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# ANNUAL RESEARCH REPORT

Development of an Agricultural Diversification
and Trade Program in Latin America

Contract Number AID/csd-3632

North Carolina State University
Raleigh, North Carolina

Fiscal Year April 1, 1973 to March 31, 1974

REPORT SUMMARY

A. 1. Project Title and Contract Number: "Development of an Agricultural Diversification and Trade Program in Latin America," AID/csd-3632.

2. Principal Investigator: Richard L. Simmons
Department of Economics
North Carolina State University
Raleigh

3. Contract Period: April 1, 1972 to March 31, 1975.

4. Period covered by report: April 1, 1973 to March 31, 1974.

5. Total AID funding of contract to date: $218,352.

6. Total expenditures and obligations through previous contract year: $108,352.

7. Total expenditures and obligations for current year: $103,584.

8. Estimated expenditures for next contract year: $135,293.

B. Narrative Summary of Accomplishments and Utilization

The objective of this contract is to develop and implement a program for agricultural diversification and trade in Latin America. In accomplishing this objective, efforts are to be directed toward:

(1) Evaluating the export potential of Guatemala and El Salvador to U. S. and Canadian markets.

(2) Analyzing alternative means and costs of transporting and distributing vegetables from the production zones to the market.

(3) Holding workshops in Central America to ensure adequate coordination of the research.

To accomplish these objectives four separate research projects were in progress during the year:

(1) The study on the demand for peppers, cucumbers and cantaloupes in the U. S. market was completed. A manuscript was sent to the project monitor for approval and was later published as North Carolina State University Economics Research Report Number 27, April 1974. In addition to this publication, some work was done on the demand for fresh winter tomatoes. The research indicates that the demand for winter vegetables shifts to the right (increases) and becomes more elastic from December to April. These results are useful for planning planting dates so that shipments can be coordinated with peak demand periods.

(2) The research on the supply of winter vegetables in Guatemala was continued and a manuscript was prepared. Because some of the data collected was rather fragmentary only tentative conclusions can be drawn at this time. Another attempt to refine the data inputs will be made in the next fiscal year. However, based on the research completed, it is possible to conclude tentatively that Guatemala can best compete for the December, January and February markets for cantaloupes and the March and April markets for cucumbers and bell peppers.

(3) The research on the supply of winter vegetables in Mexico received a considerable amount of effort during the year. Data collection and later data refinement was accomplished, the analytical model was developed and some tentative solutions were obtained.[1] The model uses linear programming with risk and emphasizes monthly programming of plantings. Tentative results show that further rapid expansion of tomatoes, peppers and cucumbers are unlikely, since recent expansions have already nearly satisfied the demand for these products at prices

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[1]The model is explained in detail in Appendix A.

about equal to variable costs (including opportunity costs for resources). Further refinement of the analysis will be necessary during the next year.

(4) The research on the export potential of El Salvador received considerable effort by University of Florida personnel under the subcontract which was let by North Carolina State University to the Food and Resource Economics Department. A manuscript was written entitled "The Economic Potential for Increasing Vegetable Production in the Zapotitan District of El Salvador." This manuscript also needs some refinement, but tentative conclusions indicate that under present technologies El Salvador cannot compete effectively with Guatemala for the Central American or U. S. winter vegetable markets.

Miscellaneous Activities

(1) A trip by the project director to Lima, Peru, March 28 to April 7, 1973 was made for the purpose of determining whether the research effort could be extended to South America. Sufficient interest was found to justify a second trip to several Andean countries by the research assistant in November, 1973 as a follow-up to the effort. This effort has not, as yet, resulted in a formal extension of the project to South America.

(2) In May, 1973 the project director traveled to Santo Domingo to determine the feasibility of including the Dominican Republic in the study of vegetable exports. Conversations were held with the agricultural officer of AID-Dominican Republic and officials of CEDOPEX, the Dominican agency responsible for promoting exports. The participation of the Dominican Republic did not seem feasible at the time of the visit.

(3) During February 28 through March 1 a workshop for participants in the project was held in San Salvador. The research studies underway were reviewed and plans were made for research for the coming year.

Training of LDC Nationals

Eight graduate students from LDC's worked on the project during at least a part of the year - four from Peru, two from Mexico, one from Guatemala and one from Colombia.

ANNUAL RESEARCH REPORT

A. General Background

The market for fresh winter vegetables in the United States and Canada is limited. Various producing regions compete for this limited market. Florida and Mexico are presently the largest suppliers and most vigorous competitors. Several Central America and Caribbean countries are attempting to expand their exports. It is widely felt that Guatemala and El Salvador (among others) have the productive resources necessary to sucessfully compete for this market, although no concrete basis for this conclusion presently exists.

Mexican exports of tomatoes, peppers, and cucumbers have expanded rapidly in the last four years, bringing reduced U. S. prices for these products. No one knows how far this expansion will go, nor around what level prices will tend to stabilize. Without such knowledge it is impossible to conclude whether or not Guatemala and El Salvador can profitably export these vegetables.

Research under contract AID/csd-3632 is designed to provide the quantitative basis for answering the questions " Can Guatemala and El Salvador profitably export fresh winter vegetables to the U. S.?" and "If so, which vegetables? During which months? In what amounts?"

