Bulletin of Agricultural Statistics published by the FAO and which gives FOB and CIF prices for many commodities, and Agricultural Statistics published annually by the USDA which provides data on farm prices for inputs in the USA.

Data were analyzed on an Apple II micro-computer using the VISICALC software package. This is a particularly useful package for this type of work since arrays of data can be managed and budgets constructed. Once constructed, sensitivity analysis can be performed or data from another year or region can be analyzed very rapidly since the methods of calculation for variables such as RCRs are recorded in the program.

In order to provide a longer term perspective on policy incentives we analyzed data for several years. This is particularly important in Mexico given that the recent economic situation is not representative of the past, nor, necessarily of the future.

3.0 The Role of Wheat in the Mexican Agricultural Sector and Major Policy Issues

The section provides a brief overview of some of the major trends in production, consumption and imports of major food and feed crops in Mexico, with particular emphasis on the role of wheat. The objective is to provide a background in which to view the analysis of major policy issues, especially those that relate to food self-sufficiency versus export crop promotion.

3.1 The Macro-Economic Scene

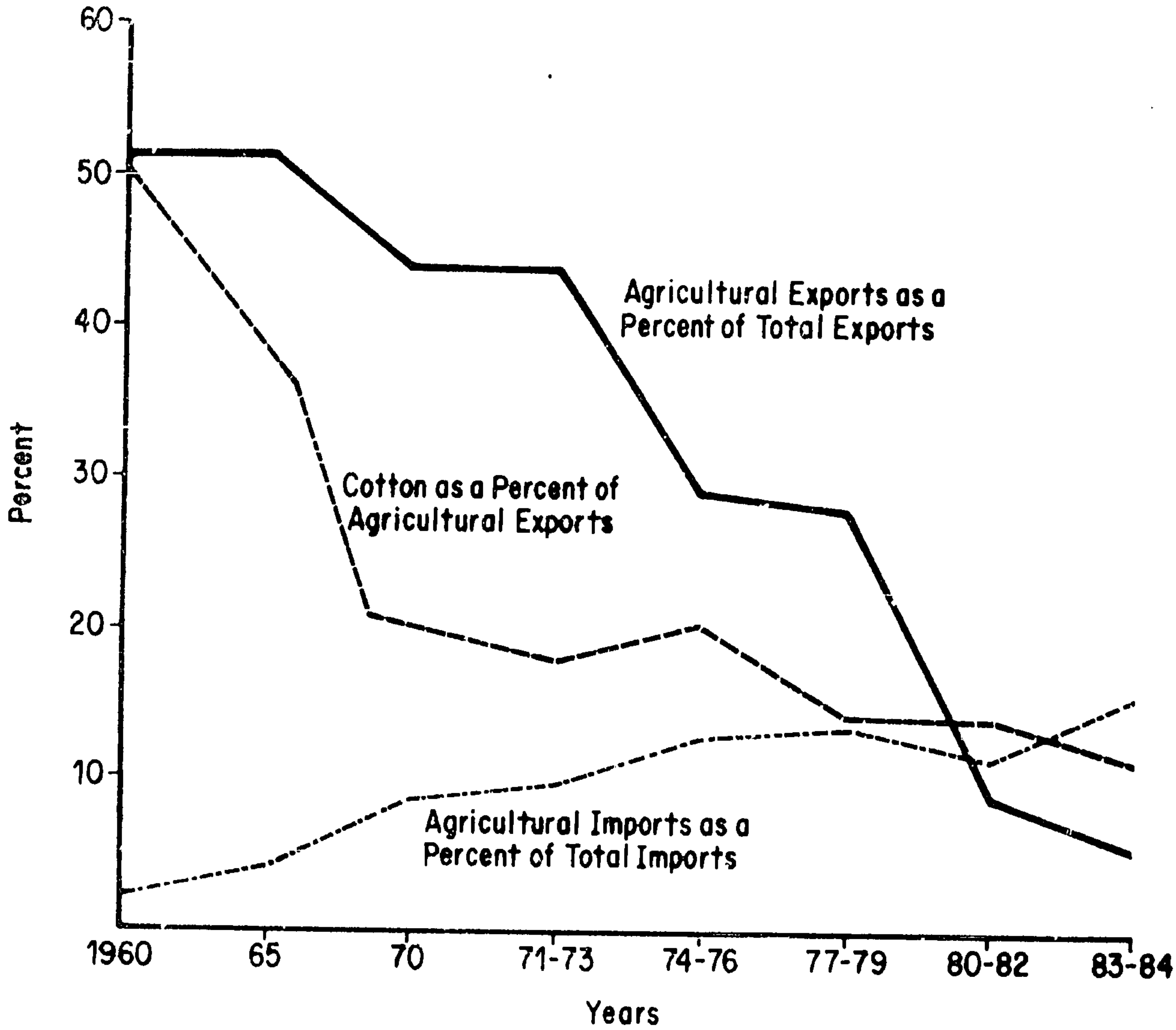
The decade of the 1970s was one of important structural adjustment in the Mexican economy. While the rate of growth of GNP was high, averaging 5.2 percent per year between 1970 and 1980, growth of the agricultural sector averaged only 2.3 percent per year, substantially below the population growth rate.

The greatest shift occurred in the role of agriculture in external trade. In 1970, agricultural exports accounted for over 50 percent of total exports earnings from goods and services. By the period 1980-82, the share of agricultural exports in trade had declined to 9 percent (see Figure 3.1), reflecting in large part, the growth of oil revenues. Cotton was until recently the single largest source of agricultural export earnings[1/]. In the early 1960s cotton accounted for 50 percent of agricultural exports. By 1980-82 the share of cotton had declined to less than 20 percent.

Overall, agricultural imports as a proportion of total imports have tended to rise (Figure 3.1) and in 1981, Mexico registered for the first time a net deficit in the balance of trade of the agricultural sector. Nonetheless agricultural imports as a proportion of total imports are lower than the average of 14 percent for all middle income developing countries.

1/ Coffee is now Mexico's most important agricultural export.

FIGURE 3.1 Role of the Agricultural Sector in Mexican External Trade.



Source: Informe Anual del Banco de Mexico, S. A.

An important aspect of macro-economic policy during the 1970s has been the management of inflation and foreign exchange rate adjustments. Domestic inflation has generally run ahead of that in Mexico's main trading partners. Exchange rates have been fixed and maintained by import controls and foreign borrowing until a sharp devaluation was forced. As a result, the exchange rate was overvalued for much of the decade. A rough measure of exchange rate overvaluation is provided by adjusting the exchange rate using 1954 (a year of devaluation) as a base, by the differential between Mexican and U.S. inflation rates. Using this measure the exchange rate was overvalued by about 20 percent at the beginning of the decade (see Figure 3.2). This increased to 45 percent in 1975, a difference that was largely eliminated by the 1976 devaluation. Continuing internal inflation led to a return to an over-valuation of 50 percent in 1981. Since then the peso has been sharply devalued and by 1982 was probably undervalued. The devaluation has been accompanied by high inflation rates approaching 100 percent per year.

In 1983 a two-tiered exchange system was in operation - an official rate for exports, essential imports and debt service repayment and a market rate for other foreign exchange transactions. This complicates the present analysis since agricultural exports and food imports were subject to the lower exchange rate, while many inputs such as agricultural chemicals and spare parts were imported at the higher rate. To facilitate analysis we used the average of the two exchange rates or about 130 Pesos/US dollar as the exchange rate for 1983.

The high inflation rate of 1982 and 1983 was also a problem in the analysis. Prices changed drastically between the beginning of the crop cycle and the end. (For example, diesel prices for the 1982/83 wheat cycle were 4 Pesos/lt for land preparation but 14 Pesos/lt for harvesting and transport.) It was also difficult to compare profitability between crops because of different cycles. At the same time, government policy toward the agricultural sector has changed in the 1980's because of the need to adjust to new economic realities. For this reason we use results over a period of years to obtain a longer term perspective on policy effects on the agricultural sector.

FIGURE 3.2 Estimated Percentage Overvaluation of the Mexican Peso Based on Differential Inflation Rates in the US and Mexico.

3.2 Recent Production Performance of Wheat in Relation to Other Crops

In Tables 3.1 and 3.2 we summarize production statistics for wheat in relation to other major crops. Crops are grouped into food grains, feed grains, oil seeds and export crops. All these crops except sorghum, rice and beans, compete with wheat in one of the areas chosen for this study. (Maize competes in both areas).

Maize is the basic food grain in Mexico. However, with rising incomes and urbanization, wheat tends to substitute for maize in the diet, and per capita maize consumption declines (increasing amounts of maize, however, are probably used for animal feed).

Wheat production increased rapidly in both the decade of the 1960s and 1970s due largely to yield increases. It should be noted, however, that the figures for the period 1970-72 to 1980-82 are heavily influenced by the excellent wheat year in 1982 when both area and yields were exceptionally high compared to previous years. Maize production has increased nearly as rapidly as wheat with the source of growth largely due to yield in the 1970s.

Over the last two decades the mix of oil seed crops has shifted markedly from cotton seed to safflower and soya beans. The latter two crops were introduced in the early 1960s and area expanded rapidly. However, yields have not increased significantly in either case.

Among feed grains the rapid expansion of sorghum is well known. However, although barley is much less important, its yield has increased consistently throughout the last two decades. In fact yields of barley - a rainfed crop -- have increased more rapidly than wheat which is largely an irrigated crop.

Finally, production of cotton, an export crop, has consistently declined due to a decline in area. This largely reflects replacement by import substituting crops, such as oil seeds and sorghum.

Table 3.1 Average Statistics for Major Agricultural Crops in Mexico 1980-83.

	Area (000 ha)	Yield (ton/ha)	Production (000 ton)	Net Imports (000 ton)	Imports as Percent of Apparent Consumption
Food Crops					
Maize	6938	1.82	12615	1706	12
Wheat	892	4.08	3642	567	13
Rice	159	3.44	547	60	10
Beans	1868	0.71	1323	257	16
Oil Seeds					
Safflower	314	1.06	334	0	0
Soya beans	336	1.79	603	966	62
Cotton seed	272	1.48	403	60 a/	13
Feed Grains					
Sorghum	1518	3.43	5204	1725	25
Barley	267	2.04	545	68	11
Export Crops					
Cotton lint	272	0.94	256	-154	-151

a/ 1982-83 not included

Table 3.2 Growth Rates of Area, Yield and Production of Major Agricultural Crops in the Two Decades of the 1960s and the 1970s.

	1961-63 to 1970-72			1970-72 to 1980-82		
	Area	Yield	Production	Area	Yield	Production
	(percent/year)			(percent/year)		
Food Crops						
Maize	1.5	2.5	4.0	-0.5	4.0	3.5
Wheat	-1.0	4.6	3.6	1.8	3.2	5.0
Rice	1.1	1.6	2.8	0.6	3.1	3.7
Beans	.8	2.4	3.2	0.4	2.0	2.4
Oil Seeds						
Safflower	20.0	2.0	21.9	4.4	-3.0	1.2
Soya	22.0	-1.1	20.6	6.9	.0	6.9
Cotton Seed	-6.2	2.8	-3.4	-4.2	1.0	-3.2
Feed Grains						
Sorghum	21.4	1.5	23.0	4.6	2.5	7.1
Barley	.1	5.2	5.2	2.9	4.2	7.1
Export Crop						
Cotton	-6.2	3.9	-2.8	-4.2	1.1	-2.9

3.3 The Demand Outlook for Wheat

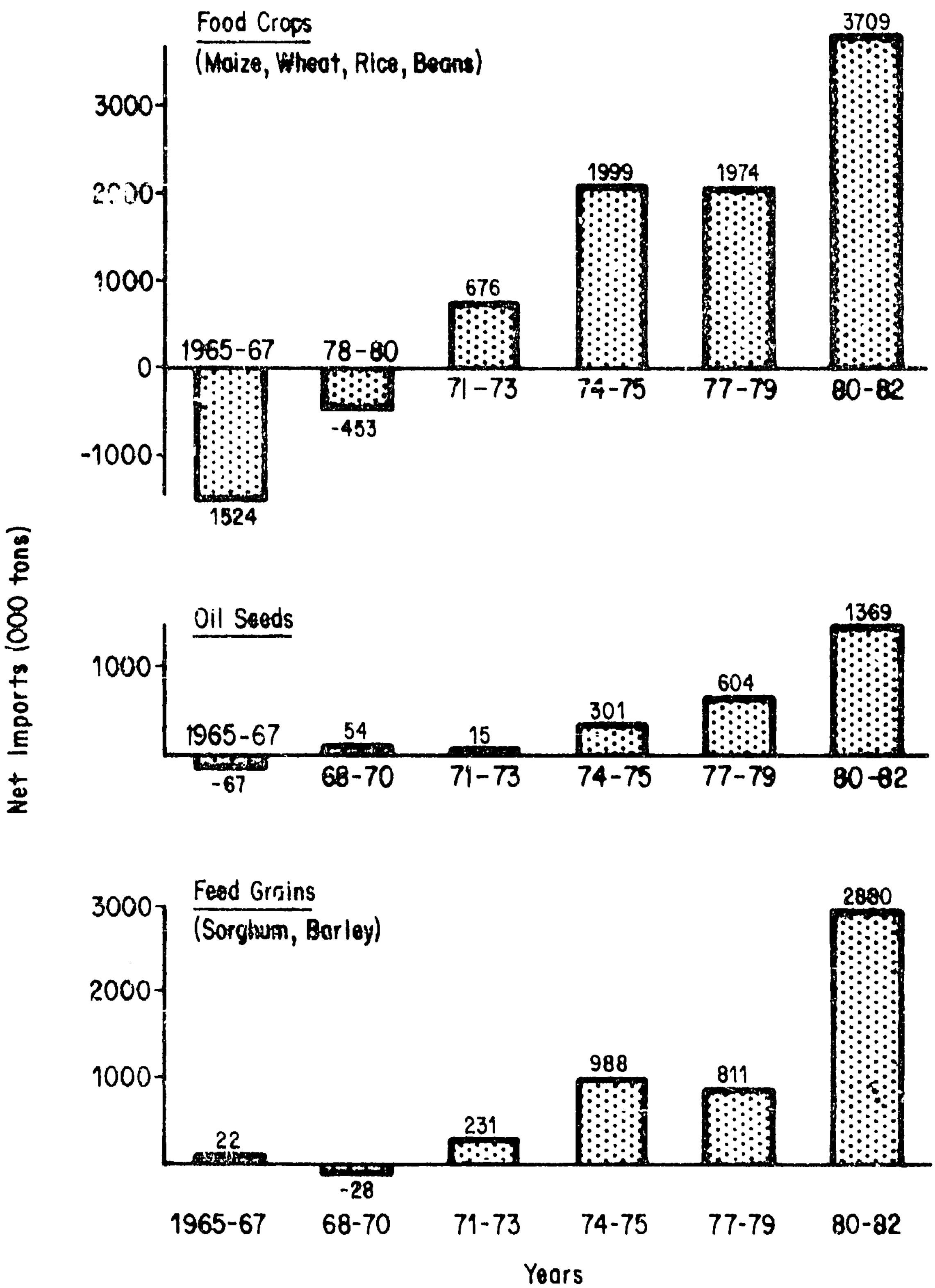
The consumption of wheat in Mexico has grown at 4.5 percent over the last decade. This reflects rapid population growth, growing incomes, urbanization and declining real prices for bread. Projections of the demand for wheat suggest a minimum growth rate of 3.5 percent annually. Population will grow at an annual rate of 2.5 percent from 1980-2000. The income elasticity of demand for wheat products is generally assumed to be around 0.4-0.5 (Lamartine-Yates, 1981) although some estimates place the elasticity somewhat higher (e.g. 0.6 by Bredahl (1983) and 0.6-1.0 by Lustig (1980)). Assuming a growth in per capita income of 2.0-2.5 percent, wheat consumption per capita is estimated to grow by 1.0 percent per year due to income gains.

At a growth rate of 3.5 percent per year, wheat consumption will reach a minimum of 5.1 million tons in 1990 and 7.2 million tons in 2000. Other projections place consumption at higher levels. For example, Lamartine-Yates (1981) forecasts consumption to grow at 5.5 percent per year reaching 6.3-6.8 million tons by 1990. Much also depends on future bread pricing policy. If consumer subsidies on bread are reduced then there will be a slowdown in growth of bread consumption.

3.4 From Food Exporter to Food Importer

Despite an impressive growth in the production of most of the major crops, there has been a sharp increase in dependence on imported food in the 1970s. Mexico became a net exporter of food grains in the 1960s in large part due to increased wheat production. However, by 1970-72, this surplus had been converted into a deficit which has steadily increased. Figure 3.3 shows these imports by three categories. Food grains (wheat, maize, rice and beans) have been imported to the extent of over 3 million tons in recent years or about 15 percent of national production. Feed grain imports have increased even more rapidly despite the rapid growth in domestic production. Finally imports of oilseeds have also jumped sharply in recent years, again despite a very high growth rate of domestic production.

Figure 3.3 Imports of Major Categories of Crops, Mexico, 1965-82.



This increased dependency on imported food has led naturally to considerable debate on the need to achieve self-sufficiency in basic foodstuffs. While self-sufficiency has been an important policy goal during much of the 1970s, major efforts were not made to reverse the trend toward increased food imports until the end of the 1970s when the SAM program (Sistema Alimentario Mexicano) provided special incentives for increasing production of basic foods. Although these incentives were largely eliminated in 1983, food self-sufficiency remains a stated goal of the Plan Nacional de Desarrollo (De la Madrid, 1983).

At the same time, with the current chronic foreign exchange constraints there is again talk of increasing production of export crops. However, given that export crops, especially cotton, compete with some basic food and oilseed crops such as wheat, safflower and soya, for land and water resources, there is obviously a conflict between the goals of food self-sufficiency and earnings of foreign exchange through export crops.

3.5 Irrigated versus Rainfed Agriculture in Mexico

The debate on comparative advantage in food crops versus export crops in Mexico is also closely tied to the debate on irrigated versus rainfed farming. Historically, most investment spent on agriculture has been directed toward irrigated agriculture. Even as late as 1971-74 the proportion of agricultural investment in irrigation was over 70 percent. The proportion of total cultivated area under irrigation has risen to over 23 percent in the 1970s and early 1980s, compared with about 18 percent in 1965. Because of low yields in much of the rainfed area, the proportion of the value of agricultural output produced in irrigated areas was nearly half.

There is a sharp division between crops grown under irrigation and those grown under rainfed conditions. As shown in Table 3.3 wheat, cotton, safflower and soya are largely grown under irrigated conditions. Maize, beans and barley are largely rainfed crops often produced under difficult climatic conditions. Sorghum is the only crop that is grown extensively under both irrigated and rainfed conditions.

Table 3.3 Percentage of Total Area and Production in Irrigated Areas Various Crops

	1960-64		1972-76	
	Percent of Area Under Irrigation	Percent Total Production from Irrigation Area	Percent of Area Under Irrigation	Percent Total Production from Irrigation Area
Food Grains				
Wheat	50 a/	73 a/	91 b/	97 b/
Maize	6 a/	12 a/	18 b/	29 b/
Rice	47	60	46	65
Beans	3	9	15	25
Feed Grains				
Barley	2	7	22	46
Sorghum	61	70	44	53
Oil Seeds				
Safflower	80	82	80	87
Soya Beans	50	44	78	85
Export Crops				
Cotton	65	na	79	95

a/ Calculated for 1960-62.
b/ Calculated for 1975-77.
na = Not available

There is naturally a debate as to whether a larger proportion of the irrigated areas should be devoted to basic food crops such as maize and beans. In fact, irrigated maize is quite important accounting for some 20 percent of irrigated area in 1981. Given considerably higher yields than in rainfed areas this is equivalent to about one third of national maize production and perhaps almost one half of marketed surplus since most maize in irrigated areas is commercially produced[1/].

The share of irrigated land devoted to export crops, especially cotton, has fallen while the production of oilseeds and other crops has

1/ During 1981 and 1982 the area under maize in irrigated areas was increased due to special incentives of SAM.

increased (Figure 3.4). Grains account for over 50% of harvested area and wheat has consistently accounted for around 20 percent of the harvested area under irrigation.

Looking to the future it seems that the area under irrigation will expand more slowly in the future because it has become increasingly costly to develop new irrigated areas. Lamartine-Yates (1981) estimates that a maximum of 1 million ha of new land could be brought under irrigated between 1975 and 2000[1/]. This places a special premium on the efficient use of existing irrigated areas.

Wheat, an irrigated crop, offers a special opportunity to diversify from the irrigated districts without sacrificing the goal of self-sufficiency. Wheat has, of course, been a major success story with rapid expansion of production through the 1960s and 1970s. Wheat production increased from 1.35mt in 1960-62 to 3.48mt in 1980-82, while area remained relatively constant. Wheat yields increased because of rapid increases in yields in irrigated areas but also because of a switch from rainfed to irrigated areas. Historically, wheat has been produced under rainfed conditions in the summer cycle. The Mexican altiplano (including the States of Tlaxcala, Mexico, Puebla and Hidalgo) in colonial times produced a wheat surplus for export to the Caribbean colonies. As late as 1962 half of Mexican wheat area was sown in rainfed areas. Since that time however the importance of rainfed wheat has declined to reach only 8 percent of area in 1974 (Figure 3.5). In the altiplano where over 100,000 ha of wheat were grown in the 1950s, wheat practically disappeared. This decline was in part due to the emphasis in government policy on promoting wheat research and production in irrigated areas as well as to the rise of competing crops in rainfed areas, especially malting quality barley.

