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Implications for U.S. Farm Labor and Land Markets of the Free Trade Agreement with Mexico

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While most analytical work on the North American Free Trade Agreement (NAFTA) and agriculture has concentrated on effects in commodity markets, the consequences for the well-being of people who make their living in agriculture depend ultimately on factor demands and factor prices under NAFTA. Particularly important are returns to labor, both of farm operators and hired farm workers, and to land. This paper assesses the prospects for farm wages and employment, and for the land market, in the United States.

Current Situation and Trends

Hueth, Just and O'Mara (1993) emphasize that NAFTA is not being introduced into a static policy environment with respect to commodity policy and trade. The same is true for factor markets. U.S. immigration law, policies with respect to illegal aliens, and programs for temporary agricultural workers have all seen significant changes in the last decade. Mexico's policies with respect to transactions in land and capital flows have been liberalized as part of its general move toward a more open and market oriented economy. These developments complicate the assessment of NAFTA's effects, since NAFTA's effects must be disentangled from trends that are already under way and are likely to continue even without NAFTA.

The most important of these trends involve employment and wages in the U.S. hired farm labor market. The number of hired farm workers has been declining for many years. Farm wage rates rose impressively in real terms between 1950 and the mid-1970s; but since 1975 real farm wage rates have stopped increasing (figure 1). One hypothesis for explaining the change in 1976-1991 is increased immigration of farm workers (both legal and illegal), principally from Mexico. The Current Population Survey of the U.S. Department of Commerce estimated in 1990 that 29 percent of U.S. farm workers, and 65 percent in the Pacific region, were Hispanic. These percentages are probably underestimates (see Oliveira, 1992). Two recent policy changes, one in the United States and one in Mexico, will influence the future supply of U.S. farm laborers from Mexico irrespective of NAFTA. The U.S. policy initiative is the U.S. Immigration Reform and Control Act (IRCA) enacted in 1986. This Act granted amnesty to illegal aliens who had lived in the United States since 1982, but tightened the restrictions on employment by requiring employers to establish the identity and employment eligibility of each prospective employee and maintain records on all employees. Employers had to be in compliance by December 1, 1988, subject to penalties up to $10,000 for violations.

Because these provisions created the possibility of seasonal labor shortages in agriculture, the IRCA modified the temporary agricultural worker (H-2) program to permit employment of foreign workers if needed. In addition, IRCA created the Special Agricultural Workers (SAW) and Replenishment Agricultural Workers (RAW) programs to regulate the use of foreign agricultural workers, and adjust their number to "needs" as determined by the U.S. Departments of Agriculture and Labor, with intentions to ensure that employment of aliens will not adversely affect the wages and working conditions of workers in the United States.

In Mexico, the policy changes are not so directly related to cross-border labor movement, but may be equally important. Perhaps most important is the post-1990 removal of restrictions on the sale and rental of farmland by ejidos, who received lands for their use under earlier

Mexican land reforms which expropriated large landholdings and distributed them among landless peasants. The hypothesis is that under the new law many of these peasants might profitably lease or sell their small holdings and engage in hired farm work elsewhere, in many cases in the United States.

There has as yet been no detailed assessment of the consequences of either IRCA or economic liberalization in Mexico on the U.S. farm labor market. The most reliable and consistent data on the U.S. hired farm work force, from the July employer survey of USDA's National Agricultural Statistics Service, indicate a continued trend toward fewer agricultural workers (Figure 2). It is notable, however, that during the post-IRCA period, after 1985, the rate of decline is less. It cannot, however, be concluded that IRCA caused an increase in hired workers through its temporary worker programs (despite tightening up on employment of illegal aliens). Too many other economic factors are involved, including the general recovery in farm income from the low levels of 1982-85.

A further indication that an increase in the supply of labor is not the cause of the post-1985 leveling off of hired farm worker numbers is that real wage rates in farm employment rose slightly in this period (figure 1).

A problem in explaining these farm wage data, and more generally in modeling the likely consequences of NAFTA in future years, is the extent to which farm labor is a specific factor to agriculture, with a farm wage rate differing from the wage rate of workers with comparable skills in nonagricultural employment. Clearly the ratio of farm to nonfarm wage rates varies over time. The ratio of the average agricultural wage to the average wage of nonsupervisory positions in nonagricultural employment has risen about 20 percent over the past 30 years. And since 1985 farm wages have risen faster relative to nonfarm wages than farm wages have risen in real dollars. The reason is that real nonfarm wages actually fell between 1985 and 1991.

With respect to returns to land, the analytical situation is simpler in that cropland is undoubtedly a specific factor to agriculture. Land prices have been more volatile than farm wage rates, more than doubling in real terms between 1960 and 1980, and then falling back to roughly their 1970 level during 1987-92 (figure 4). The question with respect to NAFTA is whether it would move land prices and rental rates from relative stability of the last five years, and if so, in what direction and how much?

Modeling the Effects of NAFTA

Our approach to modeling the effects of NAFTA is first to estimate percentage changes in U.S. farm employment, wage rates, and land prices, and second to apply these percentage changes to a 1994-1998 no-NAFTA baseline. Forecasting events of the next 5 years with any hope of accuracy is not feasible; the intention of the baseline is simply to have a frame of reference for the NAFTA effects.

For land prices, we use a baseline that simply extrapolates current trends to the 1994-1999 period. Our baseline for farm employment extrapolates the 1978-91 trend rate of decrease to 1999. This means a slightly more rapid rate of decline in employment than occurred in 1986-1991, on the grounds that this short period is influenced by the recovery from the mid-1980s farm crisis and the introduction of IRCA. The baseline for farm wage rates maintains the real farm wage rate at the 1991 level — essentially the level that has prevailed since 1980.

The factor market effects of NAFTA are treated in this study as indirect in the sense of being derived entirely from changes caused by reduced protection in product markets in Mexico and the United States. The "side agreements" negotiated in 1993 might have some effects on capital flows and investment, but IRCA and other U.S. legislation governing labor movement between the two countries are assumed to function in the same way with or without NAFTA.

The effects of changes in product-market protection on factor markets can be estimated using either a partial or general equilibrium model. The simplest partial equilibrium approach takes estimates of trade flows caused by NAFTA, and adds or subtracts the labor required according to an "employment multiplier" derived from existing worker per unit output data. This is the approach taken in most of the U.S. government analysis of job creation and job displacement under NAFTA, including the ERS analysis of job creation in agriculture (Baumes, 1993).

A more complete partial equilibrium approach considers the change in export demand or import supply as shifters of the demand for U.S. labor and land, and simulates the effects in the factor markets using econometrically estimated labor and land demand and supply functions. This is the approach used to analyze the effects of temporary farm worker programs in Morgan and Gardner (1981).

The general equilibrium approach adds three important features. First, it explicitly incorporates factor use in the whole economy, and the relationship between wage rates in different sectors (usually assuming that wages are equal in all sectors). Second, it explicitly models aggregate factor income, and the feedback to commodity demand and product prices. Third, it equilibriates domestic general equilibrium with endogenous trade flows. While these generalizations of the partial equilibrium approach are theoretically well founded, even necessary, their empirical implementation is problematical, for reasons to be discussed in the context of the existing literature.

Previous Analyses of NAFTA and Factor Markets

A large number of studies have already attempted to explain the effect of a potential NAFTA agreement on trade, economic growth and factor returns in the U.S. and Mexico. Many have focused particularly on labor issues. These studies have varied significantly in modelling approach, sectoral focus, trade liberalization scenarios, and results obtained.

Hinojosa-Ojeda and Robinson provide an overview of the linkages between the U.S. and Mexican economies and survey a selected cross-section of studies on the labor impacts of NAFTA. They note that factor market linkages, especially labor flows, actually represent a more extensive linkage between the two economies than does trade in goods. Some U.S. and Mexican labor market segments are so linked that employment levels, working conditions, and wage rates exist in an equilibrium that spans both sides of the border. Since World War II, at least ten percent of the growth in the U.S. labor supply has been due to Mexican migration, a natural result given that the growth rate in the Mexican labor force is significantly higher than that of the U.S.. These demographic trends are likely to continue for the foreseeable future.

Although Hinojosa-Ojeda and Robinson look at three types of models (partial equilibrium, single-country computable general equilibrium (CGE), and multicountry CGE), they argue strongly for the use of the general equilibrium models in analyzing the effects of NAFTA. The Congressional Budget Office (CBO) also reviews a wide range of studies and concludes that the general equilibrium approach is favored by a majority of economists in analyzing NAFTA. Trade issues have traditionally been analyzed using a two-sector, two-factor general equilibrium model and multi-commodity, multi-factor generalizations. The general equilibrium model points to a number of potential results that partial equilibrium models do not readily provide, including the Stopler-Samuelson theorem, the Rybczynski theorem, and factor price equalization.