B. Objectives of Contract

Contract objectives include:

(1) estimation of the demand for selected winter vegetables in U. S. and Canadian markets;

(2) estimation of the supply potential for winter vegetables on small, medium, and large farms in the primary production areas of Guatemala and El Salvador, compared with competing areas of Florida and Mexico;

(3) evaluation of domestic demand and consumption compared with export demand;

(4) analysis of alternative means and costs of transporting and distributing vegetables from production zones to market;

(5) summarization of all analytical data developed in (1) through (4) above by using appropriate analytical procedures and models;

(6) the holding of an annual workshop in Central America to ensure adequate coordination of the research.

C. Continued Relevance of Contract Objectives

The objectives as stated in the contract document are still relevant to the research problem and have not been modified significantly.

D. Research Accomplishments to Date

(1) Demand Estimation:

Monthly U. S. demand equations were estimated for tomatoes, peppers, and cucumbers for the winter season. The winter season was defined as December through May for tomatoes and December through April for peppers and cucumbers.

The statistical model was a single-equation least squares pooled-data type that uses dummy variables to allow for changes in intercepts and coefficients of explanatory variables. Each month was defined as a "class" and a dummy variable was used to shift the demand relations between classes. The form of the demand functions was assumed to be linear to facilitate subtraction of marketing costs. Tests of hypotheses using the error sums of squares and the F statistic were accomplished to determine if monthly differences in slopes and/or intercepts were statistically significant. Tests indicate that monthly differences in slopes and/or intercepts were significant for all three products.

The statistical model was as follows:

$$P_{it} = \alpha_o + \sum_{j=1}^{5} \alpha_j D_{jit} + \beta_o X_{it} + \sum_{j=1}^{5} \beta_j S_{jit} + \gamma_o I_{it} + \varepsilon_{it}$$

where i, j = class 1, 2, 3, 4, or 5 (i, j=1 for December, i, j=5 for April).

$t$ = crop years 1, 2, ... n.

$P_{it}$ = monthly average price for the vegetable in question, cents per pound, for i month, t year.

$X_{it}$ = monthly shipments of the vegetable in question to U. S. and Canadian markets, pounds per capita, in the ith month of year t.

$I$ = monthly disposable income, dollars per capita.

$\varepsilon$ = random disturbance with zero mean and constant variance.

$D_j$ = intercept shifting variables with

$$D_{jit} = \begin{matrix} 1 \text{ when } i = j \\ 0 \text{ when } i \neq j \end{matrix}$$

$S_j$ = slope coefficient changing variables with

$$S_{jit} = D_{jit}X_{it} = \begin{matrix} X_{it} & \text{where } i = j \\ 0 & \text{where } i \neq j \end{matrix}$$

Quantities shipped were considered predetermined, as was income per capita.

The prices used in the demand equations for peppers and cucumbers were the Florida shipping point prices, so the demand equations for these two products pertain to the demand at the first shipping point level. Demand equations for tomatoes used Nogales prices for "breakers and riper, 5x6's and larger." Estimation of demand at the terminal market or retail level would have involved estimating and subtracting a complex system of commission, brokerage, and shipping charges in order to derive the on-farm demand.

The estimated demand functions enable calculation of the magnitude of the effects on the price of vegetables of a specific change in quantity shipped. This information is crucial in planning planting dates so that peak shipments coincide with peak demand.

Estimates of the demand functions for tomatoes, peppers, cucumbers, and cantaloupes for each month of the winter season are given in Table 1. It will be noted that price elasticities tend to be smaller in December and January than in later months, possibly reflecting shifts in consumer preferences and

Table 1. Demand Estimates for Winter Vegetables in the U. S.[1(]

| Product | Month | Price Elasticity | Equation |
|---|---|---|---|
| Peppers | Dec. | -.52 | $P = 17.723 - 344.632\ Q + .016\ I$ |
| | Jan. | -.50 | $P = 20.506 - 321.037\ Q + .016\ I$ |
| | Feb. | -.92 | $P = 4.401 - 202.010\ Q + .016\ I$ |
| | Mar. | -.71 | $P = 12.911 - 240.772\ Q + .016\ I$ |
| | Apr. | -.67 | $P = 25.643 - 315.812\ Q + .016\ I$ |
| Cucumbers | Dec. | -.57 | $P = 32.352 - 168.525\ Q + .0021\ I$ |
| | Jan. | -.83 | $P = 28.330 - 104.677\ Q + .0021\ I$ |
| | Feb. | -.94 | $P = 26.825 - 77.701\ Q + .0021\ I$ |
| | Mar. | -.86 | $P = 34.519 - 134.256\ Q + .0021\ I$ |
| | Apr. | -.83 | $P = 27.628 - 82.578\ Q + .0021\ I$ |
| Tomatoes | Dec. | | $P = 37.952 - 37.300\ Q + .0037\ I$ |
| | Jan. | | $P = 28.952 - 31.300\ Q + .0037\ I$ |
| | Feb. | | $P = 17.774 - 17.268\ Q + .0037\ I$ |
| | Mar. | | $P = 36.802 - 37.766\ Q + .0037\ I$ |
| | Apr. | | $P = 23.207 - 16.197\ Q + .0037\ I$ |
| | May | | $P = 46.001 - 33.940\ Q + .0037\ I$ |
| Cantaloupes | Feb. | | $P = 20.25 - 17.9 \times 10^{-7}\ Q + .68\ P_w$ |
| | Mar. | - 6.84 | $P = 13.70 - 4.1 \times 10^{-7}\ Q + .68\ P_w$ |
| | Apr. | -10.60 | $P = 15.29 - 1.8 \times 10^{-7}\ Q + .68\ P_w$ |

1( P = price in cents per pound, N. Y. wholesale market

Q = pounds shipped per capita

I = personal disposable income per capita

Pw= price of watermelon, cents per pound

prices of related products. The inelasticity of the demand for peppers and cucumbers makes oversupply costly in terms of decreased price.