The scope for further expansion of wheat in irrigated areas is limited. Significant area expansion is only possible if wheat is

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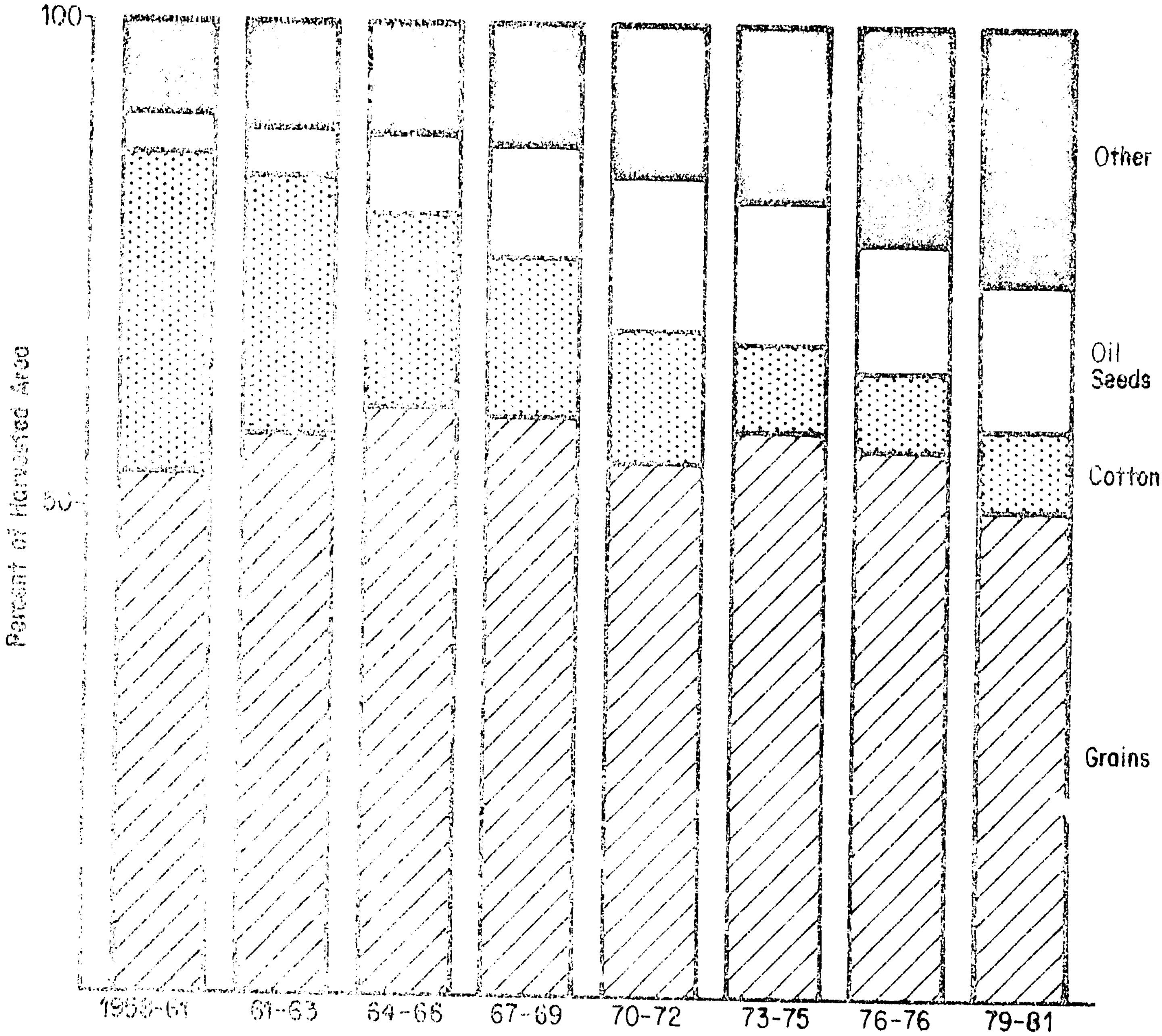
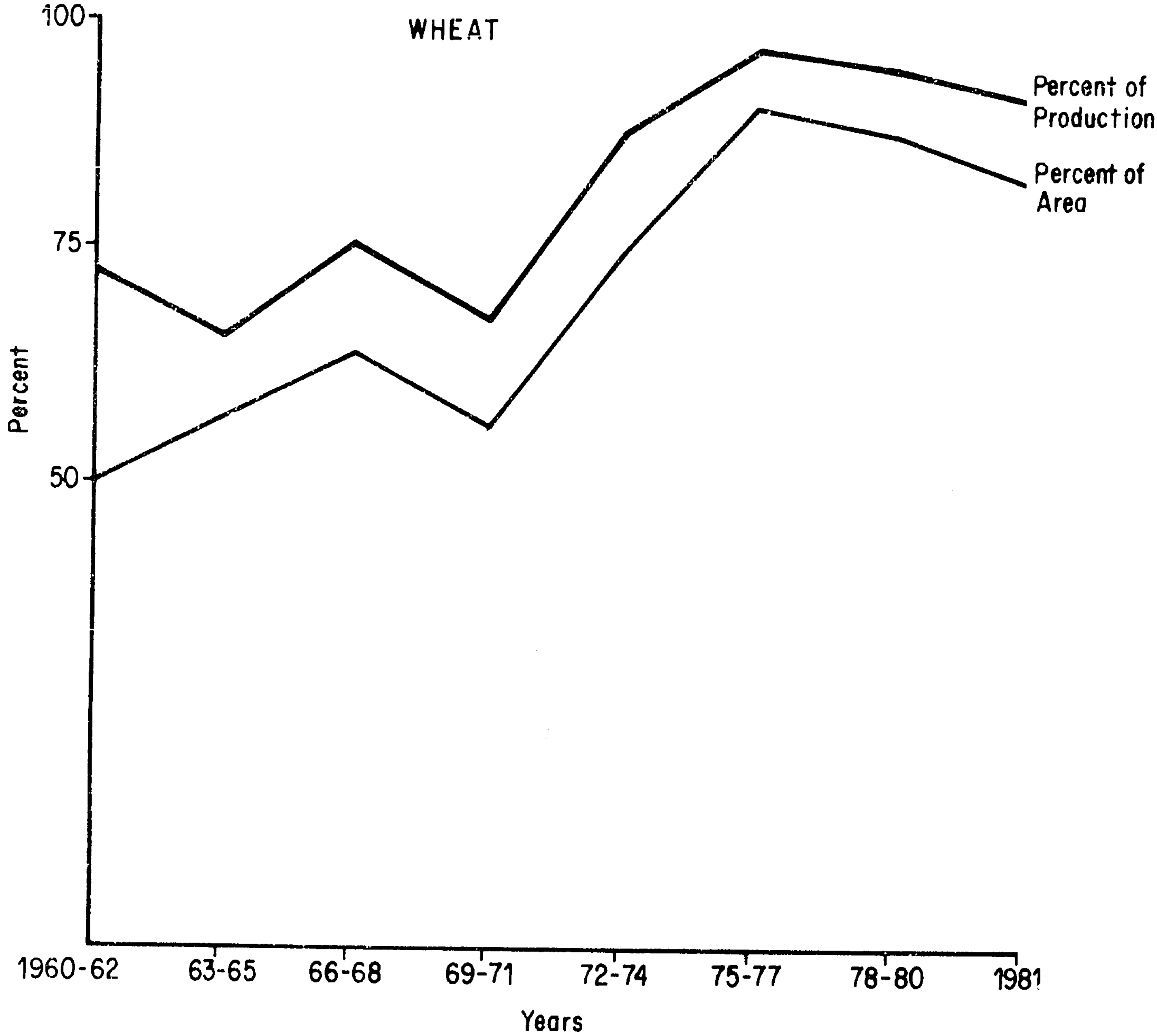
1/ There is also scope for more efficient water use in existing irrigated areas. Water use efficiency is estimated to be less than 50 percent (Palacios, 1975).

Figure 3.4 Percent of Harvested Area in Irrigation Districts in Grains, Cotton and Oil Seeds, 1958-81.



Source: Informe Estadistico, SARH.

Figure 3.5 Irrigated Wheat Area and Production as a Percent of Total Wheat Area and Production, Mexico, 1960-81.



substituted for other crops. Likewise, it is expected that the yield of irrigated wheat, which has exceeded 5.0 t/ha in recent years, will expand more slowly in the future. Recognizing this, the Mexican Government through SAM gave special subsidies for rainfed wheat production and this together with the recent release of improved varieties for the rainfed areas led to some reversal of the decline in rainfed wheat. In 1981 the area under rainfed wheat reached 154,000 ha or 18 percent of the total wheat area.

With the rapid expansion of wheat demand and limited potential for expanding irrigated wheat, the government is projecting an increased role for rainfed wheat in the future with the possibility of as much as 1.5 m ha of rainfed wheat by the year 2,000 (or double the area of irrigated wheat) (Rodríguez Vallejo, 1982). An additional advantage of rainfed wheat is that much of it could be produced closer to consuming points, thus substantially reducing the need for long distance transportation from the Northwest.

3.6 A Comparison of Wheat in Irrigated and Rainfed Farming Systems

This study analyzes the role of wheat in two contrasting regions of Mexico. The first region is the Yaqui Valley of the State of Sonora which is the most important wheat growing area of Mexico. An average of over 100,000 ha of irrigated wheat are sown annually with yields varying from 4.5 to 5.1 t/ha. The second region is the rainfed area of the States of Tlaxcala and Hidalgo, centered on the valleys of Calpulalpan and Apan and the surrounding low lying hills. Although wheat was traditionally grown in the area, it was largely replaced by barley during recent decades. Barley production was stimulated by the demand for malting quality barley for the nearby Mexico City breweries.

These regions were chosen because farm level surveys have been undertaken as part of on-farm research and training in the area. They represent an established irrigated wheat area but with a serious disadvantage of transportation costs because of the long distance to main consuming points, and an area where wheat is a minor crop but has considerable potential (Figure 3.6). General details of each area are given in Table 3.4.

The Yaqui Valley: Wheat production in the Yaqui Valley has increased rapidly as a result of yield increasing technology (Figure 3.7). Yields increased most rapidly during the 1960s with the use of semidwarf wheat varietes and improved cultural practices. Yields have risen less in the 1970s although continued release of new varieties, a narrowing of the performance gap between small ejido farmers and large private farmers and improvements in land quality through levelling, drainage and salinity control have led to average yields close to 5 t/ha in recent years.

Wheat in this area largely competes with cotton and safflower for available land and irrigation water, which is in short supply in many years. Cotton was the major crop in the valley but after the 1950s has given way to wheat and oil seeds. This reflects a drop in world cotton prices in the 1960s, rapid technological change in wheat production and government policy to encourage wheat production. Cropping patterns are set by water allocations and in most years water allocations favor wheat over cotton. This reflects a policy to encourage food crops but also the fact that cotton requires at least 50 percent more water than wheat. Farmers perceive cotton to be a risky crop because of yield variability due to insect attack and weather. Price risk is also high since there is no guaranteed price for cotton and prices vary according to international prices and exchange rates, as well as discounts charged by local cotton ginners.

Safflower is a relatively new crop whose area jumped sharply in the 1970s, although yields have changed little. It is particularly suited to the lighter alluvial soils. It also has the advantage that its water requirements are relatively low - about two-thirds those of wheat.

Both cotton and safflower are commonly grown in rotation with wheat. Cotton and safflower require row cultivation during the cooler winter months which helps eradicated the grassy weeds, phalaris and wild

Figure 3.6 Distances Between Sonora, Tlaxcala and Veracruz, Mexico.

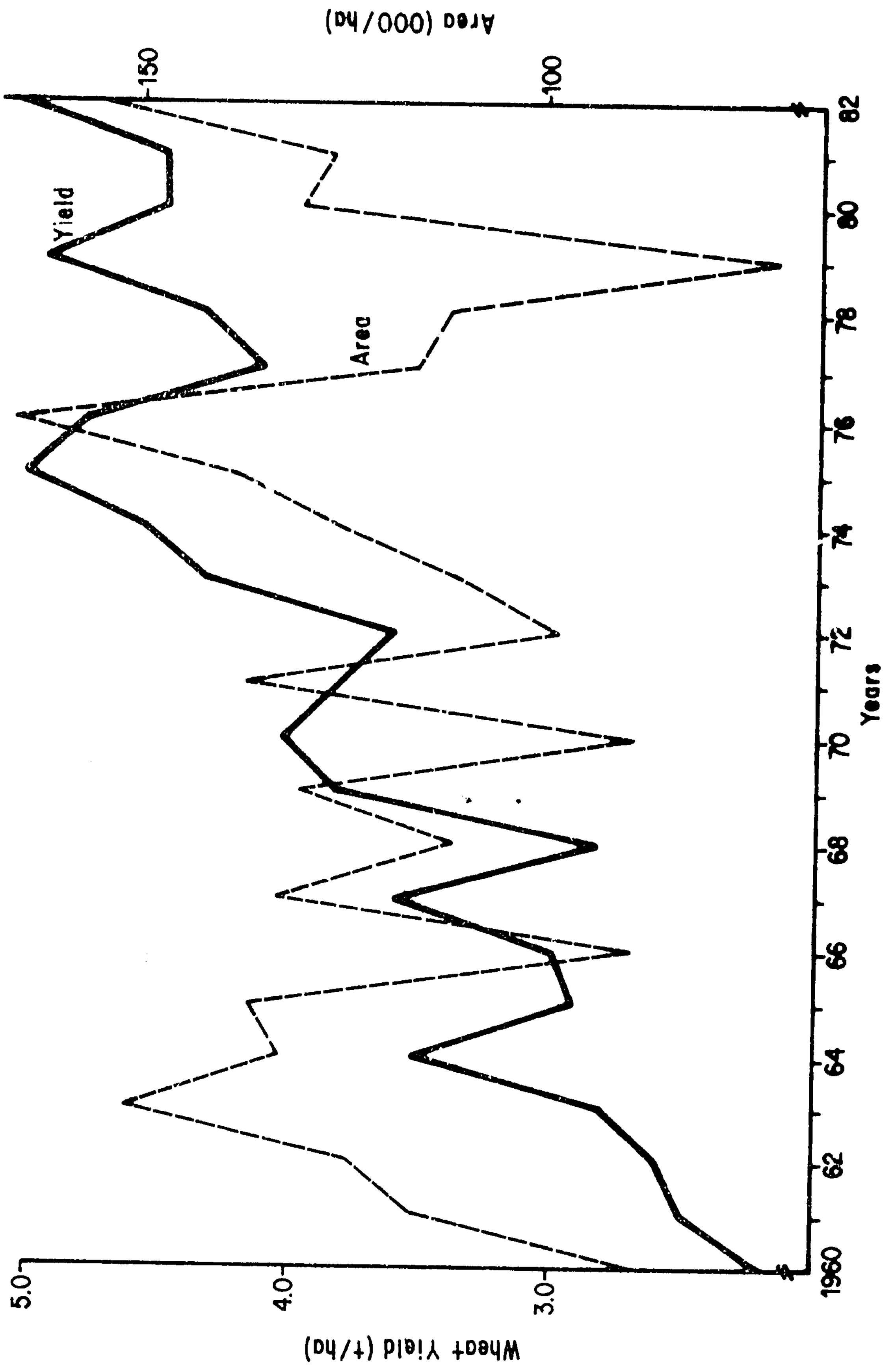
Table 3.4 Major Characteristics of the Yaqui Valley, Sonora and the Altiplano of Tlaxcala/Hidalgo

	Yaqui Valley, Sonora	Altiplano of Tlaxcala/Hidalgo
Rainfall	Irrigated	500-800mm/year
Major Crops	Wheat,Cotton,Safflower	Barley, Maize, Wheat, Maguey
Second Crop	Soya beans, Maize	None. Animal Grazing
Farm Size and Tenancy	Private farmers (20-100+ha) Ejidatarios (10-20/ha) Collective Ejidos (5ha/ member)	Private farmers (1-100/ha) Ejidatarios (3-20/ha)
Machinery	Completely mechanized for many years. Well established machinery rental services	Mechanization of major operations in recent years. Well established machinery rental services
Labor	Active labor market and considerable immigration	Active labor market with competing non-farm jobs
Credit	Nearly all farmers work with banks and credit unions	Most farmers now use bank credit
Input Distribution	Well developed input markets	Some problems in input availability
Marketing	Well developed markets. Wheat sold directly to government buying agents, millers or co-operatives.	No wheat purchased until 1981. Most farmers sell to private traders

oats, which are major problems in wheat. In fact, a wheat-cotton rotation was found to be an extremely effective means of weed control in one recent field survey (Byerlee, 1981). Likewise, such a rotation is beneficial for cotton which is subject to serious insect problems. Hence, there are substantial advantages to maintaining a crop rotation rather than dependence on a single crop such as wheat or cotton.

Maize and soyabeans are grown as second crops. Maize is commonly planted in August and harvested in January to March. It is often grown

FIGURE 3.7 Wheat Area and Yields in the Yaqui Valley, 1960-82.



as a "fill in" crop between wheat and cotton (see Figure 3.8). Soyabeans are a popular second crop in the rotation. Most farmers prefer a wheat-soyabean-wheat-soyabean rotation. However, high water requirements (about 50 percent above those of wheat) restrict the area of soyabeans in most years.

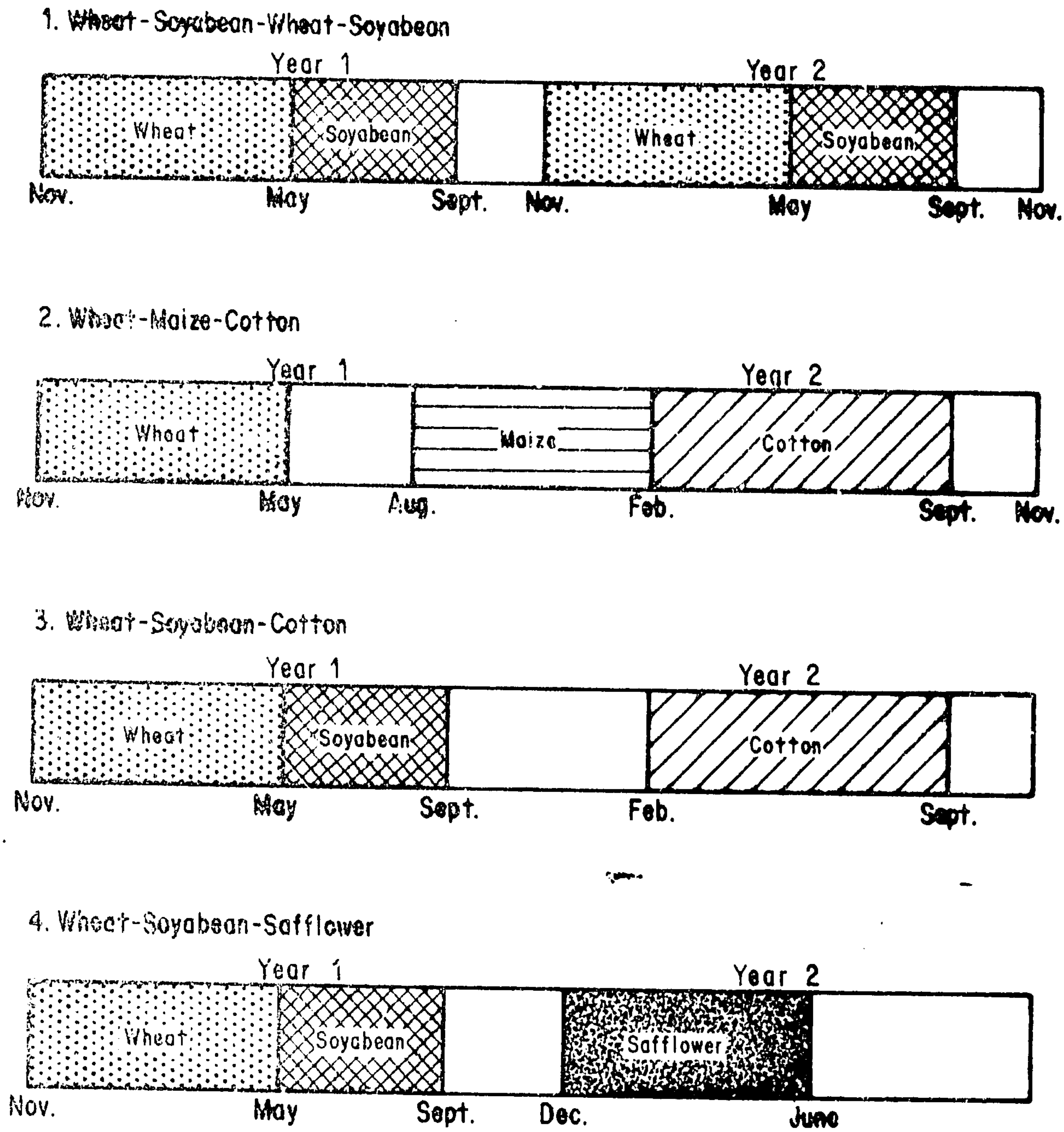
Agriculture in the Yaqui Valley is highly commercialized. Almost all operations are mechanized with most labor employed in irrigation and weed control in row crops. The labor requirements of cotton depend on whether it is harvested manually or mechanically. In recent years mechanical harvesting has become more common. Market systems are well developed for both inputs and products. Farmers generally received the guaranteed price for their sales. Most farmers also receive short-term credit from either official sources or private bank or credit unions. Extension is still deficient although new varieties are adopted quickly, largely through an efficient seed distribution program.