The Stopler-Samuelson theorem states that an increase in the price of one commodity, *ceteris paribus*, is sufficient to cause an increase in the real returns to at least one factor of production. Under certain conditions, returns to another factor may actually fall in absolute terms. In the 2x2x2 model (two commodities, two factors, two countries), the factor used most intensively in the production of the commodity favored by trade liberalization enjoys an increase in real returns while the real return to the other factor falls.

Jones and Scheinkman extend the Stopler-Samuelson result to the multi-factor, multi-commodity case where the number of factors need not equal the number of commodities produced. In the absence of joint production, the percentage change in commodity prices are bounded by the largest and the smallest factor price changes:

$$\hat{w}_i > \hat{p}_1 > \ldots > \hat{p}_n > \hat{w}_j$$

where $\hat{w}$ and $\hat{p}$ are the percentage change in factor and commodity prices, respectively. Non-joint production means that the production of each commodity requires more than one factor, with each factor being used to produce more than one commodity. However, Jones-Scheinkman provide no guidance regarding *which* factor price will increase in response to a given change in commodity prices, noting only that the exact Stopler-Samuelson effect depends "upon a description of the technology for each and every commodity-factor share and (in the case where the number of factors exceeds the number of commodities) elasticities of substitution between factors." (p. 915).

The Rybczynski theorem, in the 2x2x2 case, states that an increase in the endowment of a factor will result in an increase in the output of the industry which uses that factor more intensively and a decrease in the output of the other industry. The Rybczynski theorem does not lend itself as easily to multi-commodity, multi-factor generalizations as does the Stopler-Samuelson theorem, although generalization is possible for certain circumstances.

The factor price equalization theorem implies that the liberalization of trade between economies will result in the equalization of factor prices, even if factors cannot be traded. However, factor price equalization rests on the assumption of common technology, a somewhat unrealistic assumption in the case of trade between the U.S. and Mexico (Burfisher et. al., 1993)[1]. Where factors are mobile across borders, however, some factor price equalization will occur, regardless of technology, depending on the freedom with which factors are traded, transactions costs, and transportation costs. When factors are mobile across borders, the problem can be viewed as one of simultaneous trade in factors and goods. Trade in factors can, in turn, be viewed as a change in the factor endowments of each economy, tying the factor trade to the results of the Rybczynski theorem.

In the case of trade liberalization between the U.S. and Mexico, labor migration is the principal area of factor exchange. Both partial equilibrium and general equilibrium models have been extended to accommodate labor migration. Morgan and Gardner (1981) describe immigrant

[1]Hinojosa-Ojeda and Robinson note that Leamer argues that factor price equalization, aside from factor trade, may in fact take place between the U.S. and Mexico.

labor as an agricultural labor supply shifter in a partial equilibrium framework in studying the impacts of the Bracero Program. In this model, a simultaneous increase in the demand for agricultural commodities which used Bracero labor and a relaxation of barriers to the use of immigrant labor (such as the establishment of the Bracero program) has an ambiguous impact on wage rates, as increased commodity prices would tend to increase wages and increased labor supply would tend to decrease wage rates.

Burfisher, Robinson, and Thierfelder (1993) provide a similar extension for the general equilibrium model by deriving a single equation, based on a simple, two-factor, two-commodity model, which links changes in relative factor prices to changes in output prices and factor endowments. Their model shows that the response of wage rates to commodity price changes depends on factor intensities (i.e. the Stopler-Samuelson result) but that an increase in the labor endowment will always result in a decrease in wage rates. In the case of the U.S. and Mexico, an expansion in the U.S. labor supply comes about due to labor migration. If Stopler-Samuelson predicts an increase in the demand for U.S. rural labor (implying that labor is used relatively intensively in the U.S. agricultural sector(s) which is favored by trade liberalization), then the combined effect of good and factor trade on wage rates in ambiguous, as in the Morgan-Gardner model. Sorting out the relative strength of these two effects is also cited by Hinojosa-Ojeda and Robinson as a key empirical question regarding the wage impacts of NAFTA.

To develop realistic empirical estimates, several researchers have used CGE models. CGE techniques allow significant disaggregation in sectors and factors as well as the inclusion of features of an economy such as policy distortions or limitations on factor mobility.

CGE models are designed to simulate the full range of transactions within an economy including payments to factors and factor prices. Payments flow in a circular fashion from production activities to factors (which are owned by households, businesses, and government) to demand for products which, in turn, directs payments back to production activities. The level of disaggregation, i.e. the number of sectors, factors, and economic entities (such households, businesses, government) depends on the level of disaggregation available in the base year data and on the purpose of the CGE. For example, a study of the impact of trade liberalization on agriculture may contain significantly greater detail on agricultural sectors than other areas of the economy.

CGE models assume full employment of factors. Equilibrium is achieved through commodity and factor price adjustments (Walrasian equilibrium)[2]. As such, the results of CGE simulations are often considered to represent long run effects of the shock under consideration. Unlike macroeconometric models, which are based on Keynesian principles and assume that equilibrium is achieved through quantity adjustment, CGE models provide little, if any, insight into short run adjustment mechanisms[3]. Although a full explanation of CGE modelling and application is beyond the scope of this paper, excellent survey articles include Drud, Grais, and Pyatt and Pyatt.

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[2]CBO notes that U.S. labor markets function more effectively than Mexican markets and questions whether Mexican labor markets will achieve a full-employment equilibrium, even in the long-run.

[3]Some economists have used a dynamic CGE approach to modelling NAFTA. Unlike static CGE models, dynamic models can provide information on the path to long-term equilibrium. However, given the complexity of dynamic models, sectoral disaggregation is necessarily quite limited (CBO).

Based on their survey, Hinojosa-Ojeda and Robinson conclude, in general, that (1) the CGE models surveyed provide plausible results and (2) the changes in factor mobility (labor migration) have a much greater impact on factor returns (wage rates) than do changes in commodity trade patterns (Stopler-Samuelson effects) or factor price equalization. Moreover, CBO notes that while only a limited number of NAFTA studies consider labor migration, the magnitude of the migration response is substantial in models where it is included, suggesting that labor migration deserves wider consideration in NAFTA modeling.

Burfisher, et. al. (1993) analyze the wage rate implications of NAFTA in both the U.S. and Mexico using an 11 sector, agriculture-focused, multi-country CGE model[4]. They argue that the effect of labor migration is substantial and, depending on the circumstances, conclude that the effect of migration can outweigh the effect of commodity trade on wage rates. Labor migration is modeled by assuming that labor migrates to maintain a fixed wage differential (considering the exchange rate) between the U.S. and Mexico for relevant types of labor. Labor is assumed to be fully mobile among productive sectors in both countries. The exact level of labor migration from Mexico to the U.S. depends on three elasticities: the elasticity of labor demand with respect to the wage rate, output supply elasticity with respect to output price, and the elasticity of rural labor demand with respect to output.

[4]Sectors include: food corn, program crops, fruits and vegetables, other agriculture, food processing, other light manufacturing, oil and refining, intermediates, consumer durables, capital goods, and services. The labor market in both countries is segmented into four groups and is mobile among groups. International labor migration is between from rural Mexico to the rural U.S. or from urban unskilled employment in Mexico to urban unskilled employment in the U.S. Capital is mobile throughout each economy. Agricultural land is fixed within agriculture in both counties although it is mobile among crops.

To demonstrate the importance of labor migration in the wage effect of NAFTA, full trade liberalization is explored with and without labor migration. Without labor migration, internally within Mexico or from Mexico to the U.S. the model predicts an increase of 0.8 percent in U.S. rural wage rates while rural wage rates in Mexico decline by 5.3 percent. These effects and are linked primarily to increases in U.S. corn sales to Mexico following NAFTA. When labor is allowed to migrate both within Mexico and from Mexico to the U.S., 340,000 workers migrate from rural to urban areas in Mexico and 420,000 from Mexico to the U.S. When migration is considered, the effects of NAFTA on rural wage rates is reversed in both countries: rural wages rise by one percent in Mexico while falling by one percent in the U.S.

Burfisher et. al. (1992) use a 28-sector[5] extension of the 11-sector model to experiment with policy intervention and economic growth scenarios that would help reduce economic dislocation due to NAFTA. They present scenarios in which (1) the Mexican government provides a direct payment to farmers, similar to the U.S. deficiency payment program and (2) Mexico experiences a 10 percent growth in capital stock. Both scenarios significantly reduce migration from Mexico to the U.S and significantly alter wage effects in both countries. In the

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[5]As noted above, the amount of information available from a CGE experiment depends largely on the level of model disaggregation. The 28 sector model provide a great deal of disaggregation in the agriculture sectors. In terms of factor rewards, they define a total of seven factors--four categories of labor (rural, urban unskilled, urban skilled, and professional), two categories of agricultural land, and capital. A total of 20 agriculture and related sectors are included, 10 for production agriculture and 10 for food processing. Sectors are defined on the basis of output prices (all transactions of the composite good for each sector must take place at a common price), protection rates, subsidy rates, factor intensities, and productivity--differences which create the potential for intersectoral shifts in production and factor utilization.