The demand functions are used as restrictions in the LP supply model for Mexico, which is described in detail in Appendix A.

(2) Supply of Winter Vegetables in Mexico

The winter vegetables of interest in this project are produced in three irrigation districts in the state of Sinaloa, namely Culiacan, Guasave and El Fuerte Sur. In each of these districts the riskier export vegetables must compete with the less risky but possibly lower average valued traditional crops for the use of the productive resources.

It was necessary to formulate an analytical model to generate the complex characteristics of Mexican supply. The model is described in the Appendix.

Data requirements for the model are extensive. Help in formulating the model and obtaining the data was obtained through an informal cooperating agreement with the Comision Coordinadora del Sector Agropecuario in Mexico City. Carlos Pomareda, a Ph.D. student at NCSU spent June and July, 1973 in Mexico City working on the project with the Comision. A return visit to Culiacan in November 1973 by Carlos and the project director was necessary to obtain additional data. Trial computer solutions were obtained in January 1974. A third attempt at data refinement was made by a trip to Culiacan in March, 1974 and additional computer runs will be made in April and May, 1974.

Final results may be available by June, 1974 and a manuscript will be written. The primary question which will be addressed is "What quantities of winter vegetables would Mexico be expected to supply at various prices?"

After several computer runs for the single zone of Culiacan it appears that the model can approximate reasonably closely the complex structure of agriculture in that zone. After additional informal testing the model will be suitable for generating "solutions" for various levels of policy variables.

(3) Supply of Winter Vegetables in Guatemala

The same research approach used to estimate Mexican supplies was also used in Guatemala. The promising export regions of Guatemala are the irrigated arid valleys of La Fragua - Teculutan, San Jeronomino, Las Monjas and Asuncion Mita. Through cooperation with INDECA (Instituto Nacional de Comercializacion Agricola) field research was initiated in December, 1972 and continued until July, 1973. Julio Hernandez, a graduate student at Chapingo, Mexico was hired to direct the field work. Data on the resource base and enterprises budgets were collected during periodic visits to the producing areas.

Due to difficulty in obtaining sufficient information in San Jeronomino, Las Monjas and Asuncion Mita, the analysis was carried forward only for La Fragua. Julio Hernandez came to North Carolina State University in July, 1973 to help analyze the data and write a report. Computer work was accomplished in November, 1973 and a manuscript written.

The Guatemala study indicates (tentatively) that the best alternatives for export are melons in December, January and February and peppers and cucumbers in March and April. This results from lighter expected supplies from Mexico and Florida during those months. Although La Fragua has a low density of population there appears to be no shortage of labor even with considerably expanded export vegetable production.

(4) Export Potential of Winter Vegetables in El Salvador

The University of Florida carried forward a research project on the potential for increasing vegetable production in Zapotitan, the principle irrigated district in El Salvador. Work was initiated in December, 1972 and is being continued until May 31, 1974. David Zimet, a graduate student at the University of Florida was stationed in San Salvador as principle investigator

of the project. In February, 1974 a manuscript was written summarizing the results of the research.

The El Salvador study focused principally on the potential production of a wide variety of vegetables for both domestic use and export in Zapotitan as an alternative to importing vegetables from Guatemala.

Zapotitan is the largest irrigated area in the country, and with its proximity to a highly developed transportation network, is thought to be the area with the largest vegetable potential. However, the study indicated tentatively that dairy activities would provide more employment and a higher valued land use than vegetables. Also, given present technologies, it is difficult for El Salvador to compete with Guatemala during some months of the year.

Further work is being done on new technologies for vegetable production which involve multiple cropping, to see if such a technology can improve competitive potential.

E. Dissemination and Utilization of Research Results

The demand estimates are being published as a research report through the North Carolina Experiment Station and will receive wide distribution. Copies of the manuscript have already been sent to colleagues in SIECA and ROCAP in Guatemala, the Ministry of Agriculture in El Salvador, and the Comision Coordinadora del Sector Agropecuario in Mexico City.

Although the manuscript on the supply of vegetables in Mexico presents only tentative results, a copy was made available to interested parties so they could be familiar with the analytical model. Participants in Guatemala, El Salvador and Mexico have received copies. The manuscript was discussed in a workshop in San Salvador in March, 1974 with various officials in the Ministry of Agriculture of El Salvador, members of ROCAP and SIECA in Guatemala, as well as with project participants.

F. Statement of Expenditures and Obligations and Contractor Resources

During the FY 1973-74, expenditures were as follows:

| | |
|---|---|
| Salaries | 50,399 |
| Fringe Benefits | 1,695 |
| Travel | 14,068 |
| Consultant Fees | 4,400 |
| Other Direct Costs | 0 |
| Overhead | 23,693 |
| Sub-Contract | 8,660 |
| Total | $102,915 |

G. Work Plan for Coming Year

(1) Refinement of supply analyses in Mexico, Guatemala, and El Salvador

(a) Mexico: Additional computer work will be accomplished during May and June to refine the analyses. Final results will be forthcoming in July, and a manuscript will be prepared at that time.

(b) Guatemala: Another field trip to Guatemala will be accomplished to refine the data. This trip is planned for July. Further computer work will then be scheduled for September. Final results should be forthcoming in October.