Tlaxcala/Hidalgo[1/]. Unlike Sonora, Tlaxcala and Hidalgo are areas of traditional agriculture with large numbers of small farmers where technological change had little impact until recently. A major influence on choice of crops and technologies in this area is the incidence of climatic hazards, especially drought and frosts. Rainfall is most reliable and frost incidence least in the period June to August. This especially favors short season crops such as barley. Barley was traditionally grown for animal feed but is now largely produced for malting purposes.

Barley production received a major stimulus in the late 1960s with the release of improved varieties with good malting qualities. Improved varieties, herbicides for broad leaf weeds and fertilizers were adopted very rapidly and by the end of the 1970s nearly all farmers were using these practices (see Byerlee and Hesse de Polanco, 1982). Barley yields almost tripled in this period (see Figure 3.9) although the sharp jump in 1976 may reflect a revision of the statistical estimation procedures.

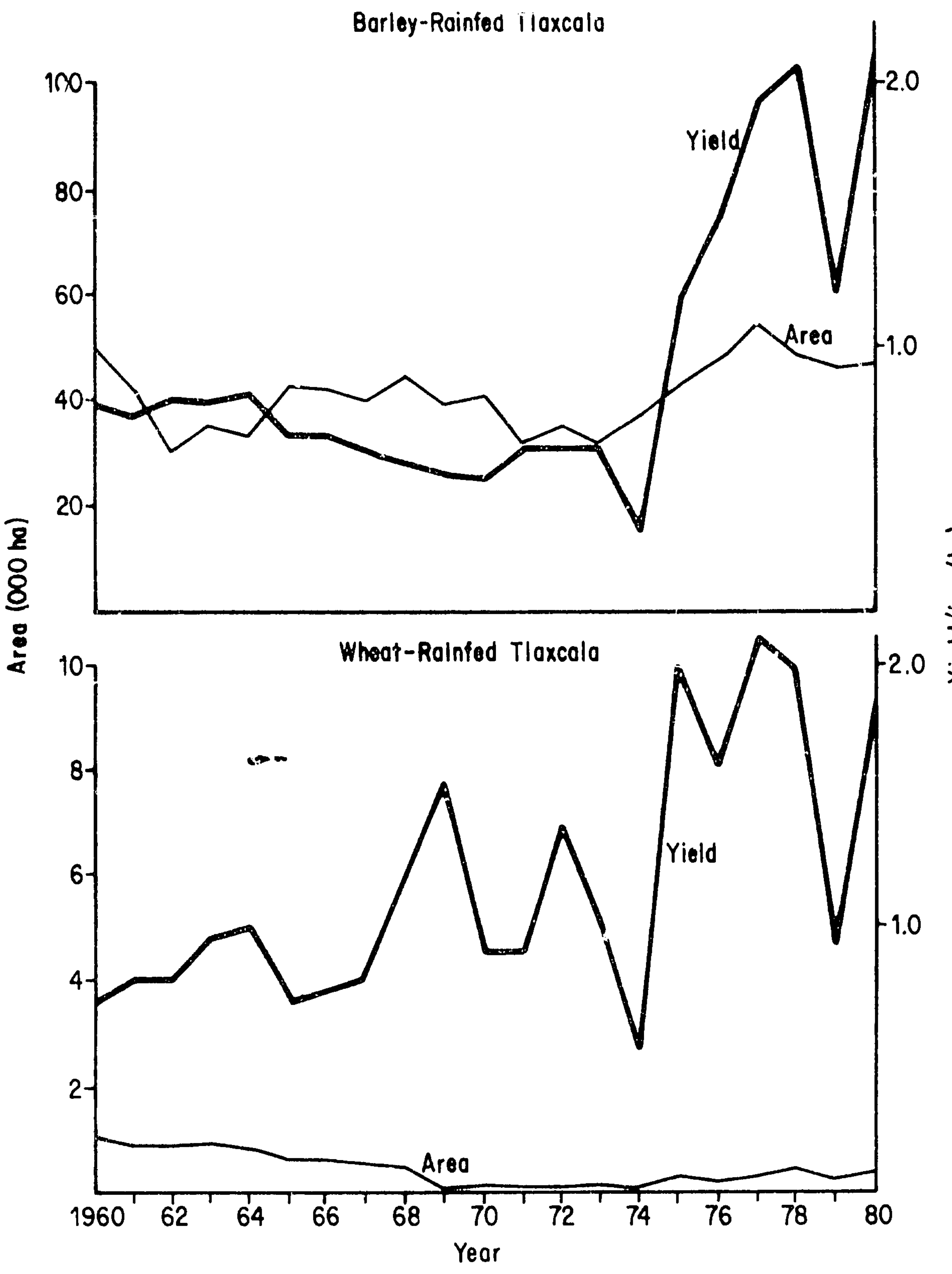
1/ For more details on cropping systems and production practices in the area, see Byerlee, Harrington and Marko (1981).

FIGURE 3.8 Major Cropping Systems in the Yaqui Valley, Sonora.[a/]



a/ Maize and Soyabeans in These Rotations are Second Crops Which are Subject to the Availability of Water.

FIGURE 3.9 Area and Yield of Barley and Wheat in Tlaxcala, 1960-80.



Wheat production declined until recently (see Figure 3.9) reflecting a) lack of a wheat marketing outlet, b) unsuitable varieties and c) lack of active promotion in contrast to barley which was promoted by a private association of brewers. By 1980 most of these obstacles had been removed. INIA had released two wheat varieties, Cleopatra and Zacatecas, for dryland conditions. The government marketing agency, CONASUPO, began to receive wheat and under SAM, credit and special incentives became available for wheat production. As a result, wheat area increased from 2900 ha in 1980 to over 13000 ha in 1982. However problems remain before wheat can replace barley on a major scale. Earlier, more disease resistant varieties are still required[1/]. Seed is a problem: farmers have often been provided with seed of older varieties quite unsuitable to the area. Marketing still needs to be improved since farmers receive a price well below the guaranteed price, in part because of problems of grain quality and impurities but largely because of corrupt practices of the marketing agency.

The other major crops, maguey and maize, are declining or stagnant crops. The declining demand for pulque, the major product of maguey, and high labor requirements have influenced the reduction in maguey area. Maize remains largely a subsistence crop. The long growing cycle exposes maize to a high incidence of climatic risks. Technological change and yield increases in maize have been modest and are largely due to adoption of intermediate levels of fertilizer use. There is substantial potential to increase maize yields but climatic risks will be a serious disincentive to increased expenditures on maize production. Also the labor intensity of maize production, particularly for harvesting, discourages area expansion.

3.7 Wheat Production Techniques in Sonora and Tlaxcala

Table 3.5 shows technical parameters used as the basis for the calculation of Resource Cost Ratios for each production technique. These

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1/ Two new varieties were released by INIA in 1982 which are earlier than Cleopatra.

parameters were derived from field surveys in the area and represent the most common production technique. As expected, input use per hectare is substantially higher in irrigated wheat. However, when converted to inputs used per ton of wheat produced the input-output coefficients are not very different. Irrigated wheat uses significantly more labor but less mechanical inputs and seed.

Technical change may alter these possibilities. In rainfed areas, availability of improved varieties and use of improved timing of operations should enable average yields of 2.5 ton/ha which is close to the yields obtained in on-farm experiments in the area over a five year period. In irrigated areas, improved varieties released in 1981, improved weed control and irrigation and possible change of sowing practices should bring average yields to 5.5 t/ha by 1990. In both cases and especially in Sonora, there are possibilities of reducing costs of operations, through reduced tillage, lower seed rates and improved fertilizer management which should improve the efficiency of wheat production.

Table 3.5 Technical Parameters for the Production of Rainfed and Irrigated Wheat

Yield	Rainfed Wheat 2.0 ton/ha		Irrigated Wheat 4.7 ton/ha	
Inputs	Per ha	Per ton of wheat	Per ha	Per ton of wheat
Tractor (Hrs.)	7.5	3.75	12.5	2.66
Combine (Hrs.)	1.0	.50	1.25	.27
Labor (person days)	2.6	1.30	9.5	2.02
Seed (kg)	120	60	170	36
Nitrogen (kg)	70	35	190	40
Phosphorous (kg)	30	15	30	6.4
Herbicide for broadleaf weeds (lt)	.75	.38	2	.43
Insecticide (No. of applic.)	0	0	1	0
Irrigation water (cm)	0	0	85	18

4.0 Agricultural Pricing Policy and Producer Incentives

4.1 Product Prices

Mexico has had a system of guaranteed prices for most food, feed and oil seed crops. As we have seen these guaranteed prices acted as effective farmer prices for the irrigated areas but are subject to discounts in the rainfed areas. Guaranteed prices are the same throughout the country so that there is no allowance made for differential transportation costs between different regions of the country.

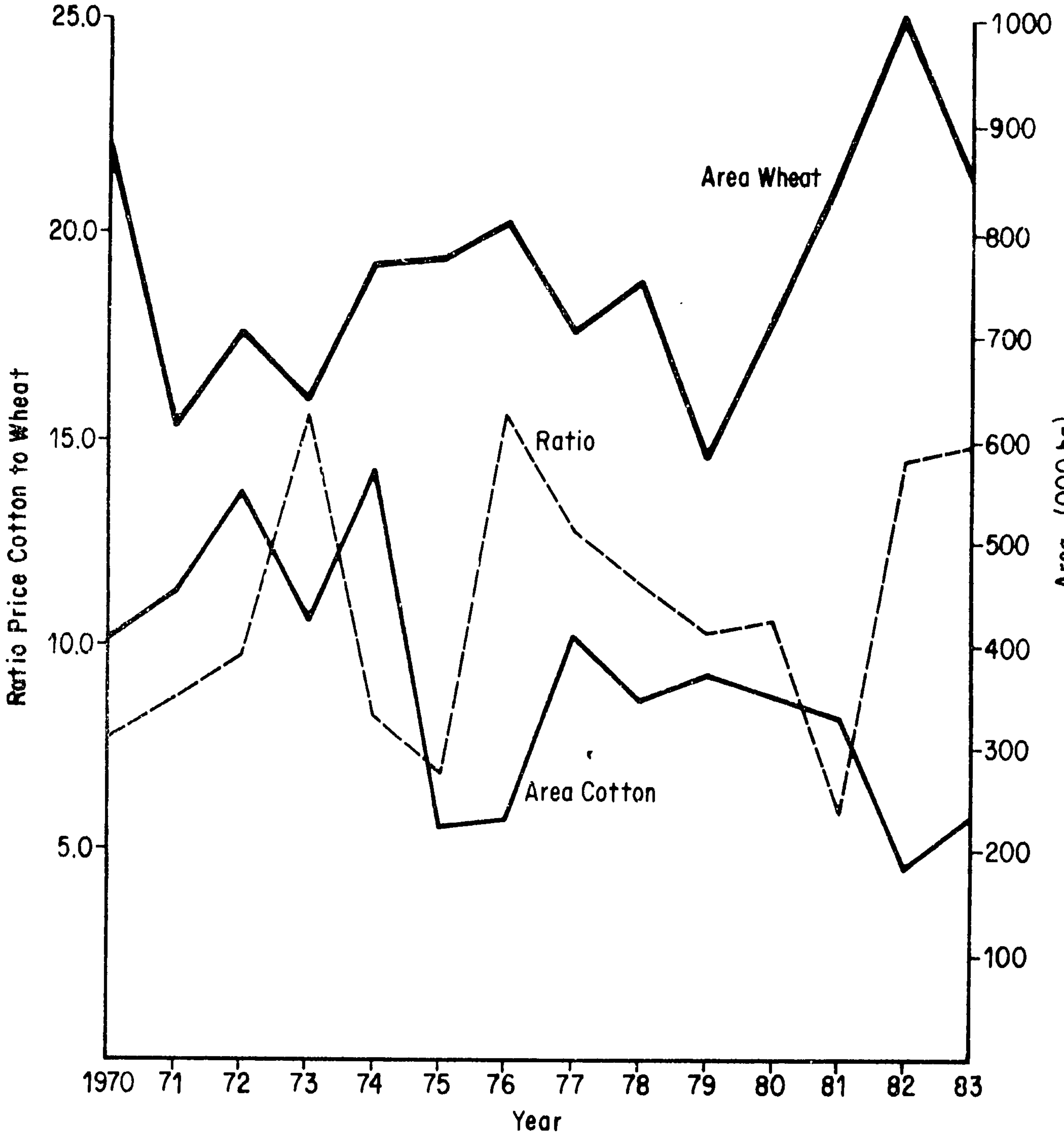
Cotton is the major crop analyzed in this study that does not have a guaranteed price. Cotton prices are fixed at world prices, converted at the official exchange rate and then increased by a factor (about 5 pesos/100lb lint in 1982/83) to obtain the local price in Sonora. The price of cotton seed is, however, set by the guaranteed price.

Much of the earlier analysis of producer prices in Mexico has focussed on declining real prices, using price indices as deflators. However, real prices are not a good guide for either farmers or policy makers. Comparison of wheat's relative price with respect to other crops, to input prices and world wheat prices are better indicators.

For those crops covered by guaranteed prices, prices maintain a fairly close relationship to one another. Maize and wheat prices generally moved together with a slight margin in favor of maize. Soyabean and safflower prices also move together with soyabean prices generally 10-20 percent above safflower prices. Wheat prices have generally been 45 to 50 percent of safflower prices.

The ratio of the wheat price, which is fixed by the government, to the cotton price, which is determined by the prevailing export price, fluctuates quite sharply from year to year as shown in Figure 4.1. In 1974 and 1975, the relative price of wheat increased sharply due to the increase in the guaranteed price of wheat. However, in 1976 the increase in international prices of cotton combined with a devaluation of the

Figure 4.1 Ratio of Price of Cotton to Wheat and the Areas of Cotton and Wheat, Mexico, 1970-83.



Source: Econotecnia Agricola VII Num. 9 Sept. 83.
Agenda Economica Agricola 1983.

Mexican peso led to a relative price of wheat only 40 percent of a year earlier. Thereafter the relative price of wheat increased in large part because of overvaluation of the exchange rate during the period, which kept increases in domestic cotton prices well below the inflation rate. In 1982, two large devaluations restored the price of cotton relative to wheat. Since then, the ratio has declined as the official peso revalued in real terms against the US dollar, at least until the current arrangements were altered in July, 1985.

These variations in relative prices of cotton and wheat often lead to large shifts in area between cotton and wheat. For example cotton area fell to a record low in 1976 in response to low prices relative to wheat in previous years. Likewise, in 1982, the wheat area in irrigated areas was well above normal because of a reduction in cotton area (see Figure 4.1). The possibilities of increasing cotton area with favorable prices (as, for example, in 1983) are limited by water restrictions as well as farmers' risk aversion.

In rainfed areas, the main competing crop to wheat is barley. Barley prices received by farmers have generally been slightly higher than the guaranteed price for wheat, but both prices move together. In the period 1980-83, wheat prices tended to be equal to or slightly higher than barley. Nonetheless, other factors such as availability of suitable varieties and an adequate marketing system are probably more important in farmers' decisions on wheat versus barley than these small variations in relative prices.

The effect of these various price interventions will depend on the response of wheat production to changes in the price of wheat and competing crops. Recent econometric analyses of supply response suggest that wheat production is only moderately responsive to price. An increase in the real price of wheat of one percent will lead to an increase in the production of wheat by 0.2-0.4 percent (Bredahl, 1981 and Rosales, 1982). There is evidence that wheat production is quite responsive to a change in safflower prices (Rosales, 1982). Although none of the studies analysed the response of wheat to cotton prices, farmers in the Sonora have in recent years clearly made large changes in their allocation of land between cotton and wheat, depending on their relative prices.

4.2 Input and Factor Prices

4.2.1 Seed

Input pricing and distribution is in the hands of both the public and private sector. Seed is multiplied by a public company, PRONASE, and certified seed is sold at a fixed price in all producing regions. Wheat seed costs have been generally double the commercial price of wheat.

We have no information on whether PRONASE is subsidized, but the relationship of the price of commercial seed to grain would suggest that there is a sufficient margin to cover seed processing and distribution costs. In the case of wheat, seed is purchased from growers at 10 percent above the guaranteed price. It is then treated, bagged, and graded and resold to farmers the following cycle at about 50-100 percent above this price. Seed can be regarded as a tradeable item since considerable quantitites of wheat seed have been exported. The price received for seed for export has been well above the national price (there is a substantial export tax on wheat seed) but since the market is very limited we shall assume here that the price of seed paid by farmers is a fair reflection of its opportunity cost.

4.2.2 Fertilizer

Fertilizer consumption in Mexico has expanded at an annual rate of 12.6 percent since 1960[1/]. Although the domestic production of fertilizer doubled in the 1970s, Mexico has consistently been a net importer of fertilizer during this period (Figure 4.2). Mexico began to export Ammonia in 1978 but substantial amounts of dry nitrogenous fertilizer

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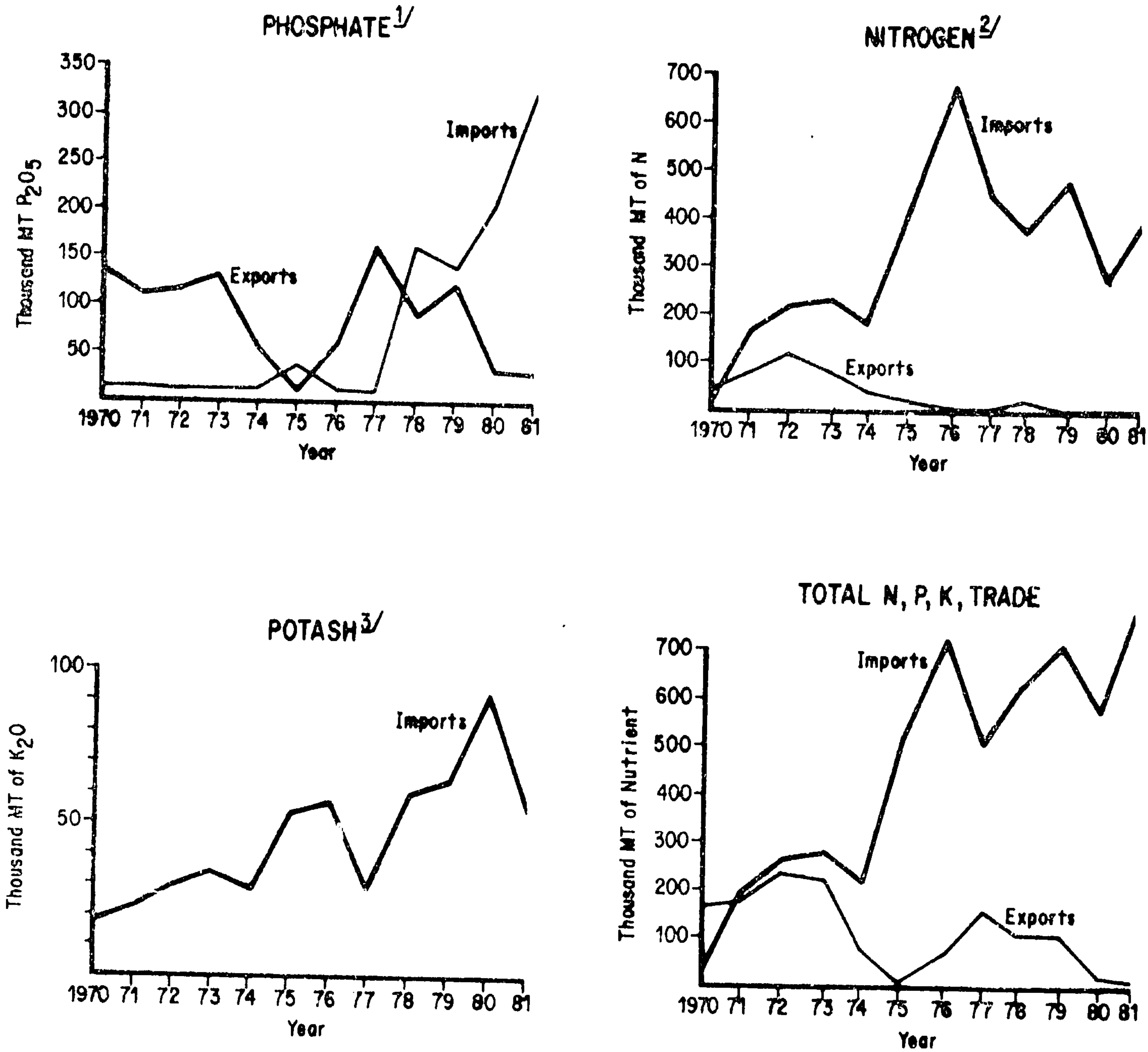
1/ For an overview of the Mexican fertilizer industry see IFDC (1981) and Secretaría de Programación y Presupuesto (1981).