U.S., rural wages fall by only 0.5 percent when direct payments are made to Mexican farmers and increase by one percent in the capital growth scenario.

In the actual NAFTA agreement reached during 1992, the many of the agriculture-related tariff reductions are, in fact, phased in over a period of 5-15 years to minimize immediate economic dislocation (CBO, May 1993). To study the impact of a trade reform phase in period on the level of labor migration, Levy and van Wijnbergen used a dynamic CGE[6] (although their research does not incorporate the actual NAFTA provisions). They estimate that labor migration is quite sensitive to the speed of trade reform. Over a nine year period, they find that all scenarios provide roughly the same level of net rural outmigration in Mexico, roughly 700,000 additional workers. Immediate liberalization, they find, results in the majority of migration taking place in the first year of the agreement while gradual elimination of trade barriers provides for a much smoother adjustment which stretches migration over the entire period of the phase-in.

Finally, the importance of labor migration is also demonstrated by modeling results in the 28 sector model with respect to horticultural crops (Burfisher et.al. 1992). Lower tariffs on Mexican imports results in reduced U.S. demand for domestically produced horticultural products. However, inflows of labor from Mexico reduce production costs leading to a net increase in U.S. horticultural output, even though the U.S. domestic price falls unambiguously.

The Model

In order to alter baseline projections for the effect of NAFTA, we estimate the change in the use and price of primary factors (labor, capital, and land) in response to trade liberalization

[6]As summarized by Hinojosa-Ojeda and Robinson.

using a partial equilibrium approach. The model specifies factor market equilibrium for three primary factors as well as intermediate inputs. We assume that the availability of land is fixed and that intermediate inputs are (1) used in fixed proportions with primary inputs and (2) available to agriculture in perfectly elastic supply. Although we do not model labor migration from Mexico, migration will obviously impact the supply of labor available to U.S. agriculture. We examine conditions under which production and factor prices are sensitive to labor supply and at a reasonable range of results, given a range of values for the elasticity of labor supply.

Grains Sector. The production function for primary factors in the grains sector[7] is:

$$(1) \qquad (1 - S_v)x = f(a,b,c)$$

where x is output, S_v is the share of output attributable to intermediate inputs, $(1\text{-}S_v)$ is the share of output attributable to primary factors, f is an industry-level, constant elasticity of substitution production function with constant returns to scale, a is the labor input, b is capital, and c is land. The demand for U.S. grain in the U.S. and Mexico is written as

$$(2) \qquad x = D(P_x) + ED_{mx}((1+t)P_x)$$

where $D(P_x)$ is U.S. and R.O.W. (Rest-of-the-World) demand for grains, ED_{mx} is excess demand for grains in Mexico, P_x is the U.S. price of grain, and t represents the tariff rate. Because the U.S. holds an overwhelming trade surplus with Mexico in grains, oilseeds, and cotton, and imposes low or no trade protection on these commodities, we model only the relaxation of Mexican trade barriers.

[7]Sectors are defined in data description. The derivation here is specific to the grains sector but derivations for other sectors will be similar.

In U.S. markets for primary factors, factor demands are represented by the profit maximizing condition that the value of marginal product equal factor price for each factor:

$$(3) \qquad P_a = P_x f_a$$

$$(4) \qquad P_b = P_x f_b$$

$$(5) \qquad P_c = P_x f_c$$

where the P_i denotes the price of factor i (i=a,b,c) and the f_i's are the partial derivatives of the production function. For labor and capital, the factor supply equations can be written as:

$$(6) \qquad P_a = h(a)$$

$$(7) \qquad P_b = g(b)$$

A fixed quantity of cropland is assumed to be available to the grains sector, so that the price of land is determined only from the demand for land in grain production, and the level of c is exogenous.

Thus, we have a total of seven equations and seven endogenous variables. A system of four equations and four unknowns is created as follows: First, both sides of equation (2) are multiplied by $(1-S_v)$ and equations (1) and (2) are combined to eliminate $(1-S_v)x$

$$(8) \qquad (1 - S_v)\left(D_{us}(P_x) + ED_{mx}((1 + t)P_x)\right) = f(a,b,c)$$

Second, we equate equations (3) and (6) and (4) and (7) to eliminate P_a and P_b, respectively

$$(9) \qquad P_x f_a = h(a)$$

$$(10) \qquad P_x f_b = g(b)$$

Finally, we note that, because of fixed supply, the land demand equation fully characterizes the land market.

Totally differentiating the four equations and using techniques detailed by Allen to convert all derivatives to elasticities, we obtain

$$(11)\qquad (1-S_v)\eta_{mx}^{ED}M_{mx}\left(\frac{t}{1+t}\right)=S_a\frac{Ea}{Et}+S_b\frac{Eb}{Et}-(1-S_v)(\eta_{us}M_{us}+\eta_{mx}^{ED}M_{mx})\frac{EP_x}{Et}$$

$$(12)\qquad 0=\frac{EP_x}{Et}-\left(\frac{1}{e_a}+\frac{K_{ba}}{\sigma_{ab}}+\frac{K_{ca}}{\sigma_{ac}}\right)\frac{Ea}{Et}+\left(\frac{K_{ba}}{\sigma_{ab}}\right)\frac{Eb}{Et}$$

$$(13)\qquad 0=\frac{EP_x}{Et}-\left(\frac{1}{e_b}+\frac{K_{ab}}{\sigma_{ab}}+\frac{K_{cb}}{\sigma_{bc}}\right)\frac{Eb}{Et}+\left(\frac{K_{ab}}{\sigma_{ab}}\right)\frac{Ea}{Et}$$

$$(14)\qquad 0=\frac{EP_c}{Et}-\frac{EP_x}{Et}-\left(\frac{K_{ac}}{\sigma_{ac}}\right)\frac{Ea}{Et}-\left(\frac{K_{bc}}{\sigma_{bc}}\right)\frac{Eb}{Et}$$

where η_{us} is the elasticity of U.S. demand, η_{mx}^{ED} is the elasticity of excess demand for Mexico, M_{mx} is the ratio of U.S. grain exports to Mexico to U.S. grain production, M_{us} is the ratio of the sum of U.S. grain consumption and U.S. grain export to the ROW to U.S. production, S_i is the total budget share for factor i (including intermediates), while K_{ij} is a "partial" budget share between factors i and j, defined as

$$K_{ij}=\frac{K_i}{K_i+K_j}$$

where K_i is the factor income for factor i, e_i is the elasticity of supply in factor markets and σ_{ij} is the elasticity of substitution between factors i and j. Finally, the operator E represents percentage change. For example, Ea is the percentage change in use of factor a (labor). The ratios containing E's represent total elasticities. For example, Ea/Et is the percentage change in labor use given a one percent change in the tariff and given equilibrium adjustments in other variables of the model. Expressions for Ea/Et, Eb/Et, and EP_x /Et are obtained using Cramer's rule. EP_a/Et and EP_b/Et are obtained by noting that $EP_a=Ea/e_a$ and $EP_b=Eb/e_b$, respectively.

Fruits and Vegetables. For inputs used to produce fruits and vegetables, the model is identical to the grains model (see equations (3)-(7) and (12)-(14)). However, U.S. product market relations are respecified to model reduction in U.S. tariffs (or tariff equivalents) against imports from Mexico. This reflects the fact that imports to the U.S. from Mexico account for 97 percent of bilateral trade in this sector (FATUS). We ignore the R.O.W. because the U.S. accounts for a large majority (70 percent) of Mexican exports in this sector (Burfisher, Thierfelder, and Hansen). Revising equations 1 and 2 we obtain

$$(15) \qquad (1-S_v)x = f(a,b,c)$$

$$(16) \qquad x = D_{us}(P_x) - ES_{mx}((1-\tau)P_x)$$

where D_{us} is U.S. demand for fruits and vegetables, ES_{mx} is excess supply of fruits and vegetables in Mexico and τ is the level of U.S. trade protection. Carrying out derivations similar to those described above, we obtain

$$(17) \qquad (1-S_v)\epsilon_{mx}^{ES}N_{mx}\left(\frac{\tau}{1-\tau}\right) = S_a\frac{Ea}{E\tau} + S_b\frac{Eb}{E\tau} - (1-S_v)\left(\eta_{us}N_{us} - \epsilon_{mx}^{ES}N_{mx}\right)\frac{EP_x}{E\tau}$$

where ε_{mx}^{ES} is the elasticity of excess supply for fruits and vegetables for Mexico, N_{mx} is the ratio of imports from Mexico to U.S. production, and N_{us} is the ratio of U.S. consumption of fruits and vegetables to U.S. production.