(c) El Salvador: The University of Florida has accomplished a study of vegetable production in the valley of Zapotitan in El Salvador. This study needs to be refined somewhat, which should be complete by May 31, 1974. This work will be done by Florida on their subcontract which expires May 31, 1974.

(2) Integration of the individual country results into a single, coordinated analysis.

This will involve additional computer work in October and November. A final manuscript will be prepared which summarizes the results for the three countries.

(3) Conduct training sessions in Guatemala, El Salvador and Mexico to enable technicians in those countries to use the models for year to year planning.

This will involve one week in each of the three countries by a team consisting of the project director and an assistant. This activity would be accomplished in December and January. As a part of the training sessions, attention will be devoted to methods of periodic refinement of the coefficients in the model in order to keep the analysis current.

(4) A special report will be written suggesting criteria for credit and technical assistance for small and medium farmers who export fresh vegetables. This will be done in February and March, 1975.

Anticipated Budget for Coming Year

| | |
|---|---|
| Salaries and Wages | 73,588 |
| Fringe Benefits | 5,370 |
| Consultants | 625 |
| Travel and Transportation | 6,616 |
| Other Direct Costs | 14,500 |
| Overhead | 34,594 |
| Total | $135,293 |

# APPENDIX: ANALYTICAL MODEL FOR ESTIMATING SUPPLY POTENTIAL FOR WINTER VEGETABLES IN MEXICO

## 1. Introduction

Exports of agricultural products have recently been one of the most active sectors of the Mexican economy. The United States has so far been the major market for exports of Mexican winter vegetables. Exports of winter vegetables occur between December and June when U. S. production is restricted to the regions of Florida and, in very small proportion, Texas and California.

Mexico's share in the total U. S. winter market for tomatoes, peppers, and cucumbers has increased from only 10 percent in 1960 to nearly 50 percent in 1970. Even though the U. S. Department of Agriculture has tried by several means to restrict U. S. imports to Mexican vegetables, the expansion has continued.

Supply fluctuations often cause serious drops in U. S. prices which, in turn results in lower returns for American as well as Mexican vegetables producers.

Other potential vegetable producing regions, e.g., Guatemala, Costa Rica, and El Salvador, are exporting possibilities in the U. S. market and production alternatives are being analyzed. Yet, the question remains of how much in each month can Mexico, the other Central American countries, and Florida produce in order to maximize farmer's net revenues.

### Objectives of the Study

EXPORT is a piece of a general market equilibrium model that includes supply functions for Florida, Mexico, and Guatemala and demand functions for Mexico, the United States, and Canada. The idea behind the overall equilibrium model was to determine, under specific demand conditions and various

alternative U. S. and Canadian tariff levels, the relative advantage of each of the supplying regions to produce a certain product in a specific month in the year.

The products to be studied were tomatoes, cucumbers, green peppers, melons, and watermelons. The competition for the U. S. and Canadian markets is stronger between December and May for the first three products and between March and June for melons and watermelons. The period for studying production possibilities was then extended from December through June.

In the case of Mexico, which this report covers in detail, the situation is not much different than what other producing regions face. Mexican vegetable producers face a situation of uncertainty in relation to what area to plant and at what time of the year to plant in order to produce a certain amount that, according to market restrictions, would maximize farmers' net returns. A comprehensive study was required to determine optimum levels of production that would result in farmers income maximization and optimal allocation of resources in the vegetable producing regions.

The general objective of this study was to explore and determine, for the area included in EXPORT, the amount of each crop to be produced subject to physical and technological constraints (weather, water, labor, land, and other input restrictions) and also, which is more important, market restrictions and uncertainty (in prices and yields) that farmers face.

The specific objectives of the study were to:

1. Identify and describe the main areas in Mexico where vegetables are produced for export purposes.

2. Formulate a linear programming model for the vegetable exporting sector (EXPORT). The model included U. S. and Canadian monthly demand restrictions and the model was explored under monopolistic and perfect competitive demand conditions. Assumptions were made about Florida supply characteristics.

3. Formulate a risk model (a modified version of EXPORT) in which different levels of uncertainty in expected prices and yields were incorporated to bring into the model more of what the real situation is.

4. Find LP solutions for EXPORT and EXPORT-RISK for the target year 1970-71 and for the 1973-74 year.

# II. Theoretical Framework

## General Structure of the Model

The model used in this analysis is a simplified version of the Mexican agricultural model CHAC.[1] It has been designed to answer questions of pricing, production, and trade policies. As CHAC, it is structured so that it is a simple matter to change factor prices to analyze the effects of such changes. The prices received by farmers and paid by consumers for exported crops also may be adjusted readily to reflect changes in tariffs and taxes.

Monthly commodity demand functions are included within the structure of the model for the most important exported vegetables (tomatoes, green peppers, and cucumbers). For these crops prices are determined by demand as well as supply conditions. Besides these vegetables, the model covers annual crops plus sugar cane and alfalfa. Long-cycle crops and livestock have been excluded. Thus, the model assumes implicitly that there is no competition for limiting resources between short-cycle crops, livestock, and long-cycle crops.

## Overview of the Model

The model used in this study intends to describe month by month production, domestic demand, and exports for the three principal exporting vegetables in Culiacan, Sinaloa. It is a one-period model for the target season of 1972-73. On the demand side, consumer behavior is regarded as price-dependent, and thus market-clearing commodity prices are

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[1]Unpublished report, CHAC, A Programming Model of Mexican Agriculture, J. Duloy and R. D. Norton, Mexico, May 1972, pp. 24-32.

Mexico enables strict control of acreages planted which enables group maximization of total revenues given expected Florida supplies.