Figure 4.2 Mexican Imports and Exports of Fertilizer, 1970-81.



1. Includes phosphate fertilizers and phosphoric acid.
2. Includes nitrogen fertilizers and ammonia.
3. Mexico does not export potash.

Source: Mexico, the Fertilizer Industry, IFDC, 1980; Plan de Desarrollo de la Industria Mexicana de los Fertilizante, Vol. II, Productos Terminados, Fertimex, S.A. 1982.

continued to be imported through 1981. Mexico has provided a substantial surplus of phosphate rock for export. Increasing demand resulted in a deficit at the end of the decade which was made up by imports. However, current large scale plans to develop local phosphate rock deposits will change this picture by the mid 1980s.

In 1980, Mexico imported 18 percent of its fertilizer needs, much of it nitrogenous fertilizer. Preliminary figures for 1981 show 1 million tons of fertilizer imports. Hence, in the recent past Mexico can be considered as an importer of finished fertilizer products, especially Urea, triple superphosphate and diamonium phosphate which are the most common fertilizers in crop production.

The bulk of domestic production of these fertilizers occurs in the State of Veracruz close to supplies of natural gas and is transported by rail throughout the country. Production and distribution is controlled by FERTIMEX which charge a uniform price for fertilizer throughout the country. Fertilizer prices have declined sharply in real terms since 1970. Figure 4.3 shows that the ratio of the price of one unit of nitrogen to the price of wheat declined from over four in 1970 to less than one in the 1982/83 winter wheat cycle. There are large explicit and implicit subsidies in these fertilizer prices from the following sources:

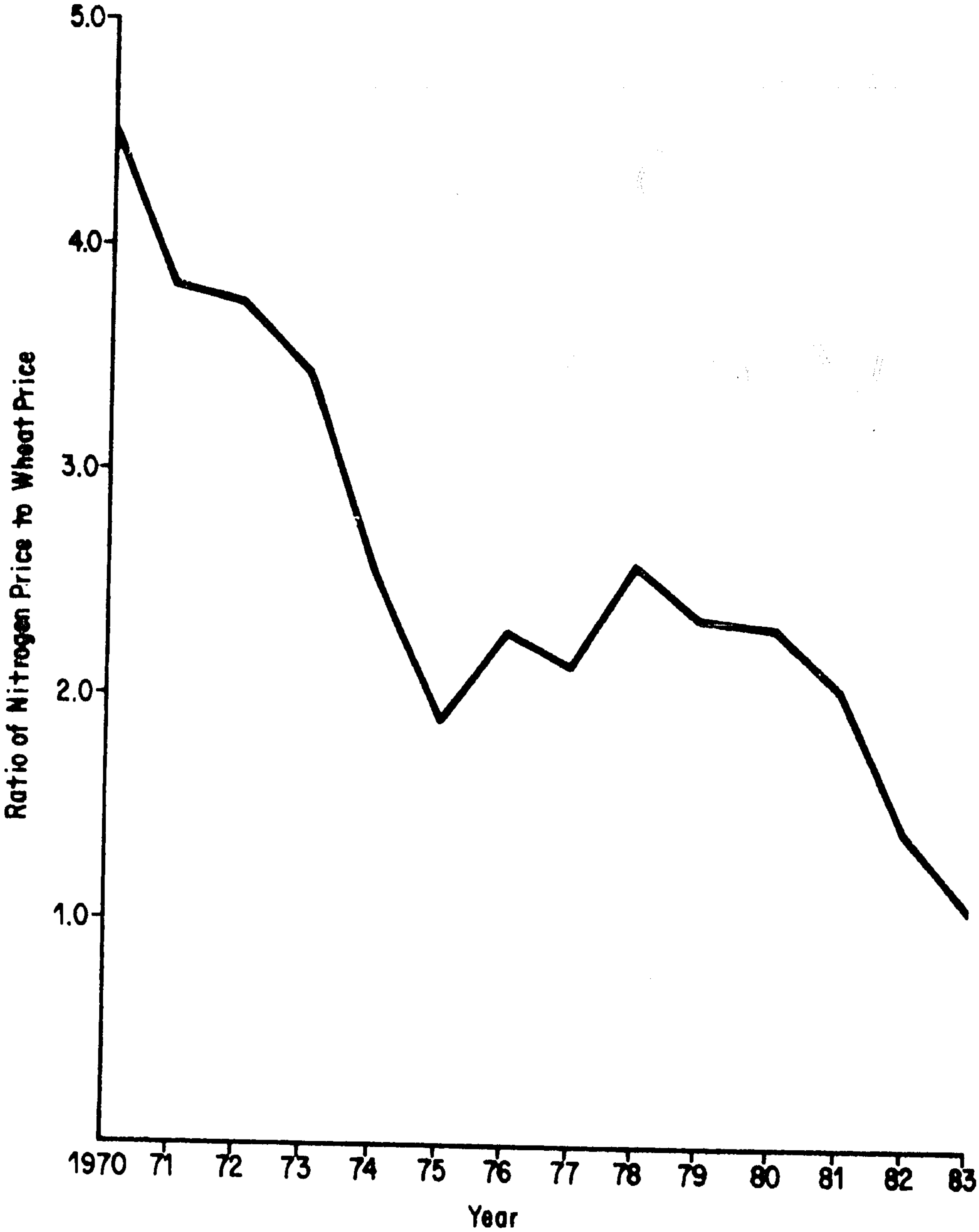
a) FERTIMEX purchased natural gas at rates well below the world price for use in fertilizer manufacturing.

b) FERTIMEX operated at a loss in many years and a government subsidy of about 10 percent of income was required to make up the deficit.

c) Transport of fertilizer is highly subsidized (see Section 4.3).

An effort was made to calculate the extent of these subsidies by computing a world price equivalent in the producing region. Since most fertilizer used in Sonora is transported from the south, the world price

Figure 4.3 Ratio of the Price of Nitrogen to Wheat, Sonora, 1970-83.



was calculated as the f.o.b. price plus unsubsidized transport costs[1]. Results shown in Figure 4.4, indicate that fertilizer subsidies began in the 1974/75 period of extremely high world prices. In recent years they have increased substantially to reach about 50 percent of the costs of urea to farmers in early 1983. In the past two years, increase in fertilizer prices have reversed this trend.

4.2.3 Pesticides[2]

Herbicides, particularly 2-4,D for broad leaf weed control, are the main chemicals used in wheat production in Mexico. Additional specialized herbicides for grassy weeds and an insecticide application are also common in Sonora. Competing crops, especially cotton and soya beans, use substantial amounts of insecticides.

Thirty percent of agricultural chemicals approved for use in Mexico are manufactured locally accounting for 70 percent of total demand. These chemicals include most of those used in wheat and cotton production. Mexican prices were, however, substantially higher than world prices. Mexican farmers paid about 50 percent above the world price for these chemicals except in 1983 when the devaluation brought Mexican prices close to the US price. In the case of wheat, however, these chemicals are a small part of total costs of production.

4.2.4 Machinery

The cost of mechanization is primarily determined by the cost of machinery and the cost of fuel. The decade of the 1970s was a particularly rapid period for mechanization in Mexican agriculture. Demand for tractors increased at an annual growth rate of nearly 10 percent between 1970 and 1980. The number of tractors sold annually nearly doubled to 23,000 units between 1976 and 1981. Much of this increase in tractor use

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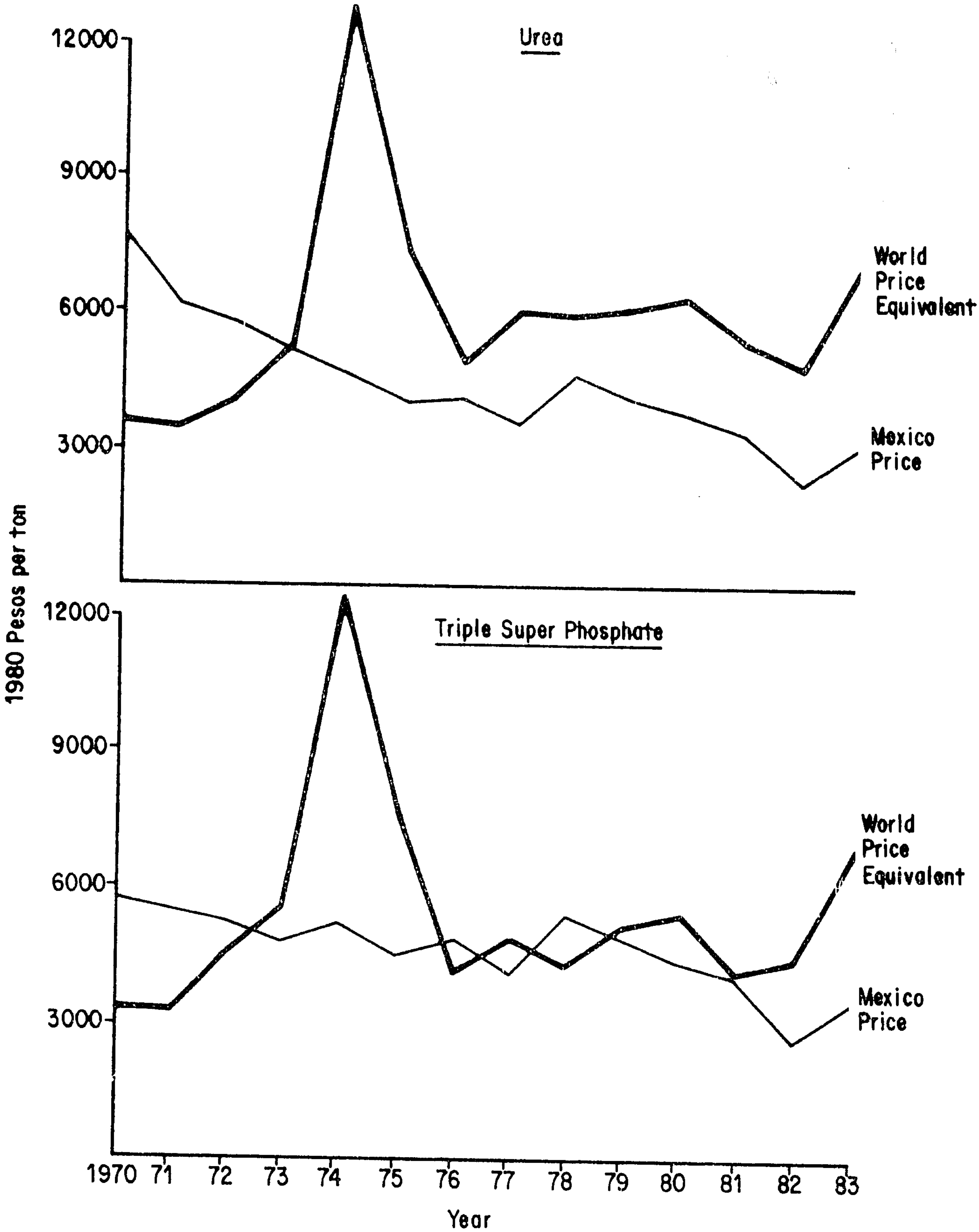
1/ This ignores costs of marketing and storage which amounted to about half of distribution costs in 1980.

2/ A review of the Mexican pesticide industry may be found in Secretaría de Programación y Presupuesto (1981).

Figure 4.4 Mexican Price and World Price Equivalent for Urea and Triple Super Phosphate in Sonora, 1970-83.



occurred in the rainfed areas since irrigated arèas were already highly mechanized by 1970.

Mexico has followed a practice of encouraging local manufacturing of tractors[1/]. The percentage of imported tractors in total tractor sales has fallen from over half in 1970 to 20 percent in 1980. Of course, tractors manufactured in Mexico, have a high import content with the percentage of directly imported components, ranging from 40 to 60 percent. By 1980, imports were mostly tractors of over 130 HP, which were imported without restrictions and free of duty. Since small tractors, as well as large ones, can potentially enter international trade, tractors may be regarded as a tradeable item.

Despite quantitative restrictions on imports of smaller tractors, the price of domestically produced tractors has generally followed the US price for the equivalent model tractor. Prices are set in relation to US prices and have in fact been below US prices in periods immediately after a devaluation. This has allowed Mexico to export tractors on a small scale; as for example, in 1983. Ploughs and harrows are also manufactured locally and prices seem comparable with US prices. In 1983, Mexico was exporting these implements to the US to take advantage of the opportunities offered by the devaluation. Other specialized equipment such as seed drills for wheat and combine harvesters are fully imported. Duties on these items are usually zero with the exception of combine harvesters which were charged a duty of 10 percent in 1983.

4.2.5 Fuel

Diesel fuel for mechanical operations is an important production input in both Tlaxcala and Sonora. It is also important in determining transport costs to consuming points. Diesel fuel has been highly subsidized throughout the period, as part of government efforts to keep transport costs low. As a result diesel prices deflated by the CPI or the price of wheat generally declined in the 1970s, during a period when

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1/ For a review of the Mexican tractor industry see Secretaría de Programación y Presupuesto (1981).

world prices were rising rapidly. This position was dramatically reversed in 1982 and 1983 when diesel prices were increased by 1,400 percent in 14 months. As a result the price of diesel in wheat equivalents increased 460 percent.

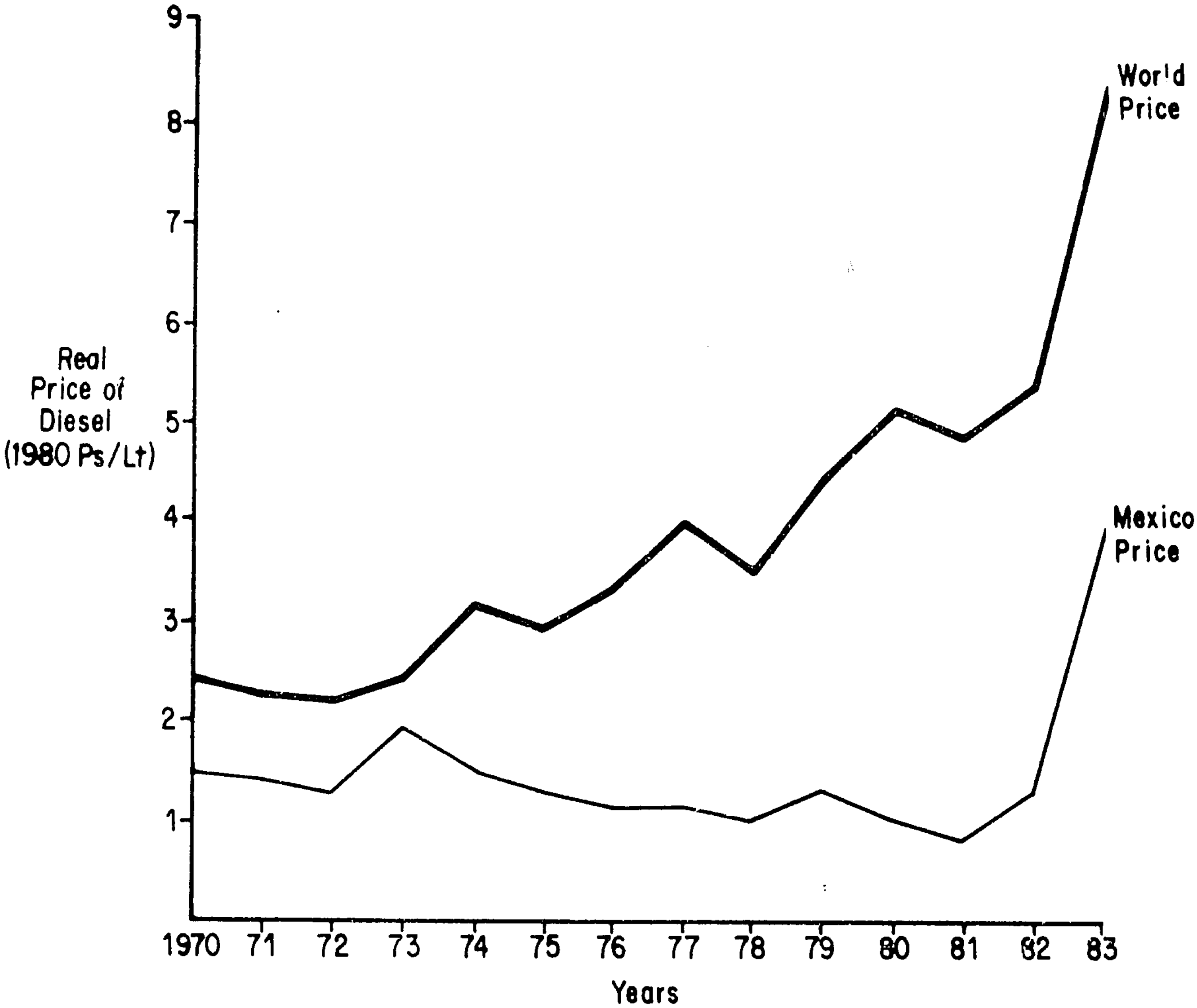
We do not have an equivalent f.o.b. price for diesel to calculate the subsidy on diesel. Instead we have used 85 percent of the US farm price for diesel to approximate world prices. This adjustment reflects the fact that Mexico is an oil exporter and also the fact that taxes are included in US prices. The implied subsidy on diesel using this method increased to 85 percent in 1981 and then dropped to 50 percent in 1983 with the change in government policy (see Figure 4.5).

4.2.6 Overall Changes in Mechanization Costs

Total mechanization costs are determined by initial capital costs, labor costs for the operator, repairs and fuel. In order to separate out these costs a simple model is developed in Appendix B and compared to the cost of machinery rental - a common practice for small farmers in both Tlaxcala and Sonora. In Tlaxcala rental costs declined in real terms from 1975 to 1980 (see Byerlee and Hesse de Polanco, 1982). This reflects a decline in the price of diesel but also the fact that returns on capital to the machinery owner have declined quite markedly from over 20 percent in 1975 to less than 10 percent in 1981. This probably reflects greater competition in the rental market since the number of tractors in the area increased sharply relative to the amount of land prepared by tractor. It probably also reflects the greater availability of loans at subsidized interest rates for the purchase of tractors.

In 1982 and 1983 machinery rental rates increased rapidly but not enough to compensate for higher costs of operations. By 1983 returns on capital to the owner had fallen to close to zero. Owners of course had gained through high inflation rates for their machinery but had lagged in raising prices to meet depreciation charges. The increased price of diesel also had a strong influence on the cost of tractor operation. Fuel accounted for only 8 percent of the cost of tractor rental in 1975

Figure 4.5 Real Price of Diesel in Mexico Compared to Estimated World Price, 1970-83.



but had risen to over 30 percent of costs in 1983.

The situation in Sonora is similar except that the rate of return on capital is somewhat lower reflecting the greater number of tractors and a more competitive rental market.

Rental costs for machinery in Mexico are very close to rates paid in the US. Table 4.1 shows comparable costs in Michigan, converted at the official exchange rate and in Sonora. In 1980, rental rates were almost identical but with the devaluation in 1982, Sonora rates had fallen relative to those in Michigan.

Overall, machinery costs have probably been lowered in Mexico through an explicit subsidy on diesel, an overvalued exchange rate during much of the 1970s and more recently through subsidized credit to purchase machinery or rent machinery services. In this study we only explicitly allow for the diesel subsidy and the overvalued exchange rate when adjusting to world prices. The removal of the subsidy on diesel would have raised the cost of tractor services by 34 percent in 1981.

4.2.7 Irrigation

Irrigation services in Sonora are managed by Irrigation District Authorities under the Secretariat of Agriculture. Farmers are charged for water per hectare for each crop, although meters are now being installed to measure the volume of water applied. The price charged to farmers for water has tended to decline sharply in real terms (see Tables 4.2 and 4.3). In 1982/83, out of a total wheat yield of close to 5 tons/ha, less than 5 percent was needed to pay the costs of water.

These low water prices have been achieved through increasing subsidies on the operation and maintenance of the irrigation districts. Subsidies increased steadily during the 1970s. For all irrigation districts of Mexico they amounted to 30 percent of irrigation services in the early 1970s, but by 1976 had risen to over 50 percent. Official data on revenues and costs are not available since 1976 but reliable

Table 4.1 Contract Hire Rates for Machinery in Michigan, U.S.A. and Sonora, Mexico, 1980 and 1982

	Plowing[a/]	Harrowing	Combine Harvesting
	(pesos/ha)	(pesos/ha)	(pesos/ha)
1980 - Michigan	550	265	920
- Sonora	550	275	900
1982 - Michigan	1150	750	1634
- Sonora	1000	500	1500

a/ Mould board plough for Michigan and disc plough, Sonora.
b/ Offset disc-harrow.
c/ Small grains harvesting.