Data and Parameters

Data and parameters used to calculate total elasticities for the base cases are listed in Table 1. Factor incomes, factor shares, as well as the trade, production, and consumption data necessary to calculate M_k and N_k, are obtained from Burfisher, Thierfelder, and Hansen. Although their data base is developed for use in a CGE model which includes 10 agricultural sectors, we aggregate selected sectors to obtain two sectors: (1) Grains, Oilseeds, and Cotton and (2) Fruits and Vegetables. We also obtain base-case parameters for Allen elasticities of substitution among primary factors from Burfisher, Thierfelder, and Hansen. A sensitivity analysis of factor substitution elasticities is discussed below.

Sectoral excess demand (grains sector) and excess supply (fruits and vegetables) elasticities for Mexico are calculated from the import demand and export supply functions, respectively. For the grains sector, we begin with the import demand function

$$ED_{mx}((1+t)P_x) \equiv D_{mx}((1+t)P_x) - S_{mx}((1+t)P_x)$$

where ED_{mx} is excess demand in Mexico, D_{mx} is total demand in Mexico and S_{mx} is total production in Mexico. It can be shown that

$$\eta_{mx}^{ED} = \sum_{j=1}^{J}\left(\eta_{mxj}^{ED}H_j^i\right) = \sum_{j=1}^{J}\left(\eta_{mxj}H_j^c - \epsilon_{mxj}H_j^P\right)$$

where the η_{mx}^{ED} is the aggregate elasticity of excess demand for the grains sector in Mexico, η_{mxj} is the elasticity of demand for commodity j in Mexico, ε_{mxj} is the elasticity of supply for commodity j in Mexico, H_j^i is the ratio of import of commodity j from the U.S. to total sector-wide imports from the U.S., H_j^c is the ratio of Mexican consumption of commodity j to total sector-wide imports from the U.S., and H_j^P is the ratio of Mexican production of commodity j to total sector-wide imports from the U.S. A similar procedure is used to obtain an excess demand elasticity for the ROW. The ROW elasticity is aggregated together with U.S. domestic demand for a combined non-Mexico demand elasticity.

Demand elasticities, supply elasticities, and data to calculate H's for the grains sector are obtained from Liapis, Krissoff, and Neff. We calculated aggregate demand elasticities for the grains sector based on six commodities: wheat, corn, course grains, soybeans, other oilseeds, and cotton. Although rice, hay, and pasture are also included in the sectoral data obtained from Burfisher et. al., it seems unlikely that the discrepancy involving these minor relatively crops will have a significant impact on our estimates.

By a similar procedure, an expression for the excess supply of fruits and vegetables from Mexico is obtained:

$$\epsilon_{mx}^{ES} = \sum_{j=1}^{J} \left(\epsilon_{mxj}^{ES} G_j^{e}\right) = \sum_{j=1}^{J} \left(\epsilon_{mxj} G_j^{p} - \eta_{mxj} G_j^{c}\right)$$

where the ε_{mx}^{ES} is the aggregate elasticity of excess supply for fruits and vegetables in Mexico, ε_{mxj} is the elasticity of supply for commodity j in Mexico, η_{mxj} is the elasticity of demand for commodity j in Mexico, G_j^e is the ratio of exports of commodity j to the U.S. from Mexico to total sector-wide exports to the U.S., G_j^p is the ratio of Mexican production of commodity j to total sector-wide exports to the U.S, and G_j^c is the ratio of Mexican consumption of commodity j to total sector-wide exports to the U.S.

Trade, production, and consumption data, as well as elasticity estimates for fruits and vegetables are somewhat more difficult to obtain. Compared to grains, the fruit and vegetable sector contains a large number of crops, many of which are relatively minor in production, trade, or both. The aggregate supply elasticity is calculated based on eight crops which account for about 70 percent of Mexico-U.S. trade in fruits and vegetables: tomatoes, cucumbers, onions, peppers, melons, strawberries, grapes, and citrus fruit. Where possible, data and elasticity estimates are obtained from Liapis, Krissoff, and Neff. Alternatively, production and trade data is obtained from FAO yearbooks[8]. When otherwise unavailable, short run supply and demand elasticity parameters are assumed to be .3 and -.4, respectively, for annual crops and .3 and .05, respectively, for perennial crops. For the long run case, we use unitary elasticities in all cases[9].

The aggregate excess demand elasticities obtained by this procedure are quite high in terms of absolute value (-6.29 for Mexico and -4.97 for U.S./ROW). (For U.S. domestic demand only, the aggregate elasticity is -.62.) The aggregate excess supply elasticities are also quite high: 3.35 in the short run case and 4.92 in the long run. Econometrically estimated import demand and export supply elasticities have typically been much lower than calculated elasticities (Gardiner and Dixit). Thus, the calculated elasticities should be considered to be upper bounds on actual elasticities.

Tariff rates are obtained from Burfisher, Robinson, and Thierfelder and are the sum of tariff rates and tariff equivalents of quotas. To calculate tariff rates for our aggregate sectors prior to NAFTA, we use a trade-weighted average of sectoral tariff rates reported in Burfisher, Robinson, and Thierfelder. A key question is what tariff rate to use in calculating total elasticities. Obviously, full trade liberalization involves a large change in the tariff rate while a total elasticity is calculated for a single point. The multiplicative factor $t/(1+t)$ in equation (11) indicates that changes in the tariff rate will make a substantial difference in the outcome. In calculating the total elasticities, we use tariff rates that are one-half the aggregate tariff prior to

[8]When trade data was unavailable from any published source, exports from Mexico to the U.S. were estimated by multiplying production by .70, the overall U.S. share of Mexican exports of fruits and vegetables.

[9]Based on personal communication with Boyd Buxton, USDA-ERS.

NAFTA[10]. While the use of this particular tariff rate is somewhat arbitrary, we place the base case result in a larger context by using the full pre-NAFTA tariff rate in calculating an upper bounds on potential NAFTA effects. This issue is discussed in more detail in the next section.

Estimates of the price elasticity of supply for labor are obtained from Duffield. For U.S. agriculture, in aggregate, Duffield estimates a short-run elasticity of .36 and long-run elasticity of .735. Since we are looking at only a portion of agriculture in any one of our four modeling experiments, the supply of labor can be expected to be somewhat more elastic. For example, in looking at individual horticultural crops in a model similar to ours, Gunter, Duffield, and Jarrett used a labor supply elasticity of 10. Since we look at a greater level of aggregation, we use values of 1.0 for the short run case and 2.0 for the long run case.

Finally, in the short run we assume that capital is available in perfectly inelastic supply (e_b approaches zero) and, in the long run, is available in perfectly elastic supply (e_b approaches infinity).

Because many of our parameter values are subject to substantial error, we conducted sensitivity analysis that consider a range of values. Our analysis shows that the estimated total elasticities are sensitive to a number of parameters, including output demand and supply elasticies, the labor supply elasticity, and selected substitution elasticities. Furthermore, experimentation reveals that sensitivity to output demand and output supply elasticities can be considered separate of the factor supply and substitution elasticities. Changes in output supply

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[10]An alternate approach would be to simulate a stepped phase-in of tariff reductions by recalculating factor incomes, factor shares, and production data following each step. Using a point elasticity to estimate changes resulting from a 20 percent change in the tariff rate would obviously be less problematic than using a point elasticity to estimate changes resulting from full trade liberalization (a 100 percent reduction in the tariff).

and demand elasticities affect the use of all factors and factor prices equally (in terms of percentage change in total elasticity in response to change in elasticity parameters).

Regarding sensitivity of the model to excess demand and excess supply elasticities, we note that previous modelling (Hueth, Just and O'Meara and Burfisher, Robinson, and Thierfelder) show that the effects of trade liberalization on U.S. agriculture are likely to be small. Hueth et. al. show almost no production response to NAFTA. Given these conclusions, we devise base cases using estimates of excess demand and excess supply elasticities which are closer to zero: -2 for excess grains sector demand from Mexico, -1 for grains sector demand from the U.S. and ROW, and fruit and vegetable sector excess supply elasticities of 0.75 in the short run and 1.50 in the long run.

The sensitivity of total elasticities to labor supply and substitution elasticities did not prompt modification of parameters used in the base cases and is discussed below.