The objective function is quadratic and in order to use a linear programming algorithm the area under the demand function, called W, which is a function of the level of production activities and yields, was segmented into steps. Each step was entered as a column.

The linear programming tableau that corresponds to a segmented approximation of the function W for a product (j) is as follows:

| | Cropping Activities | Selling Activities | Right-hand Side |
|---|---|---|---|
| Competition | $-c_j$ | $w_1, w_2, \ldots w_n$ | |
| Commodity balance | $y_j$ | $-Q_1, -Q_2, \ldots, -Q_n$ | $\geq 0$ |
| Demand constraint | | $1 \quad 1, \ldots 1$ | $\leq 1$ |

where:

$c_j$ = Costs associated with crop producing activity j

$y_j$ = Yields of the producing activity j

$w_i$ = Values of the maximand corresponding to quantities $Q_j^v$

$Q_1$ = Total quantities sold at the limit of each segment of the function W.

The objective function is

$$\text{Max } \Pi = Q[A - 0.5\ B\ Q] - C(Q)$$

where A is a vector of constants

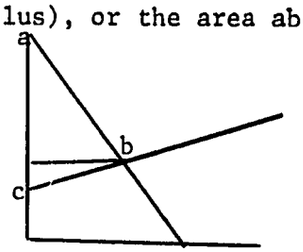
B is a diagnal matrix of slope coefficients

and C(Q) is the set of total costs

The term Q[A - .5 B Q] is the sum of areas under the demand functions. For example, in the single product case this would be

$$\int_0^q (a - bq)\ dq = q\ (a - .5\ bq)$$

The term C(Q) is total production costs, or equivalently the sum of areas under the marginal cost functions. Subtracting total costs from the areas under the demand functions gives total social payoff (consumers surplus plus producer surplus), or the area abc in Figure 1.




It has been shown that maximizing social payoff yields the competitive solution of price equals marginal costs.

The alternative formulation explored in this study was the monopoly solution characterized by the rule of equality of marginal revenue (instead of price) with marginal cost. The objective function for this case is

$$\text{Max } \Pi = Q\ [\alpha - bQ] - C(Q)$$

maximizing this function with respect to Q gives

$$\frac{\partial \Pi}{\partial Q} = \alpha - 2bq - C'(q)$$

The first term is marginal revenue and the second is marginal cost.

The monopoly case is explored because the institutional structure in

endogenous to the model. The demand functions are assumed to be linear for convenience.

For the other 13 short-cycle crops, prices are assumed to be exogenous at an estimated level for 1972-73.[2] Among these crops, three (sugar cane, watermelons, and melons) were bounded to fixed areas of production.

The model is also oriented to describe two forms of market equilibrium for the exported vegetables. In one case, the market form is taken to be competitive and in the other, the sector is taken as a monopolistic supplier of exported vegetables. The purpose of these analyses is to determine which market mechanism is closer to the actual processes which determine production and prices for the exported vegetables in Culiacan.

Factor markets are not specified in detail. Inputs and services of machinery are priced at observed market prices. The supply of these inputs is assumed to be infinitely elastic. Water charges are included at levels estimated by CAADES for reservoir water.[3] Since monthly and annual limits to the availability of water is specified, the effective water price is increased by a rental element given in the dual solution. Cultivable land is specified in limited quantities. The opportunity cost of land is determined in the model.

The labor supply functions are assumed to be perfectly elastic at observed market wages. No differentiation has been made between wages for farmer services and the services of hired labor.

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[2]These prices were estimated using a distributed-lag model based on three seasons previous to the target season.

[3]Unpublished report, Sinaloa, Costos de Produccion por Cultivos, by CAADES, Culiacan, Mexico, 1970-71.

The demand function for the exporting crops are assumed to be linear for ease of computation. It is also assumed that all purchasers pay the same prices and that all suppliers receive this price. This implies that producers and consumers are relatively homogenous and therefore they can be aggregated into macro units which can be represented by linear programming activities.

## The Objective Function

Two forms of market equilibrium are considered for exporting vegetables. First, the competitive case in which the sector maximizes total utility by equating marginal costs to the prices of products. Second, the monopolistic case in which net income is maximized by equating marginal costs to the marginal revenue of products.

Assuming linear functions and the absence of cross-price elasticities, the set of import demand curves for Mexican export vegetables is of the form:

$$P = \alpha - \beta Q \qquad (1)$$

Where Q is the total amount entering the market.

only a few crops may be planted as a second crop during the year.

Three crops, sugar cane, watermelons, and melons, were given fixed areas in the model, according to what has been observed in the region.

## Factor Supply Activities

In this model two factors are supplied in fixed quantities -- land and water. Agricultural land is not priced because it does not have an opportunity cost in the short-run, but the dual solution of the model yields the value of rents which acrue to the land. Similarly, endowments of water are not priced, but the cost of water as estimated by CAADES is charged against the objective function.

Sector-wide factor supply activities are included for labor, machinery services, chemicals, seeds, and credit. A sector-wide water pricing activity was included in order to perform sensitivity analyses on the effects of systematic sector-wide variations in water charges. All the factor supply activities but land and water are assumed to be supplied with infinite elasticity.

## The Structure of Demand for Exporting Crops

The problem stated in the model is that of maximizing total utility in the competitive case and net revenue in the monopolistic case. The maximization process is at exogenous input prices, endogenous exporting crops prices, and exogenous prices for the other short-cycle crops. The demands and product prices for the exporting crops are related endogenously through demand curves.