Source: Michigan, G. Schwab, Michigan State University, personal communication; Sonora, farmer interviews.

Table 4.2 Indices of Prices of Water and Electricity, 1965-1978.

	Irrigation Prices		Electricity	
	Price Index	Real Price[a/] Index	Price Index	Real Price Index
	(1960 = 100)		(1960 = 100)	
1965	111	93	96	81
1970	159	113	96	68
1975	294	116	73	29
1976	306	99	75	24
1977	300	74	137	34
1978	316	66	140	29

a/ Deflated by Implicit Price Index of GDP.

Source: Lamartine-Yates (1981).

reports indicate that subsidies reached over 80 percent in 1982. In Sonora, subsidy levels are probably somewhat lower than the national average because of better developed irrigation systems and more effective management. Nonetheless, one report from the Yaqui Valley in the mid 1970s indicated a subsidy level of close to half.

Table 4.3 Average Cost of Water in the Yaqui Valley for Wheat Production, 1980-1985.

Wheat Cycle	Total Water Charge	Cost of Water in Terms of Wheat
	(pesos/ha)	(kg of wheat)
1980/81	1,500	326
1981/82	1,700	245
1982/83	2,200	157
1984/85	5,722	155

Source: Farmer interviews.

One result of subsidies and water scarcity is the development of an open market for water. In 1981 and 1982 farmers commonly purchased water rights from neighbors at prices about three times the official charge for water. This practice was prohibited in late 1982 but farmers now rent the land with water rights with land rents reflecting scarcity value for water for a particular crop.

High subsidy levels on water have been criticized because they lead to inefficiency and wastage in water use (e.g. Palacios, 1982). In particular, farmers have little incentive to economize on water use by reducing the number of irrigations and choosing water-efficient crops.

There are additional subsidies in irrigation districts that are more difficult to quantify. These include special land improvement programs such as salinity control, land levelling and subsoiling. Costs of most of these operations are not included under the operating costs of the irrigation authorities. For example an extensive program of land levelling has been conducted in Sonora with loans from the official credit bank. Two thirds of the costs are paid by the government and interest rates are subsidized on the remaining one-third of the costs.

The cost of developing the irrigation infrastructure itself is a significant cost of irrigation water. The Yaqui Valley can be regarded as a mature system and these costs are essentially "sunk" costs. The question then is how to use this valuable infrastructure most effectively. At the same time new irrigation areas are being developed and if the purpose is to produce wheat, cost of development should be included along with costs of operation and maintenance.

Costs of developing new irrigation areas have generally increased simply because the easier projects have already been constructed. Table 4.4 gives some data on development costs over time. We have not been able to obtain more recent information, but if costs have risen at the same rate as the general price index, a conservative estimate would be $500,000/ha in 1983, equivalent to $US4200/ha.

Table 4.4 Real Costs of Developing New Irrigated Land

	$/ha (1970 Pesos)
1959-64	51,346
1965-70	45,833
1970-74	81,162

Source: Lamartine-Yates (1981).

4.2.8 Credit and Insurance

A major component of government incentives to agriculture has been the provision of credit through both official banks and the (formerly) private banking sector. Credit available to the agricultural sector increased very rapidly in the second half of the 1970s, especially in rainfed areas. While most Sonora farmers had long worked with credit from banks or credit unions, most farmers in Tlaxcala operated on their own sources of funds. In 1979, 37 percent of farmers in a barley survey worked with the official credit bank. By 1982, this figure was certainly above 67 percent and even higher for wheat. Only in the case of maize is private funding still important.

There are a number of explicit and implicit subsidies in the granting of official credit. The most obvious is the provision of credit at subsidized interest rates. Interest rates vary according to the type of producer (i.e. small or large farmer) and also in recent years interest rates have been crop specific. Table 4.5 shows interest rates in 1983. Note that official rates applied only to a portion of the cost, varying from 50-90 percent of the estimated cost of production. If needed, farmers must obtain funding from other sources at prevailing rates for the remaining part of the cost.

Interest rates for basic crops for small and intermediate size farmers are compared with the rate on 6-month savings certificates in Figure 4.6. In earlier years, subsidies appeared to favor the small farmer. In later years, subsidy levels have increased sharply for all classes of farmers. In particular, the rate of interest for basic food crops was only about a quarter of the commercial savings rate in 1982. It should also be noted that for most years the real rate of interest discounted for inflation is negative.

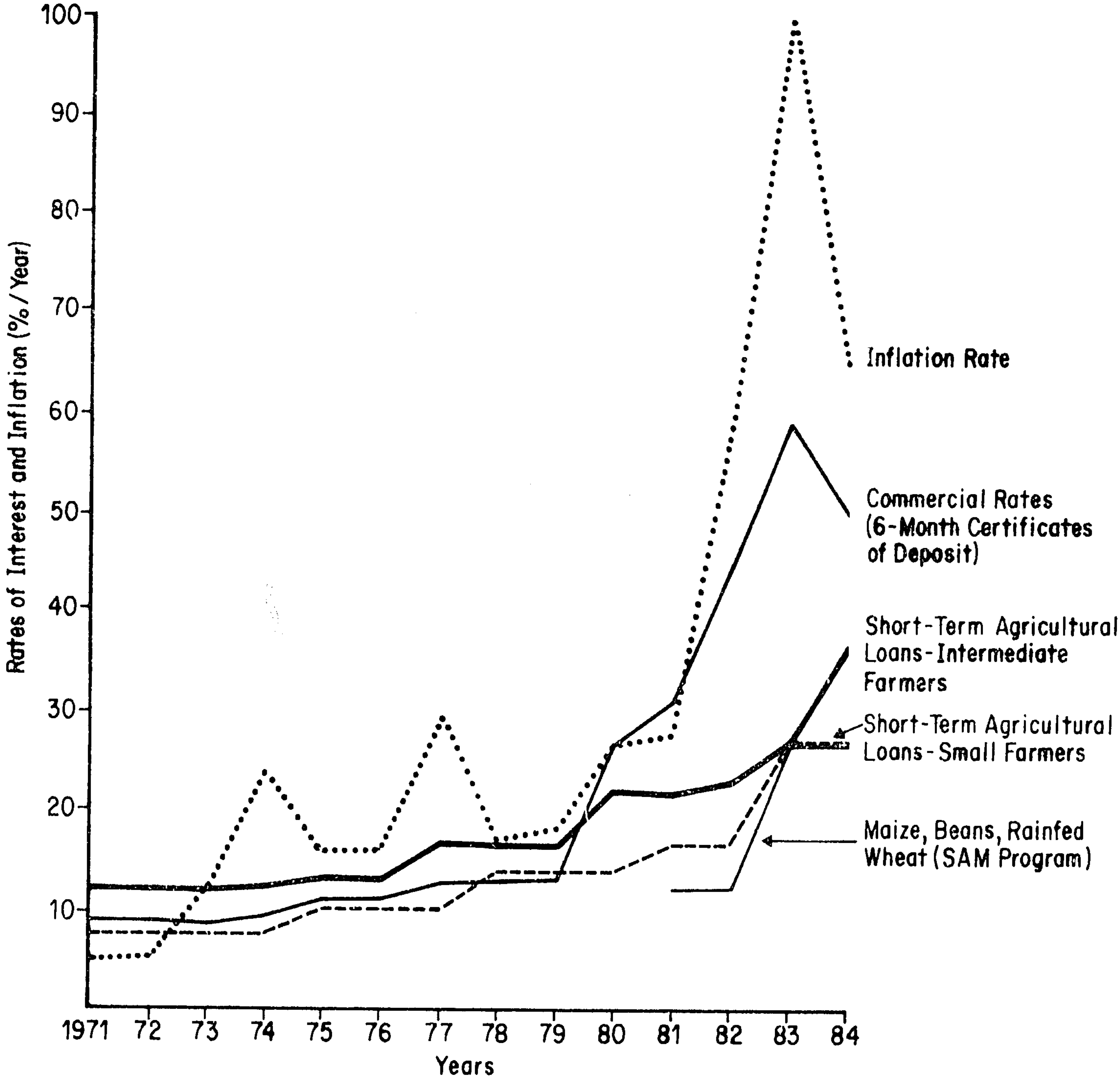
There are other implicit subsidies in bank services. For example, the official credit bank often provide inputs especially chemicals, at wholesale prices. Furthermore, all farmers receiving loans through the credit institutions must purchase crop insurance, which has also been subsidized (especially under SAM).

4.2.9 Labor

Active labor markets exist in both areas. In Tlaxcala, farmers often face a shortage of unskilled labor because of alternative job opportunities in factories in the area and the nearby Mexico City labor market. As a result, mechanization has proceeded rapidly in the 1970s and by 1982 farmers were beginning to mechanize their last major labor intensive operation, maize harvesting.

In Sonora the existence of a class of agricultural laborers and substantial inmigration and seasonal migration also leads to a

Figure 4.6 Interest Rates on Short Term Agricultural Credit Compared to Interest on 6-Month Savings Certificates, 1971-84.



Source: FIRA and Banco de Mexico.

Table 4.5 Rates of Interest on Short-Term Agricultural Loans, 1983.

Farmer group[a/]	Proportion of Loan Covered by Interest Rate	Rate of Interest, January, 1983 Maize, Beans, Rainfed Wheat	Other Basic Commodities	Industrial Crops (e.g. Cotton)
		(percent/year)		
Small farmers	90	12*	27	27.5
Intermediate size farms	80	12*	34	34.5
Large farmers	70	12*	37	60

* 27 percent as of April, 1983.

a/ Small and intermediate size farmers have incomes less than 1000 times and 1000 to 3000 times, respectively, the rural minimum wage for the region.

Source: FIRA.

competitive labor market. Irrigation and hand weeding in row-crops and cotton harvesting are the major labor using activities. Cotton harvesting has been mechanized rapidly in the 1970s and probably less than half of all cotton is now harvested manually.

The price of labor as measured by the rural minimum wage which co-rrelates closely with daily wages for farm work has increased in real terms over the period. From 1971 to 1981 the rural wage deflated by the consumer price index increased 16 percent. However, wage increases did not keep pace with high rates of inflation in 1982 and 1983.

4.2.10 Land

Well-developed land markets, especially land rental markets exist in both areas. Although ejido farmers are not legally permitted to rent their land, many do. Many private farmers also rent land. The price of land, as measured by its rental value in Sonora is mainly a reflection of the water rights associated with the land. Land rental values for soyabeans are usually similar to the price of open market water purchases. This reflects the fact that for second crops, water rather than land is the limiting factor.

Rental rates have generally risen faster than the rate of inflation or the price of wheat. Land rental for wheat was reported at $400/ha in 1970 (Hewitt de Alcantara, 1978) and by 1981 had reached $4000/ha, a 70 percent increase in real terms. This reflects the fact that improved technology and declining real costs of many inputs have been capitalized into land values. With high rates of inflation and rapid increases in costs, land rental values fell in real terms in 1982 and 1983.

In Tlaxcala, land rental values are about two-third of values in Sonora. This is despite the fact that Sonoran yields are well over double those of Tlaxcala. This is again reflection of differential cost structures as well as "site value" in Tlaxcala which is closer to large urban populations.

4.2.11 Research and Extension

Farmers in both areas are beneficiaries of the research service. For example, most crop varieties grown are the product of the research service. In Sonora, part of the cost of the research is paid by the farmers through contributions to the budget of CIANO, the official research institute. In Tlaxcala, development of improved barley varieties were financed in part from contributions from breweries. These research costs could be quantified and included in the calculations of resource cost ratios but because they are a negligible part of total costs we have ignored them.

Extension in both areas largely works through the official credit bank. Farmers do not usually use the extension service as a source of information. Because of this we have not costed extension services except in Sonora where many farmers employ the services of private extension agents.

4.3 Long Distance Transportation

Both rail and road transport are used to ship grains. However, the Mexican railway system has generally stagnated or declined so that road transport has become more important. By the end of the decade road transport was apparently more important in the shipment of grains from Sonora and from ports.

Railway transport remains important because of cheaper rates. This results from a large subsidy which amounted to 50 percent of operating costs in 1981. Road transport benefits from the diesel subsidy and it also seems that prices for trucks have been kept somewhat below world prices.

Transport charges in this study are based on actual road transport charges with an appropiate adjustment for subsidized diesel prices. Fuel consumption was estimated at 30km-ton/lt for Sonora to Mexico City and 20km-ton/lt for Veracruz to Mexico City where much of the route climbs through the mountains, and where transport rates per km-ton are substantially higher. The adjusted transport rates using these assumptions are given in Table 4.6. Tlaxcala rates are assumed to be one-quarter of the rate from Veracruz to Mexico City. The diesel subsidy provided an overall subsidy rate of 25 percent on transport costs in 1982 which was reduced to 20 percent in 1983, when fuel prices were increased sharply. In 1983, the fuel subsidy combined with a uniform price for wheat and fertilizer throughout the country benefited farmers in Sonora relative to those in Tlaxcala, to the extent of about 10 percent of the value of fertilizer.

4.4 Nominal Protection Coefficients

The Nominal Protection Coefficient, NPC, compares prices received by farmers with the equivalent world price for that commodity. This requires an estimate of the appropriate world price, the major consumption points and appropriate transportation charges.

Table 4.6 Costs of Road Transport of Grain Adjusted for Subsidized Diesel Price, 1982 and 1983

	Veracruz to Mexico City		Sonora to Mexico City	
	June,1982	June,1983	June,1982	June,1983
Distance (km)	425	425	1800	1800
Diesel Consumption (lt)[a/]	21	21	60	60
Domestic Price of Diesel (Pesos/lt)	2.5	14.0	2.5	14.0
World Price of Diesel(Pesos/lt)	10.2	29.8	10.2	29.8
Actual Transport Costs (Pesos/ton-km)	1.27	3.64	0.75	2.15
Unsubsidized Transport Cost (Pesos/ton-km)	1.67	4.43	1.00	2.68
Total Transport Cost-Unsub. (Pesos/ton)	703	1884	1810	4821
Percent Subsidy	24	18	25	20

a/ Based on 20 km-ton/lt for Veracruz and 30 km-ton/lt for Sonora.

Source: Phone interviews with transport operators and conversations with truck drivers at the local petrol station.

All crops analyzed in the study are import substitution crops for most of the period under consideration, with the exception of cotton. For cotton lint, we have assumed that the price received by farmers is a true reflection of world prices converted at the official exchange rate[1/]. The export tax on cotton is so small that it can be ignored. For simplicity, we have not considered the value of cotton seed. This value is small in relation to the value of lint and is usually equivalent to the ginning costs. Hence, the NPC of cotton can safely be assumed to be one -- i.e. farmers receive the equivalent of world prices less a marketing margin.

1/ Cotton is usually exported from Sonora through the nearby port of Guaymas. Transport and distribution charges are small and we ignore any distortions.

For other crops we required a CIF import price. These prices are not readily available in Mexico. Most commodities are shipped on a CAF basis - that is without insurance and other charges. Both land and sea routes are used but shipment to ports in Veracruz and then overland transportation to major population centers in the center of the country is the most common mode of importation.

To represent the CIF price we elected to use the CIF price in Rotterdam. In 1983, freight rates from New Orleans, USA to Veracruz, Mexico were similar or a little higher than freight rates to Rotterdam and other costs of insurance and capital are not expected to vary much.

Nearly all of Mexico's wheat imports have been No. 2 Hard Red Winter wheat although this policy has changed in recent years with imports of lower quality (and cheaper) Canadian and Australian wheat. We have used Mexico City as the consumption point for wheat. It is estimated that Mexico City alone consumes about 1 million tons of wheat. Available statistics from the mid 1970s indicate that about two-thirds of all wheat shipped by rail from Sonora was destined to Central Mexico (i.e. Mexico City, Puebla and the State of Mexico)[1/]. Hence, the farmgate price for wheat based on world prices is equal to the CIF price of wheat plus transport charges from Veracruz to Mexico City less transport charges to bring domestically produced wheat from Sonora or Tlaxcala to Mexico City. Transport charges were based on unsubsidized diesel prices as discussed in Section 4.3.

Relevant CIF prices and consuming points for other crops are given in Table 4.7. Maize is assumed to be consumed locally while two extreme assumptions are made for soyabeans--local consumption and shipment to Mexico City. In the case of safflower only the oil is assumed to be shipped to Mexico City and the cake is consumed locally in the animal feed industry. For local consumption in Sonora, no internal transportation charges are added and it is assumed that imports can be landed at Sonora ports at the same CIF price as for Veracruz.

1/ Wheat produced in Tlaxcala is normally shipped to Mexico City, because of the freight advantage.

Table 4.7 Import Prices, Consumption Points and Formulas Used to Calculate Nominal Protection Coefficients in Sonora.

Commodity	Import Price	Consumption Point	Formula for Calculating NPC[a/]
1.Wheat	a) CIF Rotterdam No.2 HRW	Mexico City	
	b) FOB Gulf ports No.2 HRW + freight rate Gulf ports to Rotterdam		$P_f/(P_i+T_v-T_s)$
2.Safflower	Estimated as in Appendix C	Oil-Mexico City	$P_f/(P_i+T_v-0.34T_s)$
		Cake-Local	P_f/P_i
3.Maize	CIF Rotterdam- No. 2 Yellow	Local	P_f/P_i
4.Soya beans	CIF Rotterdam	a) Local	a) P_f/P_i
		b) Mexico City	b) $P_f/(P_i+T_v-T_s)$

a/ P_f = farm gate price
P_i = import price
T_v = transport cost-Veracruz to Mexico City
T_s = transport cost-Sonora to Mexico City

No reliable international price information for safflower exists since world trade in safflower is negligible. An equivalent border price was constructed based on the price of competing vegetable oils (i.e. sunflower seed oil) and the price of soya cake, adjusted to the lower protein content of safflower cake. Calculations are shown in Appendix C.

Calculated Nominal Protection Coefficients (NPCs) are shown in Figures 4.7 and 4.8. All crops show a similar general pattern over the decade. At the beginning of the decade NPCs were close to one or above for most crops. Although most domestic prices were raised in the period of high world prices between 1973 and 1975 these increases were less than world prices so that NPCs fell. NPCs rose in 1975 and 1976 as world prices dropped and Mexico devalued its currency. Although world prices were generally high in 1979 and 1980, NPCs rose sharply in this period as a result of both the government efforts to stimulate basic food crop production and also because the Mexican peso was increasingly overvalued. The 1982 devaluations led to a sharp drop in NPCs of all crops.

Among crops, wheat is the least protected. In fact, Mexican wheat prices only exceeded world prices in the early 1970s when world prices were very low (and US exports subsidized) and again in 1981. During much of the period farmers in Sonora received only 80 percent of the world price equivalent while the difference is even larger in Tlaxcala which has a greater transportation advantage. However, there was a clear effort on the part of government policy makers to set wheat prices following trends in world prices.

In the irrigated areas all other crops generally had NPCs above one, especially in the period 1979 to 1982. The higher level of protection for maize compared to wheat reflects the fact that maize is significantly cheaper than wheat in world markets even though the price paid to farmers in Mexico is usually above wheat prices. There is a case for valuing Mexican maize which is nearly all white maize, at a higher price than imported yellow maize because of a strong consumer preference for white maize[1/]. Hence, the levels of protection for maize may be an overestimate.

The oilseeds, safflower and soyabeans, generally enjoyed the highest level of protection. Even in 1982 when Mexican prices were well below world prices for other crops, safflower and soya bean prices were comparable to world prices. Over the period these crops have received an average level of protection of 6 percent in the case of safflower and 14 percent for soya beans.

In the rainfed area, wheat prices were an average of 36 percent below world prices over the last ten years. This reflects low

1/ Little white maize is traded in world markets and although it usually sells for a premium above yellow maize, it is difficult to obtain reliable price information on white maize.

Figure 4.7 Nominal Protection Coefficients, Sonora 1970-85.