Results

Base case results are listed in Table 2. Reported results are the estimated effects of complete trade liberalization.[11] Our base case results are in general agreement with those obtained by previous researchers in that therer are gains in the grains sector and losses in the fruits and vegetables sector. Overall, the effect of full trade liberalization on agriculture is

[11] We calculate total elasticities, as defined above, then multiply them by 100 to obtain the effect of a 100 percent decline in the tariff. We then multiply these figures by -1 so that the reported results can be read directly as the effect of trade liberalization, rather than the response of the endogenous variables to a change in the tariff rate.

relatively small. The biggest effect is on the value of land in fruit and vegetable production, which we estimate to fall 3.44 percent.

Short Run. Short run base case results are reported in the first two columns of Table 2. In the grains sector we predict that complete trade liberalization will prompt small increases in all variables in the short run. For example, we estimate that in the short run, the price of land will rise by 0.6 percent, the price of capital will rise by .57 percent, and that wage rates will rise by .21 percent in response to elimination of Mexican trade barriers. In fruits and vegetables, the short run effect of eliminating U.S. trade barriers is to reduce all endogenous variables by a small amount (see second column of Table 2), although the impact of trade liberalization is larger (in absolute value) than in the grains sector. Because capital is assumed to be fixed in the short run, we report no quantity adjustment.

Wage rates are predicted to rise in the grains sector while falling in fruits and vegetables. We assume that workers employed in these two sectors do not have exactly the same characteristics, and that labor is not perfectly mobile between the grains and fruit and vegetable sectors. This is reasonable given the geographic separation between principal centers of grain, cotton, and rice production and the main areas of fruit and vegetable production. If a single, national agricultural labor market exists, our estimates will overstate the effects of trade liberalization in both sectors.

Short run upper bounds are reported in Tables 3 and 4. Factor prices and labor use are quite sensitive to the labor supply elasticity and to elasticities of substitution between labor and capital (σ_{ab}) and between labor and land (σ_{ac}). Since both capital and land are fixed in the short run, the results are independent of the elasticity of substitution between capital and land (σ_{bc}).

Bounds on base case results are devised by running the simulation for all eight possible combinations of the extreme values of these parameters. Parameters values ranged from lower limits of e_a=0.5, σ_{ab}=0.1, and σ_{ac}=0.1 to upper limits of e_a=1.5, σ_{ab}=1 and σ_{ac}=1. In other words, we calculated total elasticities (and transformed them as described above) for a series of combinations: e_a=0.5, σ_{ab}=0.1, and σ_{ac}=0.1; e_a=0.5, σ_{ab}=0.1, and σ_{ac}=1; e_a=0.5, σ_{ab}=1, and σ_{ac}=0.1; etc. The reported upper bound on any specific result is the highest value produced from among the eight combinations of extreme values. As noted above, we use the full pre-NAFTA tariff rate to calculate upper bounds. The pre-NAFTA rate is the largest possible relevant tariff rate and, thus, is appropriate for an upper bound.

Graphically, short run upper bounds are shown along side no-NAFTA projections in Figures 3-6. Upper bounds for the grains sector tend to confirm initial conclusions that NAFTA effects are small. The no-NAFTA and upper bound projections are nearly identical. However, even in the short run, results for fruit and vegetables indicate that the effects of NAFTA are potentially significant for the owners of fruit and vegetable sector land and capital.

Obviously, our results depend critically on the assumption that land and capital are fixed to each sector. The availability of additional resources to the grains sector or the availability of alternative uses for resources in the fruit and vegetable sector will tend to reduce the effect of trade liberalization under NAFTA. Assuming both capital and land are fixed in the short run, production adjustment depends on the extent to which labor (1) is available from other sectors of the economy and (2) can substitute for capital and land in production. When labor is readily available and can substitute for capital and land, short run labor and wage rate adjustment, as well as land price adjustment, is relatively large. The opposite is true when labor is not readily available and does not easily substitute for land and capital.

We do not calculate lower bounds. Calculation of lower bounds is complicated by the necessity of choosing an appropriate lower bound for the relevant tariff rate. As noted above, because of the way the tariff rate enters the model, the selection of a tariff rate is extremely important in the calculation of total elasticities. While it is clear that the full pre-NAFTA tariff is appropriate for an upper bound, no similarly obvious rate is available to calculate a lower bound.

Long Run. Long run base case results are reported in third and fourth columns of Table 2. Factor use and factor price adjustment is, in general, larger in the long run, with the exception of wages in the grains sector. Although the wage rate does rise with trade liberalization it rises less than in the short run case due to greater availability of labor to the sector in the long run.

Long run upper bounds are reported in Tables 5 and 6. In the long run, we find that the simulation results are quite insensitive to the elasticity of substitution between labor and capital (σ_{bc}) and relatively insensitive to the labor supply elasticity when compared to the short run case. These results are not surprising given that we assume no constraint on capital adjustment in the long run[12]. To calculate upper bounds, we use parameters ranging from lower limits of e_a=1.5, σ_{ac}=0.1, and σ_{bc}=0.1 to upper limits of e_a=2.5, σ_{ac}=1 and σ_{bc}=1. Again, full pre-NAFTA tariff rates are assumed to be the relevant rate for calculation of the upper bounds.

[12]The long run model is also relatively insensitive to the labor supply elasticities in the 0.5 to 1.5 range, indicating that the change in capital availability, not the increase in the labor supply elasticity, is primarily responsible for the reduction in sensitivity when compared to the short run case.

In the grains sector, we find that each of our estimated total elasticities fall within a relatively narrow range indicating that changes will be small under a broad range of conditions. The largest upper bound (in absolute value) is -3.16 (for land prices). All other upper bounds are -.77 or lower (in absolute value).

In fruits and vegetables, NAFTA has a much larger potential impact, if extreme conditions which define the upper bounds are realized. For example, the upper bound for output prices and land prices are -11.39 and -44.85, respectively. These bounds occur when neither labor nor capital readily substitute for land (i.e. when $\sigma_{ac}=\sigma_{bc}=0.1$). Thus, where there are no alternative uses for land and production cannot be adjusted through changes in labor or capital, the effect of NAFTA on the wealth position of fruit and vegetable producers can be quite large. Other long run upper bounds are also significantly higher than in the grains sectors, ranging from -2.38 (wage rate) to -4.78 (quantity of capital), but are still quite modest when compared to the potential change in land prices.

Conclusions

The results presented here generally highlight the fact that the U.S. economy and agricultural sectors are huge when compared with their Mexican counterparts, particularly the grains sector. These results are generally consistent with the results of previous studies. However, our modelling effort is in contrast to most CGE models in terms of assumptions about (1) relevant labor markets and (2) capital adjustment. A number of CGE models, including Burfisher, Robinson, and Thierfelder also assume that land inputs are fixed sectorally.

By focusing on the sensitivity of the results to various parameters, both individually and in combination, our results point out several potentially important issues in modelling the impact of NAFTA on factor markets in U.S. agriculture.

First, given certain conditions, trade liberalization may result in significant reduction in the wealth position of fruit and vegetable producers through significantly reduced land prices. This occurs only when labor and capital are poor substitutes for land and, implicitly, when there are few profitable alternatives to fruit or vegetable production on acreage now producing them. Secondly, in direct contrast to CGE modelling, our approach assumes that labor is not necessarily perfectly mobile between sectors. Wage rates may, in fact, adjust in different directions in different sectors depending on the degree of labor mobility.

Finally, we find that factor use is relatively sensitive to labor supply in the short run but relatively insensitive in the long run. Experimentation reveals that this is a direct consequence of capital adjustment assumptions rather than labor market considerations. This result is in contrast to Burfisher, Robinson, and Thierfelder, who assume that the endowment of capital is fixed in the U.S. economy. In their model labor supply issues, including labor migration, are extremely important; so important that U.S. output of fruits and vegetables actually rises on the basis of reduced labor costs despite an unambiguous reduction in output price[13].

[13]This result is not reported in Burfisher, Robinson, and Thierfelder but is based on personal communication with Mary Burfisher.

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Table 1. Data and Parameters for Base Cases.

Variable or Parameter	Grain, SR	F & V, SR	Grains, LR	F & V, LR
K_{labor} (billion $)	9.86	4.95	9.86	4.95
$K_{capital}$ (billion $)	8.17	2.91	8.17	2.91
K_{land} (billion $)	5.43	2.39	5.43	2.39
S_{labor}	.20	.28	.20	.28
$S_{capital}$	.17	.16	.17	.16
S_{land}	.11	.13	.11	.13
$S_{intermediate}$	.52	.42	.52	.42
M_{mx}	.02	.73	.02	.73
M_{us}	.98	.12	.98	.12
ε_{mx}	--	.75	--	1.50
η_{mx}	-2.00	--	-2.00	--
η_{us}	-1.00	-.44	-1.00	-1.00
σ_{ab}	.80	.80	.80	.80
σ_{ac}	.80	.80	.80	.80
σ_{bc}	.80	.80	.80	.80
e_a	1.00	1.00	2.00	2.00
e_b	--	--	--	--
tariff rate	.30	.13	.30	.13

Table 2. Base Case Simulation Results (Percentage Change for Complete Removal of Tariffs).