In the solution for the competitive case, the maximand used is the sum of producers' and consumers' surpluses. This ensures that the optimal solution will be a competitive market equilibrium. In the monopolistic case, net revenue is maximized.

## Basic Structure of the Model

The model contains multiple-step demand functions for the exported crops with no interdependence among them. It was assumed that cucumbers and green peppers are sold for export but not sold in Mexican markets. Tomatoes use one additional activity for sales in the domestic market for each of the six months included.

The demand for land and water are defined at monthly intervals. All other inputs are treated on an annual basis.

## The Production Technology Set

The model contains 16 cropping activities to describe production for the three exported crops. For the other short-cycle crops, except corn, one cropping activity is described.[4] Each cropping activity defines a yield per hectare, together with fixed proportions of the following inputs: Land (monthly), water (monthly and annually), labor, machinery services, chemicals, purchased seeds, and credit. The relation between inputs and outputs are obtained from CHAC and adjusted using CAADES figures. Land is grouped into one class, based on an average efficiency of gross water use. Only fully mechanized activities were included. No changes in techniques were permitted in the model. The input requirements make it possible that

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[4]Corn was described by two cropping activities --- winter and spring corn.

## DEMAND FOR EXPORTS

Monthly U. S. demand equations were estimated for tomatoes, peppers, and cucumbers for the winter season. The winter season was defined as December through May for tomatoes and December through April for peppers and cucumbers.

The statistical model was a single equation least squares pooled-data type that uses dummy variables to allow for changes in intercepts and coefficients of explanatory variables. Each month was defined as a "class" and a dummy variable was used to shift the demand relations between classes. The form of the demand functions was assumed to be linear to facilitate subtraction of marketing costs. Tests of hypotheses using the error sums of squares and the F statistic were accomplished to determine if monthly differences in slopes and/or intercepts were statistically significant. Tests indicates that monthly differences in slopes and/or intercepts were significant for all three products.

The statistical model was as follows:

$$P_{it} = \alpha_o + \sum_{j=1}^{5} \alpha_j D_{jit} + \beta_o X_{it} + \sum_{j=1}^{5} \beta_j S_{jit} + \gamma_o I_{it} + \varepsilon_{it}$$

where i, j = class 1, 2, 3, 4, or 5 (i, j=1 for December, i, j=5 for April).

t = crop years 1, 2, .. n.

$P_{it}$ = monthly average price for the vegetable in question, cents per pound, for i month, t year.

$X_{it}$ = monthly shipments of the vegetable in question to U. S. and Canadian markets, pounds per capita, in the ith month of year t.

I = monthly disposable income, dollars per capita.

$\varepsilon$ = random disturbance with zero mean and constant variance.

$D_j$ = intercept shifting variables with

$$D_{jit} = \begin{matrix} 1 \text{ when } i = j \\ 0 \text{ when } i \neq j \end{matrix}$$

$S_j$ = slope coefficient changing variables with

$$S_{jit} = D_{jit} X_{it} = \begin{matrix} X_{it} \text{ where } i = j \\ 0 \quad \text{where } i \neq j \end{matrix}$$

Quantities shipped were considered predetermined, as was income per capita.

The prices used in the demand equations for peppers and cucumbers were the Florida shipping point prices, so the demand equations for these two products pertain to the demand at the first shipping point level. Demand equaticns for tomatoes used Nogales prices for "breakers and riper, 5x6's and larger." Estimation of demand at the terminal market or retail level would have involved estimating and subtracting a complex system of commission, brokerage, and shipping charges in order to derive the on-farm demand. The demand questions are given in Table 1.

In order to focus the analysis on the 1972-73 crop year the 1972-73 per capita income, $3,795, was substituted into the demand equations. Table 2 gives the demand functions with the income effect incorporated in the intercept.

The intercepts for tomatoes must be adjusted to reflect the fact that all tomatoes sold are not 5x6's and larger. The average price for all grades weighted by quantities sold in each grade was 97 percent of the price for 5x6's in 1971-72. Hence, the intercepts were multiplied by .97.

Table 1. Estimated Demand Functions for Tomatoes, Peppers, and Cucumbers

| | | |
|---|---|---|
| Tomatoes[1] | December | $P = 37.952 - 37.300\ Q + .0037\ I$ |
| | January | $P = 28.952 - 31.300\ Q + .0037\ I$ |
| | February | $P = 17.774 - 17.268\ Q + .0037\ I$ |
| | March | $P = 36.802 - 37.766\ Q + .0037\ I$ |
| | April | $P = 23.207 - 16.197\ Q + .0037\ I$ |
| | May | $P = 46.001 - 33.940\ Q + .0037\ I$ |
| Peppers[2] | December | $P = 31.588 - 397.119\ Q + .0104\ I$ |
| | January | $P = 32.165 - 346.822\ Q + .0104\ I$ |
| | February | $P = 16.444 - 226.657\ Q + .0104\ I$ |
| | March | $P = 30.521 - 300.054\ Q + .0104\ I$ |
| | April | $P = 41.462 - 363.343\ Q + .0104\ I$ |
| Cucumbers[2] | December | $P = 27.831 - 141.397\ Q + .00084\ I$ |
| | January | $P = 26.706 - 98.358\ Q + .00084\ I$ |
| | February | $P = 27.209 - 84.448\ Q + .00084\ I$ |
| | March | $P = 34.276 - 135.837\ Q + .00084\ I$ |
| | April | $P = 23.962 - 23.622\ Q + .00084\ I$ |

[1] P = price in cents per pound at Nogales, breakers and riper 5x6's and larger.