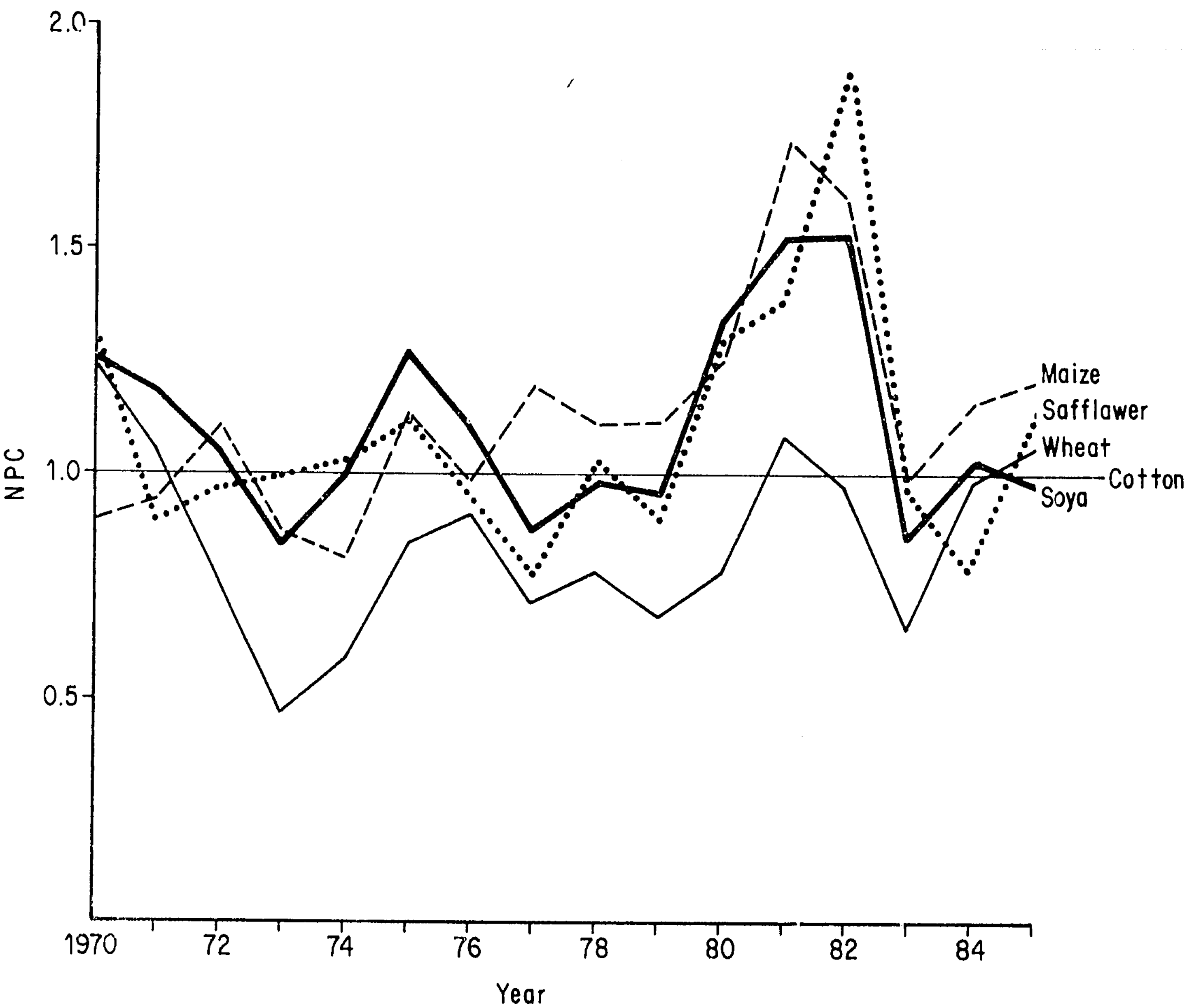
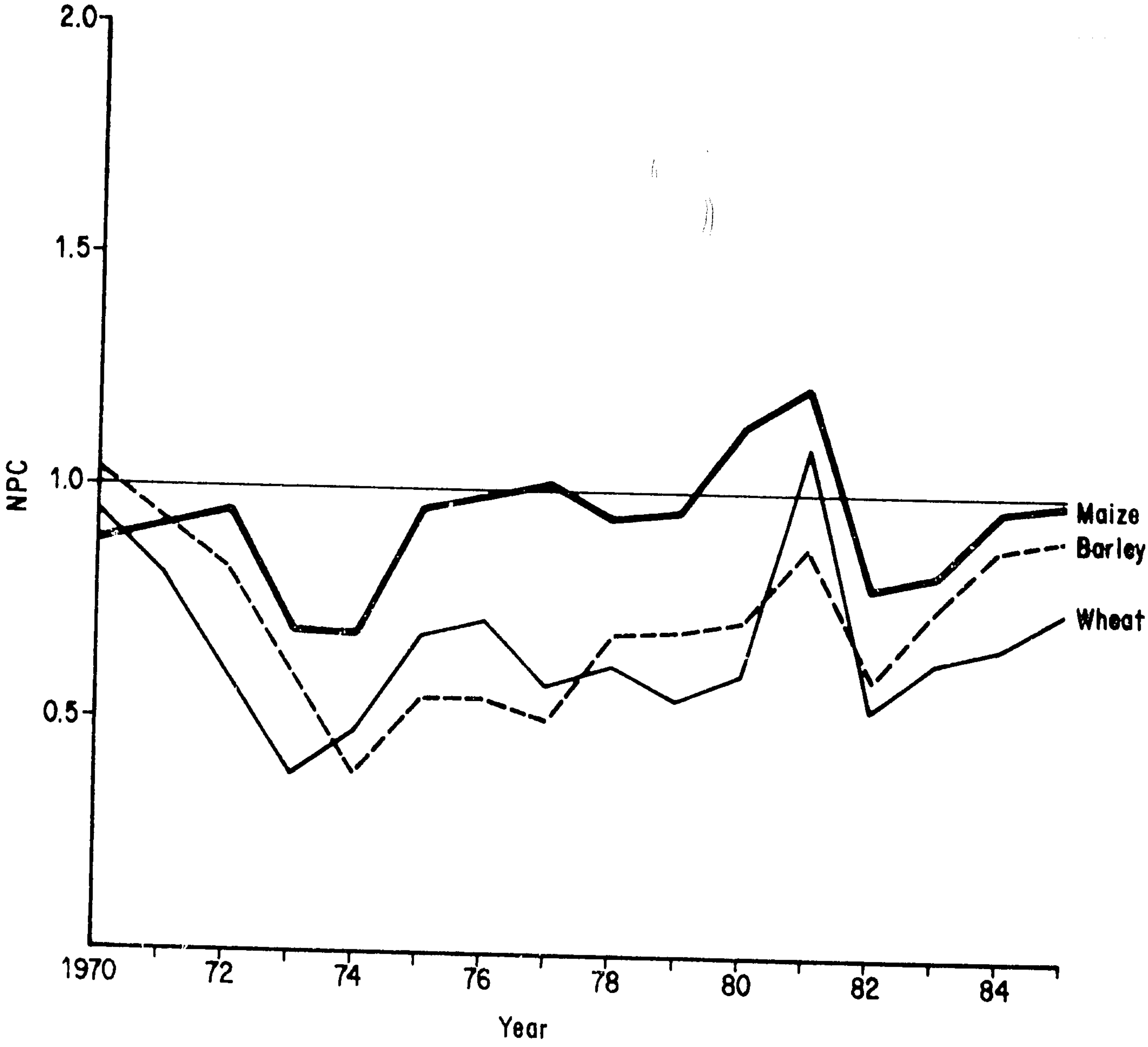


Figure 4.8 Nominal Protection Coefficients, Tlaxcala, 1970-85.



transportation charges to consuming centers as well as the fact that farmers in this region received only about 90 percent of the guaranteed price because of a poorly developed marketing system for wheat. NPCs for barley are generally similar or slightly higher than for wheat. Finally NPCs for maize were substantially higher and often above one.

Corrected NPCs were also calculated to allow for the fact that the Mexican peso was significantly overvalued in some periods. The corrected NPC for wheat, as shown in Figure 4.9, was generally well below the unadjusted NPC. The overall implicit tax on wheat was 30-40 percent for much of the period.

4.5 Effective Protection Coefficient (EPCs)

Government policy often tries to compensate producers for low farm gate prices by subsidies on inputs. The Effective Protection Coefficient takes into account the difference in domestic and world prices for both outputs and inputs. EPCs have been calculated for each crop and region based on technical coefficients (e.g. units of Nitrogen per ton of wheat) prevailing in recent years. The assumption of fixed technical coefficients should not be a major problem in Sonora where these technical coefficients have not changed much in the 1970s. However, in Tlaxcala the rate of technological change has been more rapid.

Figure 4.[illegible] compares NPCs and EPCs for crops in Sonora. Because Mexican fertilizer prices were higher than world prices in the early 1970s, the EPC was less than the NPC. Thereafter they were similar until 1980 when subsidies on fertilizer and fuel reached such high levels that the EPC was significantly above the NPC. Nonetheless, in the case of wheat, the EPC was significantly above one in only two years, 1981 and 1982, of the last ten years. In the case of oil seeds and maize, the EPCs are much higher than NPCs in most years, reflecting higher levels of subsidy per unit of output valued at world prices. These crops received substantial levels of protection throughout most of the period. In 1981, farmers effectively received double the value added measured at world prices for oil seeds.

Figure 4.9 NPCs for Wheat in Sonora Using the Corrected Exchange Rate, 1970-85.

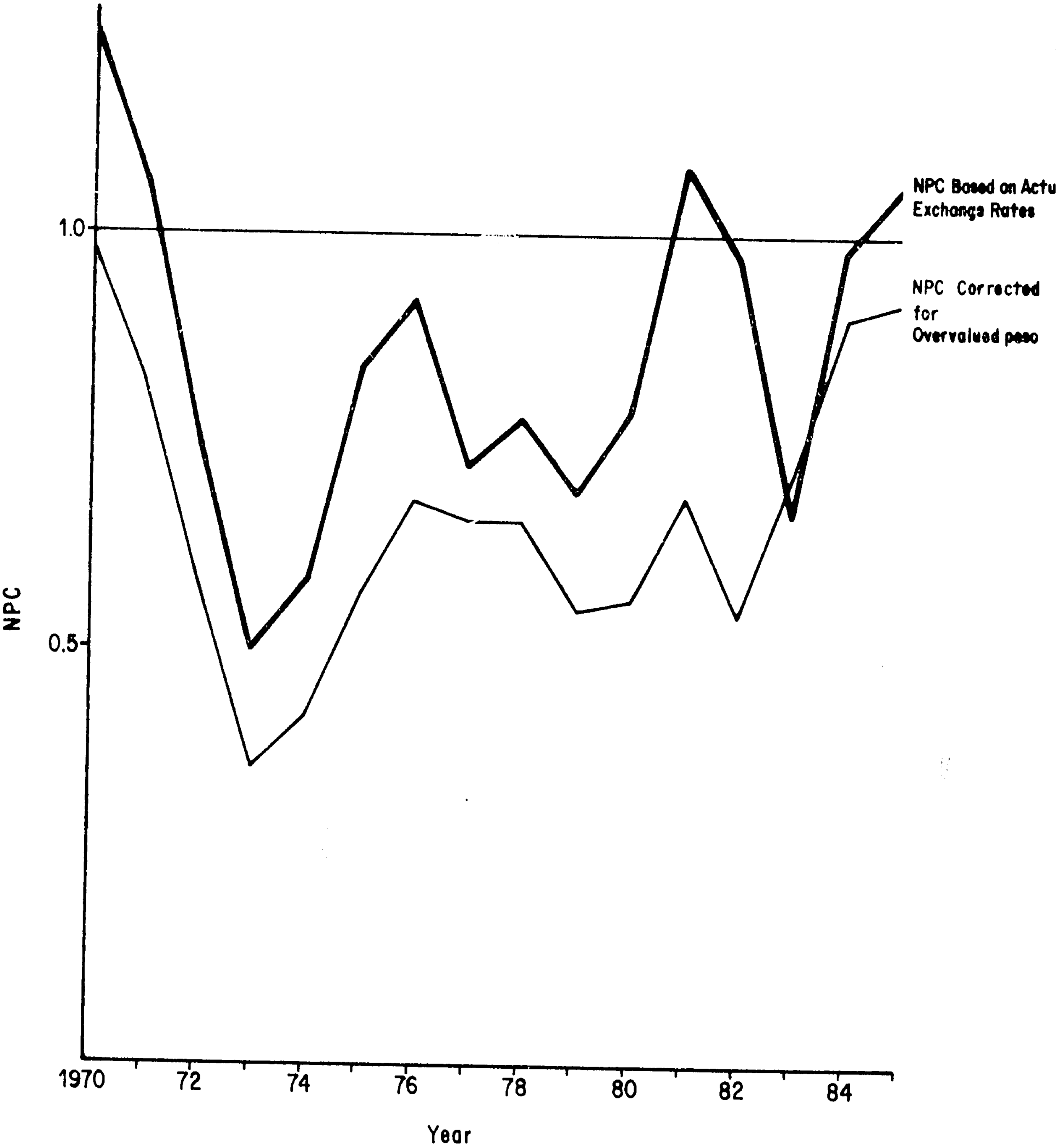


Figure 4.10 Nominal and Effective Protection Coefficient for Crops in Sonora, 1970-85.

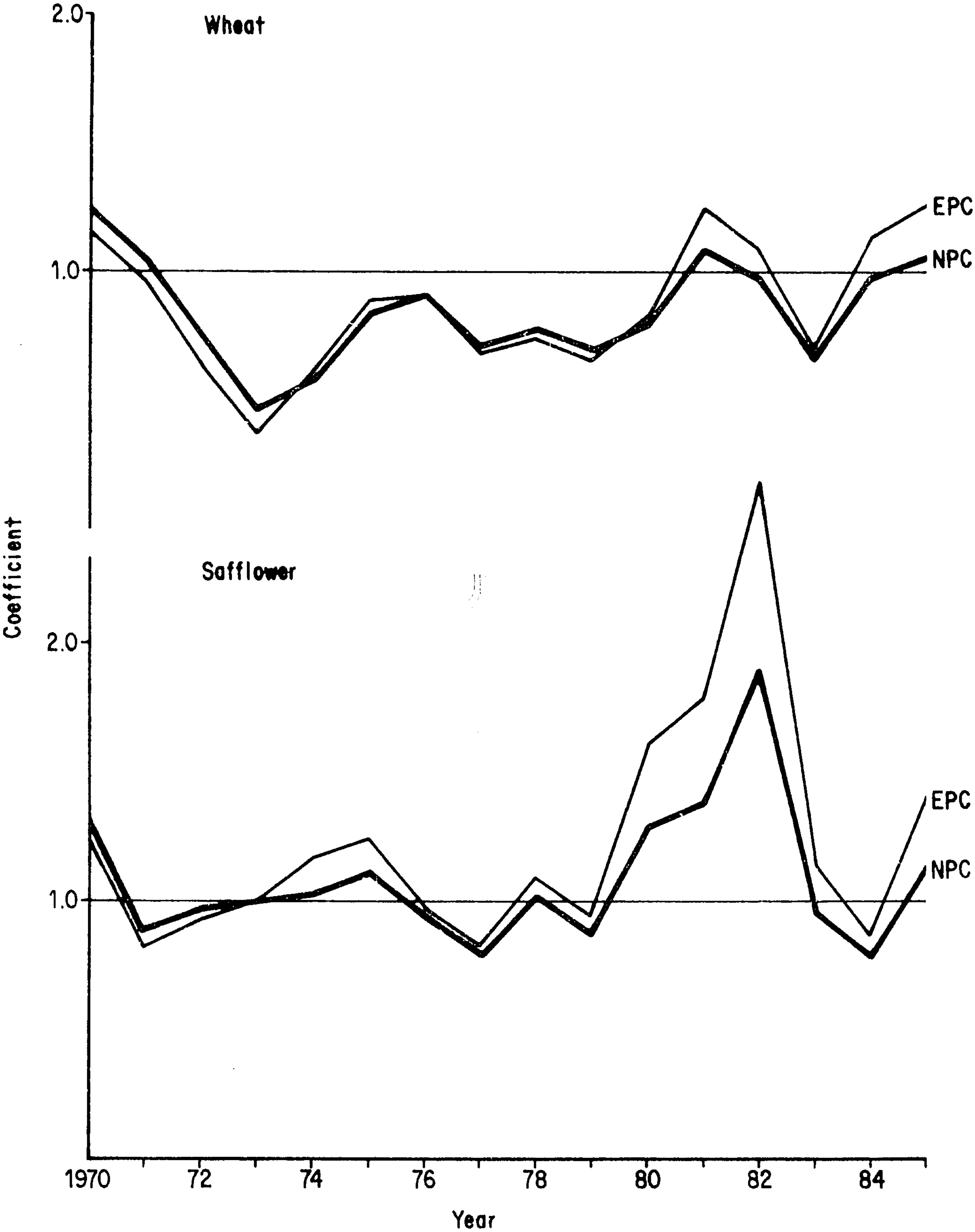


Figure 4.10. (Cont.)

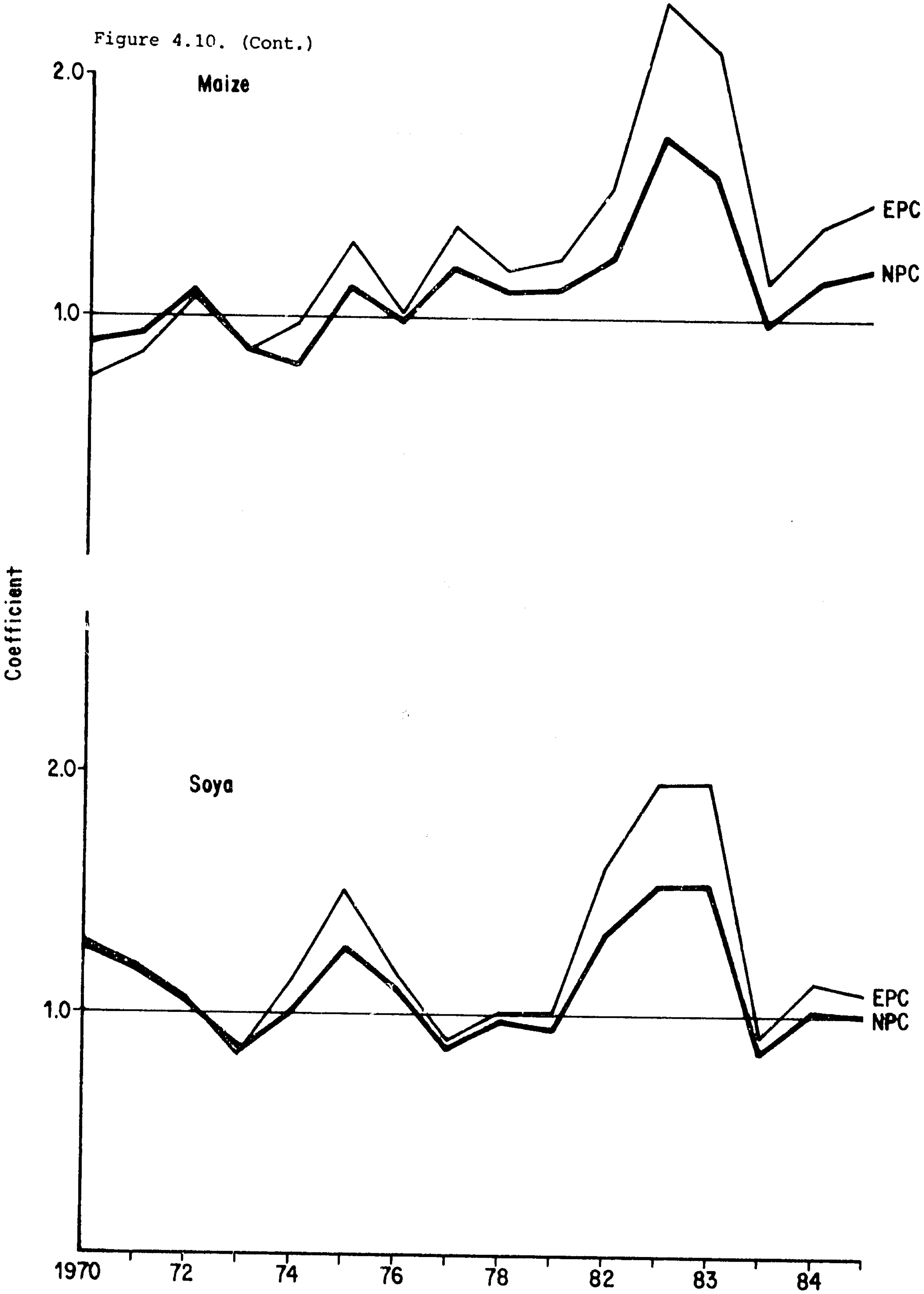
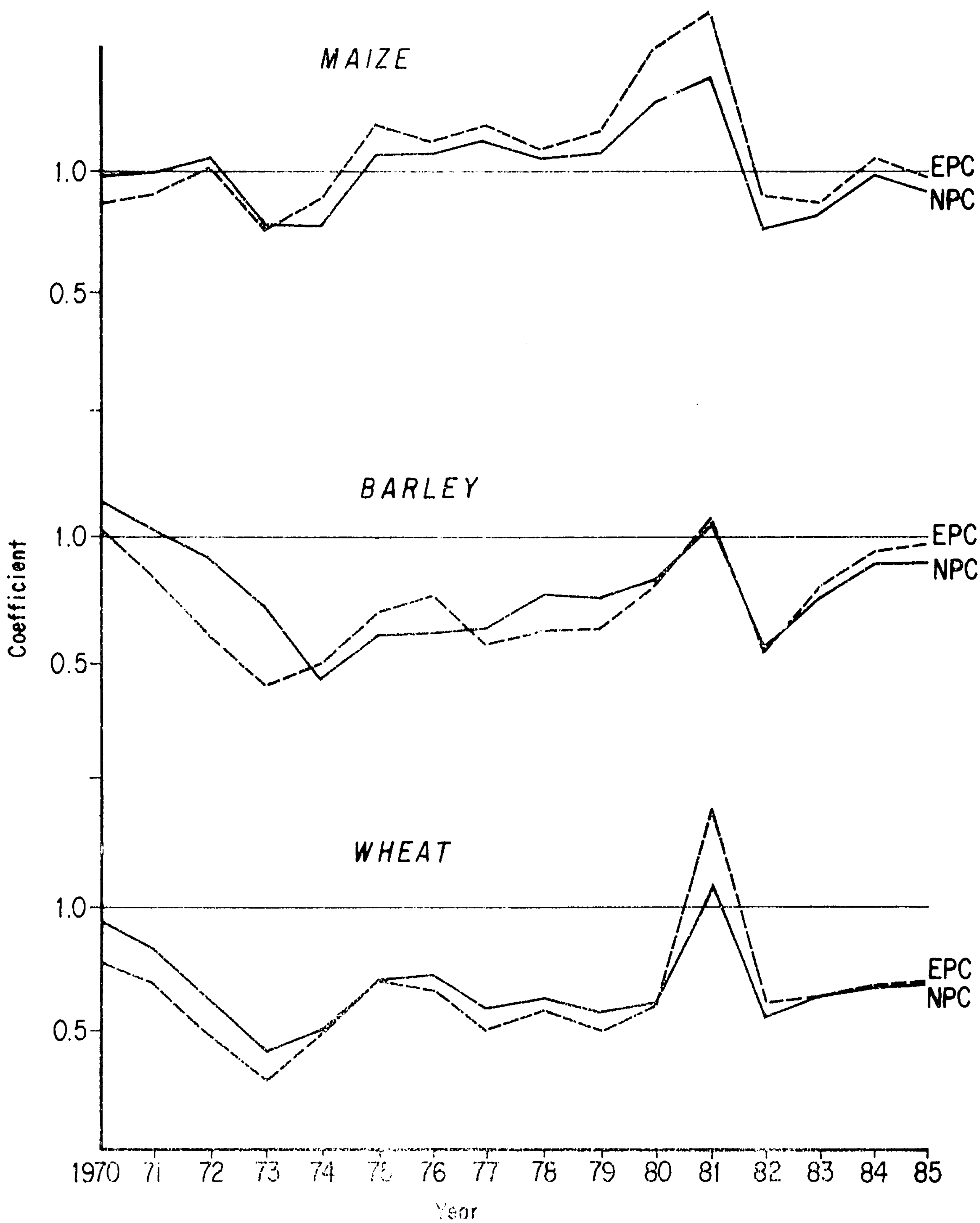


Figure 4.11 Nominal and Effective Protection Coefficients for Crops in Tlaxcala, 1970-85.