	Grains, SR	F & V, SR	Grains, LR	F & V, LR
Labor Hours	.21[a]	-.52	.31	-1.39
Wage Rate	.21	-.52	.16	-.69
Quantity of Capital	0	0	.39	-1.65
Price of Capital	.57	-1.38	0	0
Price of Land	.60	-1.40	.80	-3.44
Price of Output	.43	-.97	.25	-1.14

[a] .21 means .21 of one percent, not 21 percent

Table 3. Short Run, Grains. (Percentage Change for Complete Removal of Tariffs).

	Base Case	Upper Bound
Labor Hours	.21	.48
Wage Rate	.21	.56
Quantity of Capital	--	--
Price of Capital	.57	1.68
Price of Land	.60	1.99
Price of Output	.43	.87

Table 4. Short Run, Fruits and Vegetables. (Percentage Change for Complete Removal of Tariffs).

	Base	Upper
Labor Hours	-.52	-1.31
Wage Rate	-.52	-1.72
Quantity of Capital	--	--
Price of Capital	-1.38	-5.27
Price of Land	-1.40	-6.27
Price of Output	-.97	-2.94

Table 5. Long Run, Grains. (Percentage Change for Complete Removal of Tariffs).

	Base Case	Upper Bound
Labor Hours	.31	.62
Wage Rate	.16	.36
Quantity of Capital	.39	.76
Price of Capital	--	--
Price of Land	.80	3.16
Price of Output	.25	.77

Table 6. Long Run, Fruits and Vegetables. (Percentage Change for Complete Removal of Tariffs).

	Base Case	Upper Bound
Labor Hours	-1.39	-3.64
Wage Rate	-.69	-2.38
Quantity of Capital	-1.65	-4.78
Price of Capital	--	--
Price of Land	-3.44	-44.85
Price of Output	-1.14	-11.39

Figure 1. FARM WAGE RATES

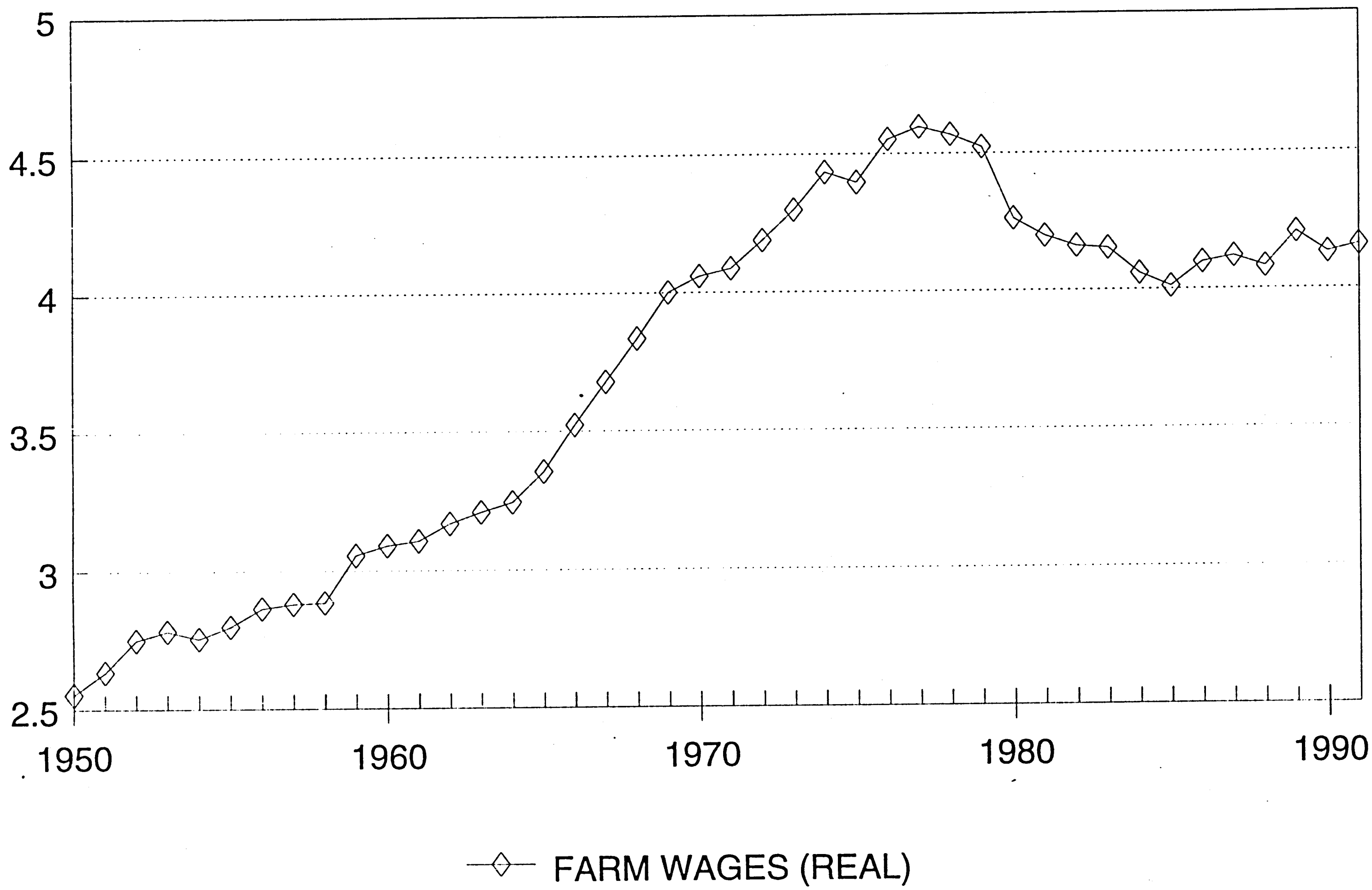
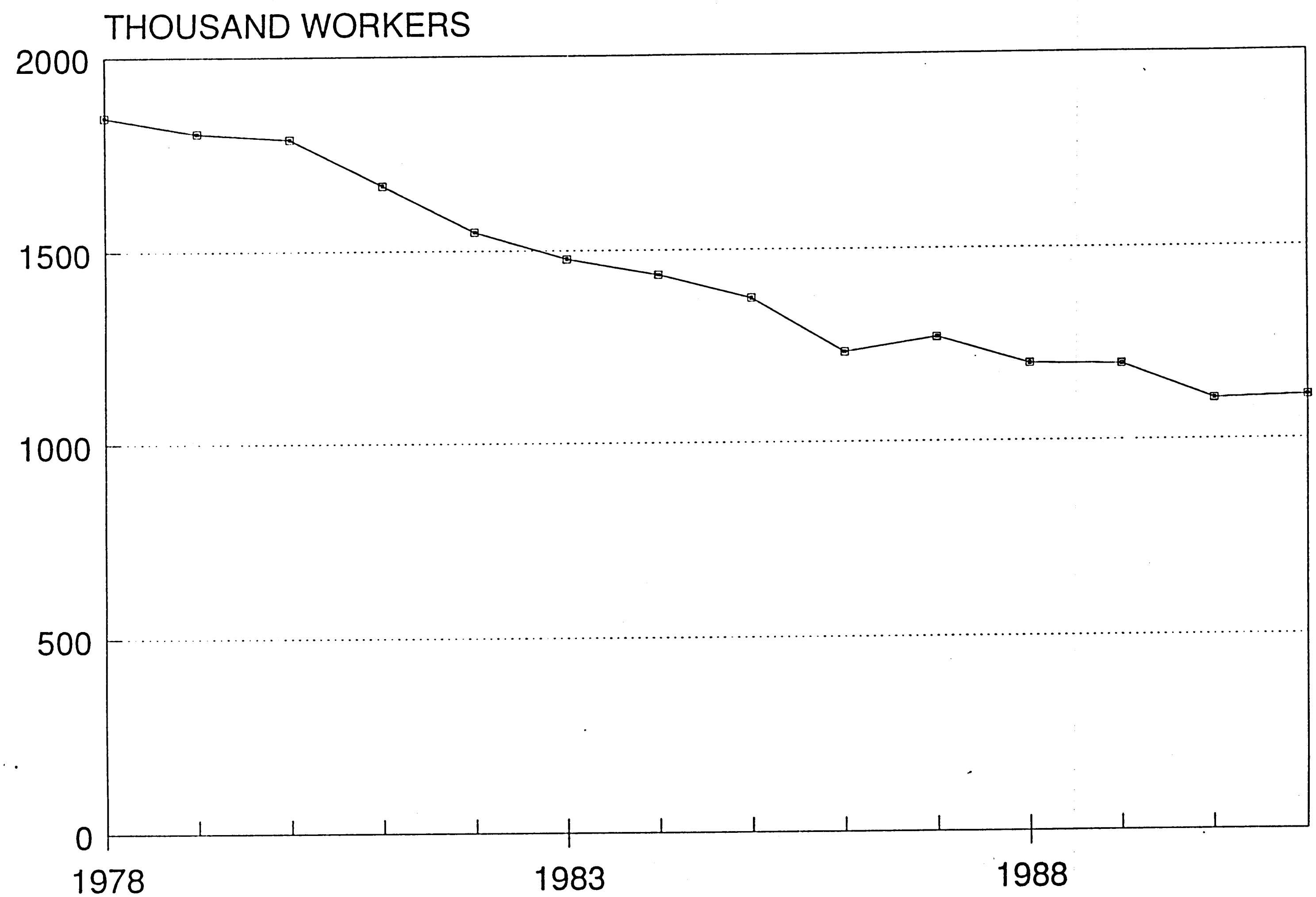