Q = quantity shipped, pounds per capita.

I = disposable per capita income.

[2] P = price in cents per pound, Florida Shipping point.

Q = quantity shipped, pounds per capita.

I = disposable per capita income.

Table 2. Estimated 1972-73 Demand Functions for Tomatoes, Peppers, and Cucumbers

| | | |
|---|---|---|
| Tomatoes | December | P = 53.270 - 37.300 Q |
| | January | P = 44.270 - 31.300 Q |
| | February | P = 33.092 - 17.268 Q |
| | March | P = 52.120 - 37.766 Q |
| | April | P = 38.525 - 16.197 Q |
| | May | P = 61.319 - 33.940 Q |
| Peppers | December | P = 74.644 - 397.119 Q |
| | January | P = 75.221 - 346.822 Q |
| | February | P = 59.500 - 226.657 Q |
| | March | P = 73.577 - 300.054 Q |
| | April | P = 84.518 - 363.343 Q |
| Cucumbers | December | P = 31.309 - 141.397 Q |
| | January | P = 30.184 - 98.358 Q |
| | February | P = 30.687 - 84.448 Q |
| | March | P = 37.754 - 135.837 Q |
| | April | P = 27.440 - 73.622 Q |

Source: Per capita disposable income of $4,140 was multiplied by the income coefficient and added to the intercept.

In order that these equations reflect on-farm demand in Culiacan, it is necessary to:

(1) subtract Florida supplies from the demand function,

(2) subtract all shipping and marketing costs from Culiacan to the port of entry, and

(3) correct for any normal price premium or discount received by Mexican growers because of quality.

## Florida Supplies

Expected Florida supplies of the winter vegetables for 1972-73 was the simple average of the three years, 1970-71, 1971-72, and 1972-73. No attempt was made at this point to construct a simulation model which would generate "expected" Florida supplies on a year to year basis and compute optimal decisions for Mexico given the latest prediction for Florida. Rather the emphasis at this point was placed on long-run equilibrium values of market shares and product prices.

Florida supplies for the past three years are given in Table 3, along with the simple three-year average. Table 4 gives demand functions net of Florida shipments.

## Marketing Charges - Culiacan to Nogales

The only ad valoren marketing charge at the shipping point level is the sales commission, which is 12 percent. Demand functions are adjusted for sales commission in Table 5. All other marketing changes are fixed charges per unit. U. S. tariff charges vary over the winter months. Table 6 lists marketing and transportation charges. Table 7 gives demand functions at the far level in Culiacan.

Table 3. Supplies of Vegetables from Competing Areas[a] (primarily Florida)

| | Year | | | | Average | | |
|---|---|---|---|---|---|---|---|
| | Month | 1970-71 | 1971-72 | 1972-73 | Carlots | Million lbs. | Per capita (lbs) |
| Tomatoes | December | 2830 | 2837 | 2398 | 2685 | 107.40 | .5196 |
| | January | 1989 | 2143 | 1762 | 1965 | 78.60 | .3803 |
| | February | 1057 | 1388 | 882 | 1109 | 44.36 | .2146 |
| | March | 731 | 1803 | 1093 | 1209 | 48.36 | .2340 |
| | April | 1343 | 1647 | 1863 | 1618 | 64.72 | .3131 |
| | May | 2915 | 2966 | 3559 | 3822[b] | 152.88 | .7396 |
| Peppers | December | 1259 | 1279 | 1073 | 1204 | 28.65 | .1386 |
| | January | 921 | 867 | 778 | 855 | 20.35 | .0984 |
| | February | 237 | 523 | 494 | 418 | 9.95 | .0482 |
| | March | 166 | 691 | 621 | 493 | 11.73 | .0568 |
| | April | 472 | 686 | 895 | 684 | 16.28 | .0788 |
| Cucumbers | December | 236 | 596 | 579 | 470 | 16.45 | .0796 |
| | January | 196 | 268 | 268 | 244 | 8.54 | .0413 |
| | February | 112 | 254 | 192 | 186 | 6.51 | .0315 |
| | March | 101 | 206 | 259 | 189 | 6.61 | .0320 |
| | April | 293 | 880 | 737 | 637 | 22.29 | .1079 |

[a]Assumes 40,000 lbs. per carlot for tomatoes, 28,500 for peppers, and 50,000 for cucumbers, and a population of 206,700,000 people.

[b]Includes 675 carlots from areas besides Florida for May.

Table 4. Demand Function Net of Florida and Other Shipments

| | | |
|---|---|---|
| Tomatoes | December | P = 33.889 - 37.300 Q |
| | January | P = 32.367 - 31.300 Q |
| | February | P = 29.386 - 17.268 Q |
| | March | P = 43.280 - 37.766 Q |
| | April | P = 33.454 - 16.197 Q |
| | May | P = 36.217 - 33.940 Q |
| Peppers | December | P = 19.603 - 397.119 Q |
| | January | P = 41.098 - 346.822 Q |
| | February | P = 48.575 - 226.657 Q |
| | March | P = 56.534 - 300.054 Q |
| | April | P = 55.887 - 363.343 Q |
| Cucumbers | December | P = 20.054 - 141.397 Q |
| | January | P = 26.122 - 98.358 Q |
| | February | P = 28.087 - 84.448 Q |
| | March | P = 33.407 - 135.837 Q |
| | April | P = 19.496 - 73.622 Q |