In Tlaxcala, the EPC for wheat was always below the NPC except in 1981 and 1982. That is, subsidies have not generally provided compensation for the low producer prices received by farmers. The major exception was in 1981 when the EPC reached 1.4 as a result of both the high producer price relative to world prices (in part because of an overvalued exchange rate) and also because of the special incentives provided under SAM.

4.6 Subsidy Coefficients

Total subsidies were calculated for selected years and are shown in Tables 4.8 and 4.9. Subsidies for seed (rainfed wheat), fertilizer and fuel had already been calculated in the analysis of EPCs. Subsidies on water and credit were calculated using the following rough and probably conservative guides. Water was assumed to be subsidized by 50 percent in 1977 and 67 percent in the period 1981-85. Credit was assumed to be subsidized by 30 percent in 1975 and 1977 and 50 percent in 1981-83 for irrigated wheat and 67 percent in 1981 and 75 percent in 1982 for rainfed wheat where special low interest rates prevailed. Subsidies on credit in the latest year were calculated as the difference between the rate of inflation plus the assumed real interest rate (7.5% per annum) and the actual rate of interest paid by farmers on short-term borrowings.

The pattern of the results was similar in both Sonora and Tlaxcala. When domestic wheat prices were well below world prices, subsidies on inputs, water and credit did not compensate farmers for the low wheat price. However, when domestic wheat prices were similar to world prices, subsidies provided a substantial transfer to farmers. The effective subsidy level reached 38 percent in both Tlaxcala and Sonora in 1981. However, 1981 and 1982 were years of unusually high incentives for Mexican farmers. In general, irrigated farmers have received higher levels of subsidies than rainfed farmers for wheat production.

Table 4.8 Subsidies on Wheat Production, Tlaxcala, 1975-1984.

Year	Producer Price Above World Price	Seed	Fertilizer	Fuel	Credit	Crop Insurance	Subsidy Coefficient a/
	(Pesos/ton wheat)						
1975	-703	0	194	49	35	0	-19%
1981	496	382	235	385	239	211	38%
1982	-4760	450	886	1112	825	317	-8%
1984	-9500	0	1530	1030	4370	2800	0%

a/ Total subsidy divided by world price equivalent for wheat.

Table 4.9 Subsidies on Wheat Production, Sonora, 1977-1985.

Year	Producer Price Above World Price	Fertilizer	Fuel	Credit	Water	Subsidy Coefficient a/
	(Pesos/ton wheat)					
1977	-801	127	88	16	211	-13%
1981	339	226	270	98	631	38%
1982	-215	455	408	316	716	23%
1983	-6967	1831	1080	421	926	-13%
1985	-600	4000	1040	4680	2410	31%

a/ Total subsidy divided by world price equivalent for wheat.

5.0 Farm Budgets and the Calculation of RCRs

5.1 Farm Budgets for Tlaxcala

Enterprise budgets were constructed for each major crop as a measure of farmer profitability and also as a basis for calculating resource cost ratios. Enterprise budgets are shown in Tables 5.1 to 5.2 for Tlaxcala in 1984. Technical parameters were employed as described in Table 5.1. These parameters were unchanged from year to year. Price data (Table 5.2) and a simple model to estimate machinery costs (Appendix B) enabled us to then construct Table 5.3.

Table 5.1 Technical Parameters for Farm Enterprises in Tlaxcala

	Wheat	Barley	Maize
Mechanical Operations (No/ha)			
Plough	1	1	1
Harrow	2	2	1
Cover Seed	1	1	0
Harvest	1	1	0
Animal Powered Operations (d/ha)[a/]			
Furrow	0	0	1
Plant	0	0	1
Cultivate	0	0	3
Labour (days/ha)			
Planting	.5	.5	0
Weeding	0	0	3
Fertilizing-Chemical	.5	.5	1
-Organic	0	0	4
Applying herbicide	.5	.5	0
Harvesting	0	0	9
Inputs (kg/ha)			
Seed	120	120	30
Fertilizer-Nitrogen	70	70	50
-Phosphorous	30	30	30
Herbicide-2,4-D (lt/ha)	1	1	0
Outputs (tons/ha)			
Grain Yield	2.0	1.85	1.5
Straw Yield	3.6	3.6	2.7

Table 5.2 Farmer Prices and World Price Equivalent of Inputs and Outputs, Tlaxcala, 1984.

	Farmer Price	World Price Equivalent
Inputs		
Urea (pesos/kg)	18.6	36
Triple Superphosphate (pesos/kg)	21.9	28.2
Esteron 47 (pesos/lt)	887	887
Seed - Wheat (pesos/kg)	42	42
- Barley (pesos/kg)	42	42
- Maize (pesos/kg)	41	41
Animal Power (pesos/day)	1120	1120
Labour (pesos/day)	560	560
Bank Interest (%/year)	36	67.5
Tractor ('000 pesos)	3750	3750
Combine ('000 pesos)	20600	18730
Diesel (pesos/lt)	26	42
Estimated Total Tractor Cost (pesos/hour) a/	1210	1420
Estimated Total Combine Cost (pesos/hour)	11330	10700
Outputs		
Wheat (pesos/kg)	27.3	36.8
Barley (pesos/kg)	33.5	34.3
Maize (pesos/kg)	33.4	31.1
Barley Straw (pesos/kg) b/	0.8	0.8
Maize Straw (pesos/kg)	1.0	1.0

a/ See Appendix B for method of calculating costs.

b/ Wheat straw value is negligible when baling costs are substracted.

c/ Exchange rate US$1.00 = 192 pesos.

Table 5.3 Budgets for Wheat, Barley and Maize in Tlaxcala Using Average Prices Paid by Farmers, 1984

	Wheat	Barley (pesos/ha)	Maize
Costs of:			
Machinery	22080	20800	6560
Labour	2060	2060	9890
Animal Power	0	0	5590
Inputs			
Seed	5040	5040	1230
Fertilizer	4260	4260	3450
Herbicide	890	890	0
Other			
Insurance	4100	9700	3200
Bank Interest	8280	8280	6450
Total Variable Costs	47110	52710	36760
Gross Revenues	54600	64760	52800
Gross Margin a/	7490	12050	16040
Land Rent	14000	14000	14000
Net Profit b/	-6510	-1950	2040
Net Return on Capital c/	.03	.11	.19

a/ Gross revenue less total variable costs.
b/ Gross margin less land rental charge.
c/ (Gross revenue/(total variable costs + land - interest charges)) - 1.

The budget given does not conform to traditional farm management budgets in at least two respects. First, we have estimated machinery costs as a charge to machinery services. The estimated charge is very close to actual machinery costs. The advantage of estimating the charge is that we are able to disaggregate these costs into depreciation, labor and fuel, etc. for calculating resource cost ratios. Second, interest charges are usually not subtracted out in calculating gross margins. However, since most farmers use bank credit to purchase fertilizer, fuel and other inputs it is reasonable to subtract interest charges so that gross margins represent the farmers return to their own resources of capital, land and management.

Table 5.4 Gross Margins and Returns on Capital for Wheat, Barley and Maize in Selected Years.

	Wheat	Barley	Maize
		(1982 pesos/ha)	
Real Gross Margins			
1975	4643	4774	3605
1981	6841	4416	3346
1982	4571	3162	664
1984	2235	3596	4784
Real Return on Capital[a/]		(% per crop season)	
1975	na	na	na
1981	59	15	- 1
1982	6	- 24	- 72
1984	- 57	- 49	- 41

a/ Rate of return less inflation rate
na = not calculated because the price of land was not available.

Data on gross margins, converted to 1982 prices by the consumer price index, and the real return on capital deflated by the inflation rate are shown for various years in Table 5.4. In the early years, maize was the least profitable crop. This resulted from both higher costs and lower yields per hectare than for the small grains. Even the special incentives of SAM failed to arrest the decline in incomes from maize production. Maize continued to be cultivated for subsistence purposes and even this seems to be declining as small farmers increasingly depend on the market for food staples. This trend has been accelerated in recent years by the high subsidy on tortillas and bread, which the rural population close to larger towns is increasingly purchasing.

In 1975, barley prices were higher than wheat which resulted in slightly higher incomes from barley. By 1980, wheat had become more profitable than barley and this was emphasized in 1981 and 1982 when wheat received special incentives under SAM.

The sharp increase in costs resulted in a real decline in incomes in 1982 and 1984 for wheat and barley. In particular, machinery costs, increased rapidly in this period to reach 46 percent of total variable costs in wheat in 1984 compared to only 38 percent in 1975. Fuel costs alone were less than 10 percent of tractor hire costs in 1981 but had increased to over 30 percent of the cost in 1984. This sharp increase in machinery costs had less effect on maize profitability and in fact, maize was more profitable than wheat for the first time in 1984.

5.2 Resource Cost Ratios in Tlaxcala

Table 5.5 shows values of inputs and outputs divided into tradeable and nontradeable items. Tradeable inputs were valued at their world price equivalent. These included machinery depreciation, fuel and spare parts, which were valued at their US price equivalent with a 15 percent adjustment downward for diesel as before. Maintenance and repair costs were divided into 75 percent for spare parts (a tradeable) and 25 percent for labor (a nontradeable). Seed prices were assumed to reflect their real cost. Fertilizer was valued at FOB prices plus internal transport charges. Herbicide was valued at US farm prices.

All nontradeable inputs are valued at actual farm prices, except land and capital. A real cost of capital was assumed to be 7.5 percent per year. This seems to be close to real returns to capital of machinery owners in the area and would also correspond to average inflation and risk adjusted returns on capital in barley production - the major crop. Land values were computed as a residual return in the best competing alternative, since land is assumed to be the major limiting resource in the area. For example, to calculate the opportunity cost of land in wheat, a residual value to land in its best alternative, barley, was calculated. The residual return to land in wheat production was 8,500 pesos/ha, which was then employed as the opportunity cost of land in maize and barley production.

Outputs were also divided into tradeable and nontradeable components. The grain produced was valued at its import price adjusted for transport costs. Transport costs were divided into fuel, a tradeable, and nonfuel items which were regarded as nontradeable. Domestic production of grain produces a benefit in savings of transportation

Table 5.5 Calculation of Resource Cost Ratios in Tlaxcala, 1984.

	Wheat	Barley	Maize
	(Pesos/ha)	(Pesos/ha)	(Pesos/ha)
Inputs:			
Tradeable			
Machinery depreciation	7020	7020	1970
Fuel	4940	4940	2410
Spare parts	5570	5570	1660
Other inputs	12950	12950	6980
Nontradeable			
Machinery maintenance (labor)	1860	1860	550
Labor	2060	2060	9890
Animal Power	0	0	5590
Capital	20760	20760	14420
Insurance	9700	9700	9700
Land-Opportunity Cost a/	1070	8330	8330
Outputs:			
Tradeable			
Grain (CIF)	69040	60230	43230
Fuel for transport b/	1080	1000	810
Nontradeable			
Straw	0	2880	2700
Non-fuel transport costs b/	3490	3230	2610
National Profitability	7270	-7270	-12550
Opportunity Cost Domestic Resources c/	32360	37010	43570
Value Added (Tradeables)	39624	29740	31020
Resource Cost Ratio	0.82	1.24	1.40

a/ Residual return to land in best competing alternative valued at world price equivalent, i.e. barley in the case of wheat and wheat in the case of barley and maize.

b/ Net transport costs to bring imported grain to Mexico City less cost of transport from Tlaxcala. Fuel for transport is valued at world prices.

c/ Sum of nontradeable inputs less nontradeable outputs.

costs of imported grain to the consuming point. Straw was treated as a nontradeable and valued at its actual farm price.

The result of all these calculations for Tlaxcala produce no surprises given our earlier discussion of policy incentives and farmer profitability. We have seen that despite favorable maize prices, farm level profitability of maize is very low or negative. Relative to wheat, yields are lower, world prices lower and costs higher; therefore the resource cost ratio has to be above one. Likewise for barley, relative to wheat, world prices are usually slightly lower, yields slightly lower and costs the same. Hence, wheat has a resource cost ratio slightly below one and barley slightly above one. The only exception was in 1975 (Table 5.6) when world prices for malting quality barley were higher than for wheat.

Table 5.6 Resource Cost Ratios for Wheat, Barley and Maize, Tlaxcala

Year	Wheat	Barley	Maize
1975	1.12	.85	2.20
1981	.88	1.07	1.90
1982	.83	1.06	2.32
1984	.82	1.24	1.40

Based on the above analysis of comparative advantage, there is a strong case for promotion of research and extension in wheat production in Tlaxcala/Hidalgo. There is a comparative advantage in production of wheat relative to barley and its development would be consistent with the government's food security objective. The major obstacles that need to be overcome are a) a price incentive for wheat that reflects its cost of importation relative to barley, b) a marketing system that effectively transmits these prices to farmers and c) a variety that reduces risks relative to barley, especially one with early maturity and disease resistance.

Considerable productivity gains need to be achieved for maize in the Tlaxcala region to become competitive, from the national perspective. With no change in fertilizer application, maize yields would have to increase by around 0.5 ton/ha to become competitive with wheat, an increase of over 30 percent. If we allow for a higher fertilizer dosage of 100-50-0 of NPK, an average yield of maize of 2.4 ton/ha is needed to compete with wheat. There are prospects, however of reducing costs of maize production through reduced tillage and chemical weed control.

5.3 Farm Budgets and Returns for Sonora

A similar methodology was used to calculate returns in the case of Sonora. The situation is of course more complicated because of a larger number of crops and crop combinations. The number of operations performed on each crop is also larger. Some simplifying assumptions had to be made. For example, we did not attempt to calculate detailed costs for a mechanical cotton harvester. Rather we assumed that these costs bear the same relationship to each other as in the case of mechanical wheat harvesting. Likewise many different insecticides are used. We noted that one insecticide application for cotton and soyabeans usually costs double that for wheat and safflower and used this relationship for each year.

The technical parameters and prices used in Sonora are shown in Table 5.7 and 5.8 for the 1984-85 cycle. This leads to budgets for 1984-85 shown in Table 5.9 and estimated gross margins and real returns on capital for several years (Table 5.10).

Wheat consistently provided good returns to farmers. Gross margins for wheat increased each year, even when adjusted for high levels of inflation. (In 1982/83, land preparation, planting, and many inputs were purchased before the sharp price rises of late 1982). Real returns on capital including land rents in wheat production have been 20-35 percent from 1981 to 1985 Gross margins and returns on capital were higher for cotton in most years. However, profitability of cotton was subject to considerable price risk. (Yield risk is also higher but that is not considered here). In particular, cotton was unprofitable relative to a

Table 5.7 Mechanical Operations and Inputs Used in Constructing Farm Budgets, Sonora, 1985.

	Wheat	Safflower	Cotton	Maize	Soya
Mechanical Operations (number/ha)					
Chopping	0	0	1	0	0
Plow	1	1	1	1	0
Harrow	3	3	3	3	2
Levelling	2	1	2	1	1
Furrowing	0	2	4	2	2
Cultipacker	0	0	1	0	1
Planting	1	1	1	1	1
Cultivation	0	2	4	2	2
Fertilizer Application	1	1	1	1	1
Insecticide and Herbicide Application	2	1	3	1	2
Making Borders	1	1	1	1	1
Making Canals	1	1	1	1	1
Harvesting	1	1	1	1	1
Total Tractor Hours/ha	12.15	14.85	25.05	14.85	13.55
Total Combine Hours or Equiv./ha[a]	1.25	1.44	7.5	1.66	1.44
Labour (days/ha)					
Finishing Borders	.7	.7	.7	.7	.7
Clearing Canals	1.2	1.2	1.2	1.2	.6
Weeding	0	1.3	9	4	6
Irrigation	4.5	2.4	6.6	4.5	6.6
Thinning	0	0	1	0	0
Harvesting	0	0	0	5	0
Total Labour Days/ha[b]	7.9	7.5	21.6	17.3	15.6
Inputs					
Seed (kg/ha)	170	20	50	20	100
Nitrogen (kg/ha)	190	110	190	150	65
Phosphorous (kg/ha)	46	46	46	46	46
Herbicide (No. of Applic.)	2	0	0	0	0
Insecticide (No. of Applic.)	1	1	3	1	2
Yield (ton/ha)	4.75	2.0	3.0[c]	3.75[d]	2.0

a/ Conversion made on the basis of rental charges for harvesting of each crop.

b/ Includes tractor driver's labor, assuming 8 hours per day.

c/ Yield of seed cotton, assumed to be 33 percent lint.

d/ Yield for August planting.

Note: Year 1985 refers to the 1984-85 crop cycle.

Table 5.8 Farmer Prices and World Price Equivalent of Inputs and Outputs, Sonora, 1985.

	Farmer Price	World Price Equivalent
<u>Inputs</u>:		
Urea (pesos/kg)	27.5	67.7
Triple Superphosphate (pesos/kg)	32	56.1
2, 4-D Herbicide (pesos/lt)	2115	2115
Insecticide - Wheat (pesos/application)	2380	2380
Insecticide - Cotton (pesos/application)	4280	4280
Seed - Wheat (pesos/kg)	62	62
- Safflower (pesos/kg)	103	103
- Cotton (pesos/kg)	156	156
- Maize (pesos/kg)	85	85
- Soyabean (pesos/kg)	120	120
Tractor ('000 pesos)	3800	3800
Combine ('000 pesos)	25575	23250
Diesel (pesos/lt)	32	46.8
Bank Interest (%/year)	36	67.5
Labour (pesos/day)	975	975
Water (pesos/ha) (for wheat)	5720	17160
<u>Outputs</u>:		
Wheat (pesos/kg)	37	37.6
Safflower (pesos/kg)	63	36.3
Cotton (pesos/kg) a/	343.5	343.5
Maize (pesos/kg)	37	36.3
Soyabean (pesos/kg)	82.7	64.6

a/ Net price of lint, with cotton seed price offsetting cost of ginning.

Note: Exchange rate US$1.00 = 275 pesos.
Year 1985 refers to the 1984-85 crop cycle.

Table 5.9 Farm Budgets for Wheat, Safflower, Cotton, Maize and Soya, Sonora, 1985

	Wheat	Safflower	Cotton	Maize	Soya
			(pesos/ha)		
Machinery Costs					
Depreciation	8720	10350	34760	11110	9800
Cost of capital	3600	4280	13720	4580	4040
Fuel	5840	7080	15520	7240	6460
Spare parts and maintenance	9270	11030	35900	11790	10410
Driver	3340	4060	8390	4130	3690
Labour	6240	5460	18040	15020	13550
Inputs					
Seed	10540	2060	7800	1700	12000
Fertilizer	14560	9780	14560	12170	7090
Herbicide and Insecticide	6610	2380	12850	2380	8570
Others					
Water Charge	5720	6690	5780	3190	8140
Insurance	3190	5670	7260	4900	5390
Subsidy on Inputs	0	0	0	5900	0
Miscellaneous	600	600	1300	600	600
Transport to Market	1690	1510	2500	1500	1950
Interest	8450	7500	19000	7870	9690
Land	28000	28000	50400	28000	28000
Total Variable Cost	88370	78440	197380	82270	101380
Gross Revenue	175750	126000	343500	138750	165400
Gross Margin	87380	47570	146120	56480	64020
Return on Capital (%)	55	25	43	32	33

Note: Year 1985 refers to the 1984-85 crop cycle.