FIGURE 2. HIRED FARM WORKERS



JULY NASS SURVEY OF EMPLOYERS

Figure 3. WAGE RATES
Grains Sector, Short Run Analysis

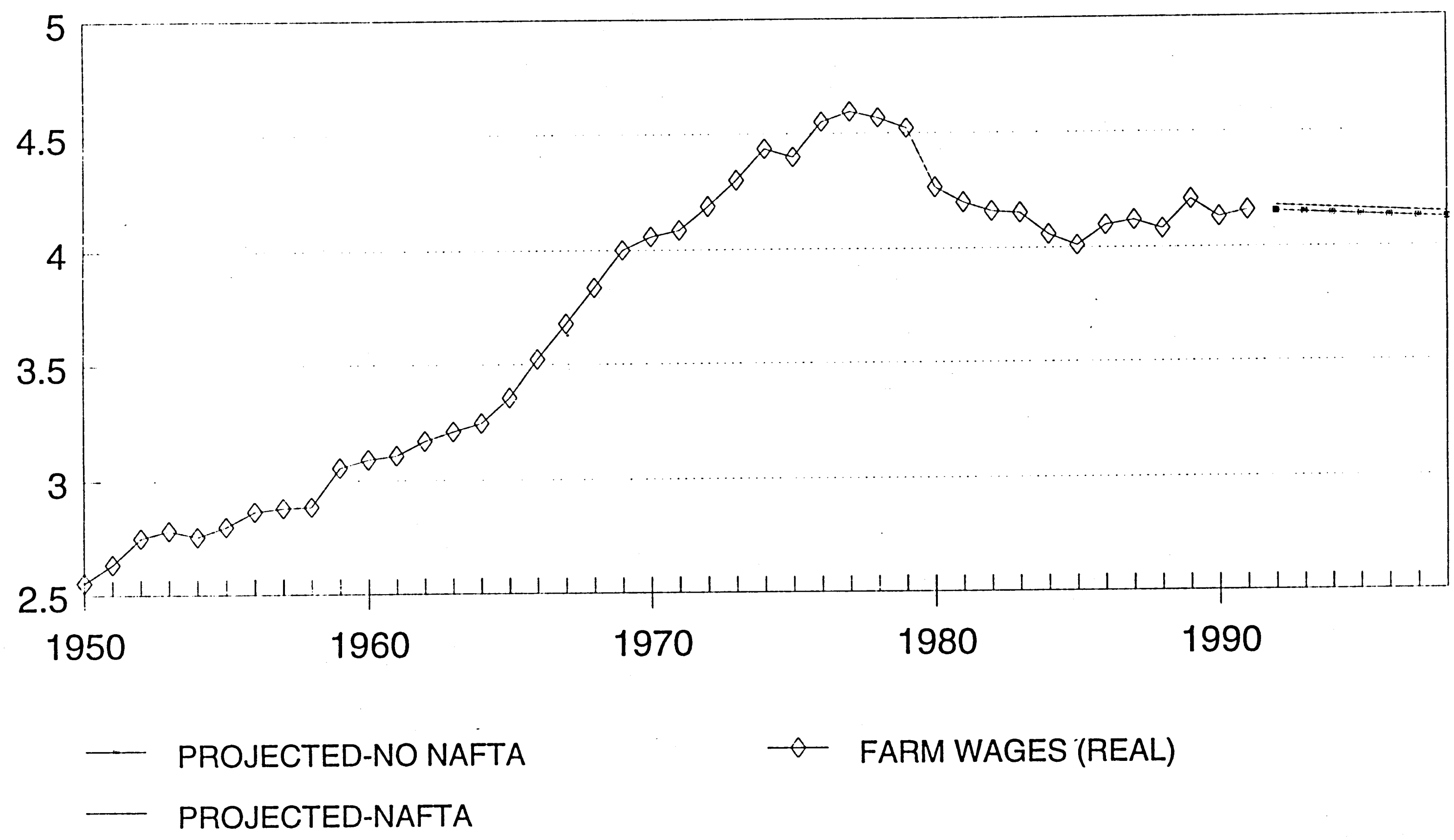
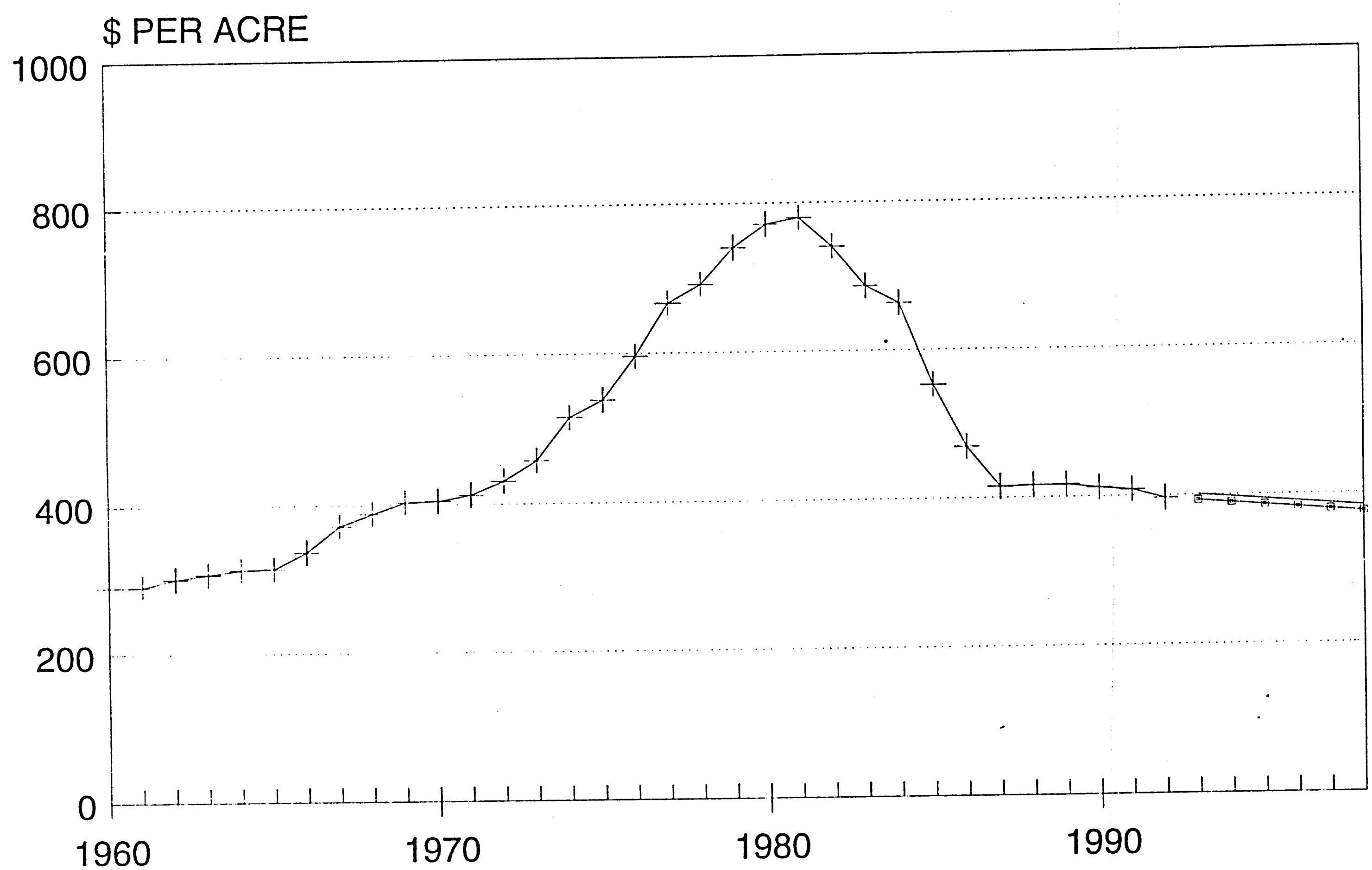