Table 5. Estimated 1972-73 Demand Functions[1] for Tomatoes, Peppers and Cucumbers, net of sales commission[1]

| | | |
|---|---|---|
| Tomatoes | December | P = 29.822 - 32.824 Q |
| | January | P = 28.483 - 27.544 Q |
| | February | P = 25.860 - 15.196 Q |
| | March | P = 38.086 - 33.234 Q |
| | April | P = 29.440 - 14.253 Q |
| | May | P = 31.871 - 29.867 Q |
| Peppers | December | P = 17.251 - 349.465 Q |
| | January | P = 36.166 - 305.203 Q |
| | February | P = 42.746 - 199.458 Q |
| | March | P = 49.750 - 264.048 Q |
| | April | P = 49.181 - 319.742 Q |
| Cucumbers | December | P = 17.648 - 124.429 Q |
| | January | P = 22.987 - 86.555 Q |
| | February | P = 24.717 - 74.314 Q |
| | March | P = 29.398 - 119.537 Q |
| | April | P = 17.156 - 64.787 Q |

[1]Sales commission estimated at 12 percent.

Table 6. Marketing and Transport Costs, Culiacan to Nogales

| | | Tomatoes | Cucumbers | Peppers |
|---|---|---|---|---|
| U.S. Tarriff | December | 1.5 ¢/lb. | 2.2 ¢/lb. | 2.5 ¢ |
| | January | " | " | " |
| | February | " | " | " |
| | March | 2.1 ¢/lb. | 3.0 ¢/lb. | " |
| | April | " | " | " |
| | May | " | " | " |
| Transport costs | | 1.51 | 2.43 | 1.51 |
| Classification and packing | | 3.06 | 1.63 ¢/lb. | 2.34 ¢/lb. |
| Miscellaneous payments | | .66 | .70 ¢/lb. | .36 ¢/lb. |
| Total | December | 6.73 ¢ | 6.96 ¢ | 6.71 ¢ |
| | January | 6.73 ¢ | 6.96 ¢ | 6.71 ¢ |
| | February | 6.73 ¢ | 6.96 ¢ | 6.71 ¢ |
| | March | 7.33 ¢ | 7.76 ¢ | 6.71 ¢ |
| | April | 7.33 ¢ | 7.76 ¢ | 6.71 ¢ |
| | May | 7.33 ¢ | - | - |

Table 7. Demand Functions for Tomatoes, Peppers, and Cucumbers at Culiacan

| | | |
|---|---|---|
| Tomatoes | December | P = 23.092 - 32.824 Q |
| | January | P = 21.753 - 27.544 Q |
| | February | P = 19.130 - 15.196 Q |
| | March | P = 30.756 - 33.234 Q |
| | April | P = 22.110 - 14.253 Q |
| | May | P = 24.541 - 29.867 Q |
| Peppers | December | P = 12.291 - 349.465 Q |
| | January | P = 31.206 - 305.203 Q |
| | February | P = 37.786 - 199.458 Q |
| | March | P = 43.990 - 264.048 Q |
| | April | P = 43.421 - 319.742 Q |
| Cucumbers | December | P = 10.938 - 124.429 Q |
| | January | P = 16.277 - 86.555 Q |
| | February | P = 18.007 - 74.314 Q |
| | March | P = 22.688 - 119.537 Q |
| | April | P = 10.446 - 64.787 Q |

Quality Premiums

Observation of weekly prices in several major cities in the Northeast part of the U. S. indicated that peppers from Mexico obtained a price premium of two cents per pound. Consequently two cents per pound are added to the intercepts for peppers in Table 7.

The prices in the demand functions (intercepts) are converted to pesos and the quantity variable is converted to kilograms in Table 8.

Demand for Tomatoes in Mexico

Total annual production of tomatoes in Mexico in 1971-72 was about 430,000 metric tons, according to published statistics. Sinaloa produced 108,000 tons, or about 25 percent. However, in the January to June period Sinaloa produced clost to 50 percent.

Average annual price was 15,000 pesos per ton. For lack of data on production or consumption by months it was assumed that the demand was equal in each month.

Assuming a price elasticity of -.5 and assuming the point (1.5 pesos, 35,833 tons) represented a point on the demand function, the monthly demand for Mexico would be:

$$P = 4.500 - .8372 \times 10^{-4} Q$$

where P = price in pesos per kg.

Q = quantity in metric tons.

Assuming other areas already produced 18,000 tons, the monthly net demand function for Sinaloa would be:

$$P = 2.993 - .8372 \times 10^{-4} Q.$$

Table 8. Demand Functions for Tomatoes, Peppers, and Cucumbers at Culiacan, pesos per metric ton

| | | |
|---|---|---|
| Tomatoes | December | P = 2.886 - .000043755 Q |
| | January | P = 2.719 - .000036722 Q |
| | February | P = 2.391 - .000020254 Q |
| | March | P = 3.844 - .000044305 Q |
| | April | P = 2.764 - .000019006 Q |
| | May | P = 3.068 - .000039815 Q |
| Peppers | December | P = 1.786 - .00046591 Q |
| | January | P = 4.176 - .00040690 Q |
| | February | P = 4.973 - .00026592 Q |
| | March | P = 5.749 - .00035203 Q |
| | April | P = 5.678 - .00042629 Q |
| Cucumbers | December | P = 1.367 - .00016589 Q |
| | January | P = 2.035 - .00011539 Q |
| | February | P = 2.251 - .00009907 Q |
| | March | P = 2.836 - .00015937 Q |
| | April | P = 1.306 - .00008637 Q |

P = pesos

Q = metric ton