Table 5.10 Farmers Returns by Crop, Sonora, 1977 to 1985.

Year	Wheat	Safflower	Cotton	Maize	Soya
		Real Gross Margins (1981 Pesos/ha)			
1977	9445	5121	36474	3698	10363
1981	9725	4440	12354	4326	8047
1982	11667	6759	34712	4976	8316
1983	12301	6421	27959	2545	7511
1985	14224	7743	23790	9190	10420
		Real Returns on Capital (percent/cycle adjusted for inflation)			
1977	na	na	na	na	na
1981	22	-12	3	-13	13
1982	34	- 1	78	-21	10
1983	32	-17	35	-58	0
1985	15	-15	3	-9	-7

na = not calculated because no rental value for land was available.

Note: Year 1985 refers to the 1984-85 crop cycle.

wheat-soya bean rotation in 1981 and 1985 when cotton prices were low because of the overvalued peso. In other years, wheat-soya beans returned less than cotton.

Soyabeans were also a profitable crop although less so than wheat and cotton. Of course soyabeans are a short season crop so that gross margins or returns on capital on a monthly basis are more favorable[1/].

Safflower and maize were generally unprofitable crops. Gross margins for safflower were only about half of those for wheat and returns on capital were negative. The area sown to safflower usually reflects problems in wheat such as missing the wheat planting date,

1/ Our results for soya beans for 1982 and 1983 are overestimates since we have used the same input prices as for wheat even though six months of rapid inflation resulted in substantially higher costs for soya beans.

severe weed problems or water problems. Safflower yields were also higher on alluvial soils providing a stronger position to compete with wheat. Maize is generally a minor crop. The incentives of SAM in the early 1980s led to some improvement in returns but this has been eroded more recently. Maize is usually harvested from January to March and sold before the new guaranteed price is fixed.

5.4 Resource Cost Ratios in Sonora

The methodology used to calculate resource cost ratios was adjusted to Sonora to take account of the fact that water, not land, is often the limiting factor. In the absence of reliable data, we assumed that water costs were subsidized by 67 percent which is probably a conservative assumption. We then calculated returns to land as a residual to represent the case where land is limiting. Here we assumed that wheat, safflower, cotton and winter maize competed for land. Likewise, summer maize and soyabeans compete for the same land. Hence, in evaluating the best alternative for land we considered two different seasons of the year. In the case in which water is limiting we allowed all crops to compete. Cotton was assumed to require 50 percent more water than wheat, while summer maize and soyabeans requirements were 25 percent above wheat. Safflower was assumed to require 20 percent less water and maize (winter) was assumed to use the same amount of water as wheat.

The calculation of resource cost ratios is given in Table 5.11 and results for five years are provided in Table 5.12. An important result is that safflower, soyabeans and maize provided negative national returns to land and water in 1981, 1982 and 1985. That is, if the land and water is assumed to have no value, (and no cost in the case of water) the value of output of these crops (at world price equivalent) was not sufficient to cover the cost of tradeable inputs (at world price equivalent) and labor and capital used in their production. This is in spite of the fact that we have used the favorable assumption that products of these crops (except safflower oil) are consumed locally and therefore only incur local transport costs. Returns were positive for safflower and soyabeans in 1977, which was a year of unusually high oil

Table 5.11 Calculation of Resource Cost Ratios, Sonora, 1985.

	Wheat	Safflower	Cotton	Maize	Soya
			(pesos/ha)		
Inputs					
Tradeables					
Depreciation	8330	9900	32430	10600	9350
Fuel	8540	10530	22700	10580	9450
Spare parts	6660	7940	25190	8460	7470
Inputs-Seed, Fert., Chem.	50720	26240	54230	31770	35740
Nontradeables					
Maintenance	2220	2645	8400	2820	2490
Labor	9580	9520	26430	19140	17250
Water[a]	17160	13730	25740	21450	21450
Other-Misc.	9210	7120	8580	8450	7120
Capital (Interest)	30590	24640	58470	31330	30730
Land	81060	81060	35130	nc	nc
Outputs					
Tradeables (grain, etc.)	221990	108210	343500	136130	129200
Transport					
Tradeable	8610	1230	0	0	0
Nontradeable	34770	4980	0	0	0
Total Outputs-Inputs (except land)	35130	-10260	81060	-8860	-12040
Returns/m^3 water (pesos/m^3)	615	61	834	149	74
Resource Cost Ratio (land limiting)	1.3	2.7	0.8	nc	nc
Resource Cost Ratio (water limiting)	1.1	1.8	0.9	1.8	2.5

a/ Charge for water with land the limiting resource
nc = not calculated because returns on land were negative

Table 5.12 Resource Cost Ratios for Various Crops, Sonora, 1977-1985.

	Wheat	Safflower	Cotton	Maize	Soya
Land Limiting					
1977	2.5	2.7	.5	4.4	1.3
1981	1.0	-ve	1.0	2.1	-ve
1982	.7	-ve	1.2	-ve	-ve
1983	1.3	4.4	.8	2.3	1.0
1985	1.3	2.7	.8	-ve	-ve
Water Limiting					
1977	1.9	.8	.6	1.8	1.6
1981	.7	-ve	1.2	-ve	-ve
1982	.7	-ve	1.4	-ve	-ve
1983	1.0	2.1	1.0	1.6	2.8
1985	1.1	1.7	.9	1.8	2.5

seed prices and unusually low wheat prices. Returns were also positive in 1983 when the value of traded items increased much more rapidly than that of non-traded items because of the sharp devaluation. However, if water is limiting, none of these crops compete with wheat or cotton.

Wheat and cotton clearly have the comparative advantange in Sonora, whether land or water is assumed to be limiting. If land is limiting, cotton has the advantage in three years and wheat the advantage in one. If water is limiting, wheat has the advantage in two years and wheat and cotton are equal in 1983. These years represent world prices for cotton lint ranging from 6.8 to over 10 times the CIF price of wheat. World cotton/wheat prices generally have stayed in this range except in the unusual period of 1974-76. Hence, we can conclude that wheat competes strongly with cotton in most years. These results contrast with the high resource cost ratios calculated for wheat relative to cotton in Egypt and Pakistan. The high yield levels for wheat in Sonora distinguished the Mexican case.

The question arises as to what extent our negative results on oil seeds are sensitive to assumptions about yields and prices. Sensitivity analysis on soyabeans in 1982 indicated that yields would have to reach 2.75 t/ha to cover all costs (except land). Yields would need to be 3 t/ha to allow soyabeans to compete with wheat and cotton in water use. Alternatively, the world price of soyabeans would have to increase to double the wheat price - that is a price of US$400/ton in 1984. This has only occurred in very unusual years in the past. Researchers will therefore need to judge the chances of soyabean yields reaching 3 t/ha if soya beans is to make a positive contribution to national income.

In considering the results on oilseeds and maize, note that their opportunity costs within a rotation are probably much lower than that implied in Tables 5.11 and 5.12. Firstly, we have assigned costs of fixed resources, capital equipment, farmer labor and water, proportionately to all crops according to their physical and capital requirements. If farmers were to grow only wheat and cotton and no other crops, they would only be able to grow two crops in two years. The other crops permit a third one to be grown in the two-year rotation which leads to a higher utilization of the capacity of farm and regional resources. When all fixed costs assigned to these rotational crops were deleted from their budgets of national profitability, they all yielded sizeable positive returns to the nation. In rotation, soyabeans appears an attractive option. This is especially the case where there are other potential spinoffs from these crops, including reduction of production risk, greater utilization of capacity of the farm service sector, and some potential biological benefits - especially reduction of disease incidence and improvements in soil structure.

Finally, although wheat and cotton clearly provide positive returns measured in their contribution to national income, it should be noted that returns to investment in new irrigation systems appear low, especially in the case of wheat. Assuming that it costs MEX$500,000/ha in 1983 to develop new land, the residual return on land of wheat was only about a 2 percent return on the capital investment. However, if existing water supplies could be rationed to irrigate a larger area (by higher prices for water), the additional areas of crop grown in most years would probably yield a much more attractive return on the investment in irrigation.

6.0 Conclusions

Wheat is an increasingly important food crop in Mexico as consumers with rising incomes, particularly urban consumers, switch from maize to wheat products. Although wheat production in Mexico expanded rapidly during the 1960s and to a lesser extent in the 1970s, imports of food grains have continued to increase in contrast to the decade of the 1960s when Mexico was a food exporter. Projections of increased demand for wheat products suggest increasing pressure will be placed on expanding domestic wheat production. Expansion of wheat production in irrigated areas will be limited to yield increases unless wheat substitutes for competing crops. This raises the question of whether research and policy should give more attention to rainfed wheat production.

The results of this paper clearly show the substantial involvement of government in setting output and input prices in the Mexican wheat industry. In general, Mexican wheat producers have been taxed by receiving prices below world prices for wheat. This is particularly the case in Tlaxcala, which has a transportation advantage relative to the main wheat producing areas in the Northwest. Policy has also led to changed price relationships with other crops. In most cases farmers have received prices higher than world prices for competing crops, especially maize and oilseeds. At the same time, cotton prices have been subjected to an overvalued exchange rate which has reduced real cotton prices in most years of the 1970s.

To some extent, government policy has compensated producers through subsidies on inputs. Subsidies on fertilizer, diesel fuel, credit, seed (in rainfed areas) and water (in irrigated areas) all exceeded 50 percent in the period 1979-82. Such high levels of subsidies, however, have encouraged inefficient use of inputs and high costs (in terms of national resources). Moreover, except for the incentives provided under SAM in 1981 and 1982, a large proportion of these subsidies have benefited the relatively wealthier farmers of Sonora.

Based on world prices, wheat appears to be a competitive crop in both Tlaxcala and Sonora. In Sonora over the long run, cotton probably provides higher economic returns if land is regarded as the limiting factor. However, given that water is often limiting and that world cotton prices are subject to substantial year to year variation, the case for wheat is more favorable. Because a wheat-cotton rotation is desirable from an agronomic viewpoint there is a strong case for promoting wheat and cotton. In many years Mexico has suffered a net foreign exchange loss due to reduction in cotton area as a result of an overvalued exchange rate.

The remaining crops, oilseeds and maize, seem to have no comparative advantage in Sonora. In fact, at world prices they provided a negative national return to the resources of land and water used in their production when treated as competitors for resources with wheat and cotton. However, when one of these crops is fitted into a two-year wheat-cotton rotation, this third crop does not necessarily compete with cotton or wheat, and indeed may have some complementary benefits. In this case, soyabeans appears an attractive third crop unless water is severely limiting. Technological improvements in soyabeans and safflower would further add to the value of these crops in rotation. For wheat in Sonora, a major research opportunity posed by this study is to find ways to reduce production costs. With government policy now committed to reducing subsidies there is a need to look for ways to more effectively use water, fuel (through reduced tillage) and fertilizers.

In Tlaxcala, wheat production also has a comparative advantage relative to other crops, especially maize. This potential for wheat has not yet been realized partly because price policies have not encouraged wheat (except in 1981) and partly because suitable wheat varieties have still to be developed. Even with appropriate varieties, wheat would still be a slightly more risky crop (because of its longer growing cycle) relative to barley, so some type of wheat-barley rotation has advantages for the farmer. The favorable profitability of wheat to the nation of rainfed wheat in Tlaxcala in relation to competing crops and to irrigated wheat is a strong justification for expanding wheat research and production programs for the rainfed areas.

APPENDIX A. Measures of Comparative Advantage and Policy Incentives

Measures of Comparative Advantage

Measure	Definition	Interpretation
1. National Profitability	$P_i^w - \sum_j a_{ij} P_j^w - \sum_k a_{ik} MPP_k^y P_y^w$	Efficient if NP > 0
2. Resource Cost Ratio (RCR)	$\dfrac{\sum_k a_{ik} MPP_k^y P_y^w}{P_i^w - \sum a_{ij} P_j^w}$	Efficient if RCR < 1 Represents rate of transformation between domestic resources and the value added at world price equivalents.
3. Domestic Resource Cost (DRC)	$\dfrac{\sum_k a_{ik} MPP_k^y P_v^d}{P_i^f - \sum_j a_{ij} P_j^f}$	The numerator is expressed in domestic prices and the denominator in foreign currency. Efficiency is designated when the DRC is less than a DRC shadow exchange rate.

Measures of Policy Incentives

Measure	Definition	Interpretation
1. Nominal Protection Coefficient (NPC)	$\frac{P_i^d}{P_i^w}$	Ratio of domestic producer price to border price. Protection on output price where NPC > 1.
2. Effective Protection Coefficient (EPC)	$\frac{P_i^d - \sum_j a_{ij} P_j^d}{P_i^w - \sum_j a_{ij} P_j^w}$	Ratio of value added at domestic prices to value added at border prices. EPC > implies protection on output and tradeable inputs and is a measure of potential incentive or disincentive.
3. Producer Subsidy Equivalent	$\frac{(P_i^d - P_i^w) + (\sum_j a_{ij} P_j^w - \sum_j a_{ij} P_j^d) + \sum_k S_k}{P_i^w}$	Measure of overall effects of taxes and subsidies on producer prices, input prices and resource costs. Producer taxed if PSE < 0.
4. Consumer Subsidy Equivalent	$\frac{P_i^{w*} - P_i^{d*}}{P_i^{w*}}$	Measures of distributional effects of government policies between consumers and producers.

Definition of Terms

P_i^d = domestic producer price of output i

P_i^w = world price (cif or fob) of output in local currency adjusted by transport cost to the farmgate

P_i^f = world price of output i in foreign currency, adjusted for transport cost

P_j^d, P_j^w, P_j^f = domestic and world prices (local currency) and world prices (foreign currency) for tradeable input j, adjusted by transport costs

P_y^d, P_y^w = domestic and world prices for y^{th} output from alternative use of k^{th} resource

MPP_k^y = marginal physical product of the k^{th} resource in its alternative use, y

a_{ij} = quantity of j^{th} input needed to produce one unit of i

a_{ik} = quantity of k^{th} resource needed to produce one unit of i

P_i^{d*} = domestic consumer price of output i

P_i^{w*} = consumer price of output i at world prices

S_K = Subsidy per unit of output paid on resource k.

APPENDIX B. Calculation of Mechanization Costs

Mechanization costs are an important component of total production costs in both Tlaxcala and Sonora. Most small farmers (10ha or less) rent tractor services while larger farmers own their own tractors and associated equipment. Most farmers except the largest farmers rent combine harvesters and in Sonora they also rent specialized services such as aerial application of herbicides and insecticides. Rental services are provided by farmers with surplus machinery capacity and by specialized contractors. Most operators of combine harvesters, are specialized contractors whose owners often operate in both Tlaxcala and Sonora.

In order to separate out tradeable from nontradeable inputs and correct for taxes and subsidies on machinery and fuel prices we divided costs of mechanization services into the following components: a) depreciation b) capital costs c) fuel costs d) maintenance and repair costs and e) operator's labor. These costs were calculated per hour of machine use as follows:

a) Depreciation.

$$D = [(1-v)P_a]/nh$$

where D = depreciation cost per hour

v = salvage value of machine as a proportion of acquisition value

P_a = <u>current</u> acquisition value of machine

n = number of years of life of machine

h = number of hours worked per year

b) Capital Cost

$$C = i[(1+v)P_a/2]/h$$

where C = capital cost of machine per hour

i = <u>real</u> cost of capital

Other variables are as defined above

c) Fuel

$$F = .17\ p\ A$$

where F = Fuel cost/hour of machine use

p = horse-power of machine

A = price of fuel/lt

d) Maintenance and Repairs

$$M = mP_a/nh$$

$$M_t = .75\ M$$

where M = maintenance and repair cost per hour

m = coefficient of maintenance for life of machine

M_t = nonlabor (i.e. spare parts) component of maintenance

Other variables are as defined above

e) Operator Labor

$$L = bw/8$$

where L = operator labor costs per hour

b = operator wage relative to minimum wage

w = minimum wage per day

f) Total Cost/ha

$$T = c(D_t+D_i+C_t+C_i+F_t+M_t+M_i+L_t)$$

where T = total machinery cost per hectare for a task

c = Number of hours per hectare required for task and t and i are subscripts representing the tractor and implement respectively.

The method uses simple straight line depreciation. The capital recovery formula was also tried and gave almost identical results. However, this formula does not allow a separation of capital and depreciation charges. We also elected to use the current price of machinery combined with a real interest rate to take account of the effects of inflation.

In Sonora some 20 different operations are performed mechanically and hence it was not possible to calculate mechanical costs for each individual operation as this would have involved excessive detail on such matters as the fuel consumption of an aeroplane used for crop spraying. Hence, we calculated the costs per tractor-hour for ploughing and then assumed that these costs were constant for other operations. Costs for other operations were calculated by multiplying hours required for the operation by the cost per hour for ploughing. In the case of combine harvesting we charged all costs in proportion to the respective rental rates for each crop. Aerial applications were represented by equivalent cost of terrestial applications.

Parameters used in the calculations are from the following sources: a) field interviews with machinery owners in each region, b) calculations made by Massey-Fergusson-Mexico and FIRA, Banco de Mexico and c) guides used by the American Agricultural Engineering Society. The field interviews indicated a great deal of variability in costs. The major parameters selected are shown in Table A.1. These are the same for both regions except that Tlaxcala tractor operators tend to work less hours annually than Sonora operators because only one crop cycle per year is possible.

These parameters combined with prices for machinery, fuel and labor simulated quite well the actual rental costs observed in farm surveys. This is shown in Table A.2. In the case of tractors, owner returns on capital have tended to decline over time, especially in Tlaxcala. This may be due to greater competition for rental services as the number of tractors has increased. Also, credit at negative real rates of interest has become increasingly available in recent years for machinery purchase.

The estimated cost of combine harvesting is very close to the actual cost in Sonora. In Tlaxcala, in 1982, combine rental costs failed to keep pace with the rapid increase in prices of combines as a result of currency devaluation.

Table B.1. Parameters Used to Calculate Machinery Costs

	Symbol	Tractor	Plough	Combine
Horsepower	p	75	0	130
Salvage Value	v	.2	.2	.2
Years Life	n	8	8	10
Hours/year-Sonora	h	1500	500	600
Hours/year-Tlaxcala	h	1300	300	400
Coefficient of Maintenance	m	.9	.9	.8
Real Interest Rate	i	.075	.075	.075
Relative Wage	b	2.0	0	2.5

Table B.2. Comparison of Estimated Cost of Machinery Use with Actual Rental Cost and Owner's Return on Capital

Year	Ploughing Estimated Cost	Ploughing Actual Cost	Combine Estimated Cost	Combine Actual Cost
	(Pesos/ha)		(Pesos/ha)	
		SONORA		
1977	287	300	476	460
1979	364	400	610	600
1980	393	450	669	650
1981	519	500	825	900
1982	705	700	1438	1500
1983	1123	1100	4492	4500
1985	5353	5462	10877	12392
		TLAXCALA		
1975	172	201	236	300
1979	412	400	668	600
1980	491	501	733	800
1981	573	534	895	900
1982	971	1000	2652	1500
1983	1978	2000	5278	na
1984	4790	4415	11330	7500

na = not available

In calculating farm budgets we used actual rental rates, while for calculating resource cost ratios we used estimated costs following the above formulas, with fuel and machinery prices set at border prices. This calculation method resulted in two capital costs - a capital cost on fixed investment in machinery and a charge on working capital. The farmer who rents machinery would normally be charged a capital cost on rental charges as part of normal costs of working capital. A farmer who owns his own machinery incurs the same cost but as an opportunity cost; by using the machine on his own farm he forgoes the opportunity to earn money from renting it outside.

APPENDIX C. Computing the CIF Price of Safflower

Little safflower is traded in world markets. However, safflower is a tradeable commodity because both its principle processed products, safflower oil and safflower seed cake compete closely with traded commodities such as sunflower oil or soyabeans cake.

In order to compute the equivalent CIF price of safflower we made the following assumptions:

1. Safflower oil and sunflower oil were assumed to be perfect substitutes and safflower oil was valued at the same CIF price as sunflower oil.

2. The value of different oilseed cakes was estimated to be proportional to the protein content. Soyabean cake with protein content of 44 percent is the main traded oilseed cake. Safflower seed cake was discounted to reflect the fact that its protein content is only 2[illegible] percent.

3. The CIF price of safflower was then imputed using the information that safflower is 34 percent oil and 66 percent oilseed cake. Furthermore, this value was discounted by 23 percent to reflect costs of processing safflower into oil and cake.

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