Figure 4. REAL LAND PRICE
Grains Sector, Short Run Analysis



Real=Deflated by the CPI

Figure 5. WAGE RATES

Fruit and Vegetable Sector, Short Run

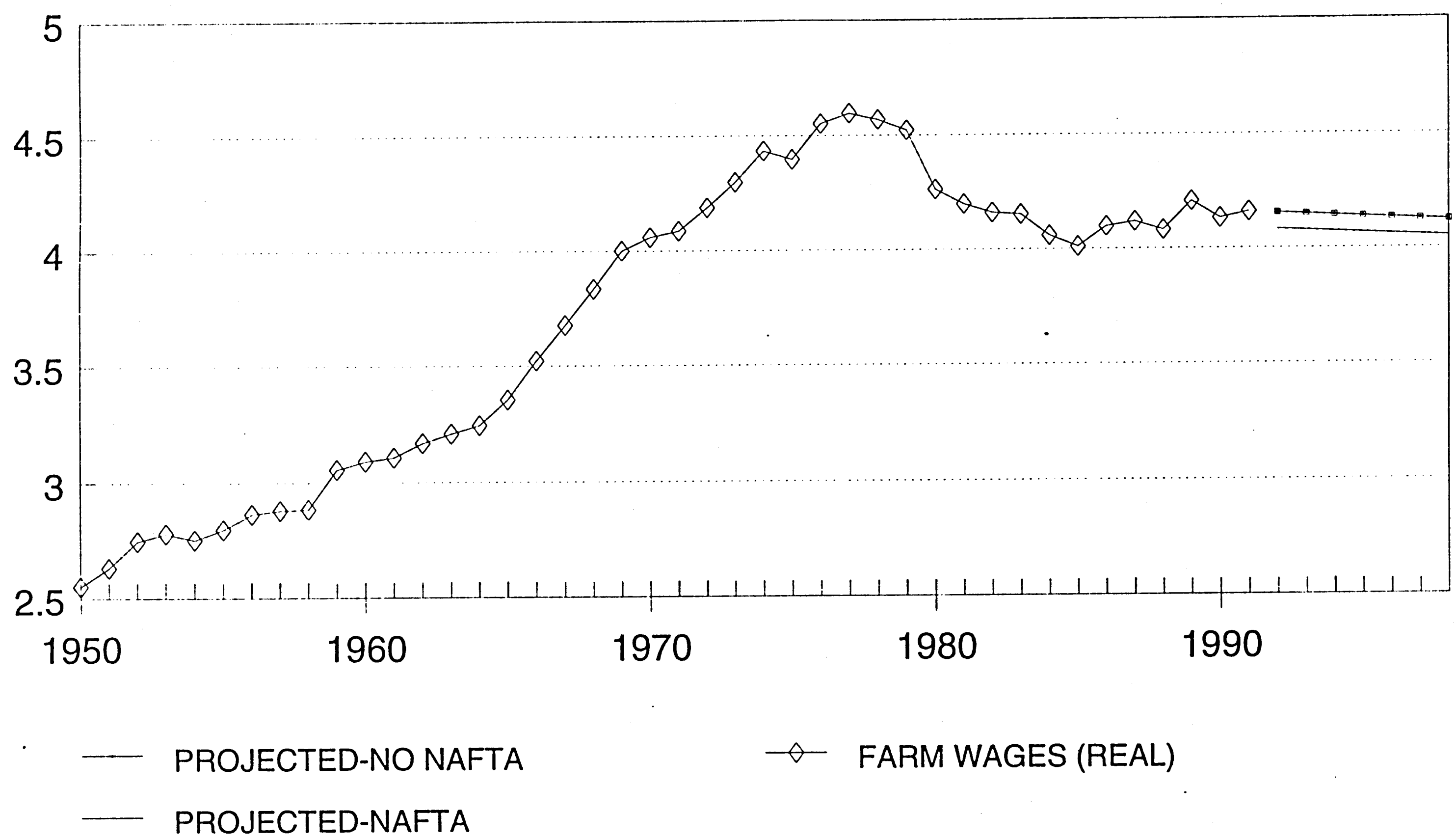
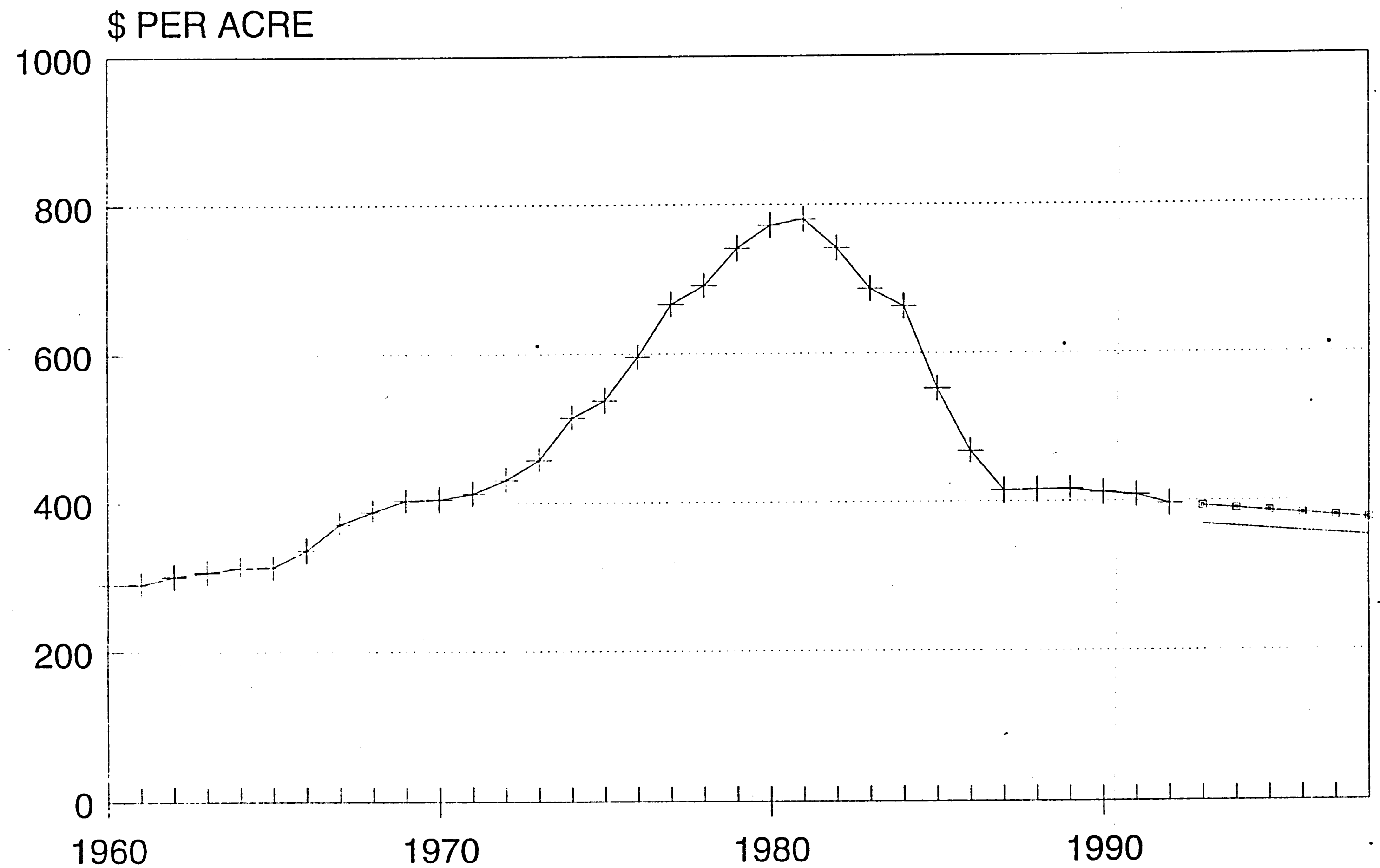


Figure 6. REAL LAND PRICE
Fruit and Vegetable Sector, Short Run



Real=Deflated by the CPI