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A Comparative Static Analysis of Oklahoma's Vegetable Industry

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ABSTRACT

The impact of hypothetical changes in yields, costs, and demand that might result from the organization of Oklahoma vegetable growers into cooperatives or other multifarmer marketing associations is estimated using a sector programming model. A comparative static analysis is used to evaluate the impact of these changes on planted acreage, growers' revenues, and consumers' and producers' surplus. The results of this analysis indicate that changes in demand are most effective in increasing revenues for Oklahoma growers.

Key Words: comparative static analysis, Oklahoma vegetable crops, produce cooperative association, sector programming model.

Currently, there are relatively few vegetable growers in Oklahoma, and most of the local market is supplied by out-of-state growers. Because many of the production operations in Oklahoma are small, individual growers have a difficult time marketing to wholesalers. Joint marketing by groups of growers might provide an opportunity for more of the growers to enter the wholesale markets. The general goals of marketing cooperatives or many of the multifarmer marketing organizations are to provide efficient production methods and marketing outlets, to increase demand for their members' commodities, to provide better coordination between production and consumption, and to provide more dependable market outlets (Rhodes, p. 265). Therefore, by joining a marketing organization, the members may benefit from increased demand as well as production and marketing cost savings.

Oklahoma has a relatively long growing season during the summer months, an abundance of good land, and a sufficient supply of water. These characteristics make the production of many vegetables in Oklahoma possible (Schatzer, Wickwire, and Tilley). Previous research (Schatzer, Wickwire, and Tilley; Henneberry and Willoughby; Henneberry and Kang) has shown profitable marketing opportunities for Oklahoma fresh produce in the commercial wholesale markets.

The general objective of this study is to analyze the economic impacts of the expansion of selected vegetable crops in Oklahoma that might result from the organization of the growers into cooperatives or other multifarmer marketing associations. To accomplish this objective, the impacts of hypothetical changes in yields, costs, and demand on farmers' incomes and the production of selected vegetables are estimated. Moreover, the impact on consumers' and producers' surplus is evaluated. A comparative static analysis is used for this purpose. Seven vege-

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tables are examined: tomatoes, green peppers, cucumbers, cabbage, muskmelons, sweet corn, and squash.

The Model

A programming approach was used to compare the impacts of various hypothetical changes in yields, costs, and demand on the Oklahoma vegetable industry that might result from the consolidation of farmers into a marketing organization or a cooperative. The design of the Oklahoma programming sector model closely follows the model developed by Hazell and Norton. Based on their research, they assert that a sector programming model should contain five elements: the economic behavior of producers, the production functions or technological sets available to growers, resource endowments available in the sector to be studied, market environment specifications, and policy specifications.

The model used in this study incorporates the supply and demand for the seven selected Oklahoma vegetable crops under study. A one-period model with a 1989 base year is used. The production side of the model is decomposed into submodels for each of the seven crops. Activity budgets for small farms are used in this model because vegetable production in Oklahoma is characterized by small acreage. On the demand side, consumer demand is regarded as price dependent, and thus market clearing commodity prices are endogenous to the model. Demand segment variables, along with associated convex combination constraints, are included in the model.

The model assumes that individual consumers and producers are price takers and operate in a perfectly competitive environment, while market clearing is assumed in output and factor markets. These assumptions are realistic for the current situation in the fresh vegetable industry in Oklahoma, because it is dominated by many small producers. Furthermore, given that data are limited, and to simplify the analysis, demand curves are assumed to be linear.

The Objective Function

The objective function used in this study maximizes the sum of consumers' and producers' surpluses, which is measured by the area between the linear demand and supply curves. The objective function is specified in a quadratic form and is algebraically measured as the area under the total demand curve, minus total cost. Total demand includes out-of-state as well as in-state demand.

A linear price-dependent (inverse) demand function is used in the model to represent demand. The price/quantity relationship is assumed to be exogenous to the model. The model solution will determine which segment of the demand function will maximize the objective function. The supply function for each vegetable exhibits constant average cost as production increases, due to fixed yields per acre as acreage expands.

The mathematical form of the objective function can be written as follows:

$$\Pi = \Sigma_i \Sigma_s W_{is} D_{is} + \Sigma_i \Sigma_r U_{ir} E_{ir} - \Sigma_f P_f J_f - \Sigma_i \Delta_i M_i,$$

where i is the crop type, s is the in-state demand segment, r is the out-of-state demand segment, f is the input type, W_{is} is the area under the in-state demand curve for crop i at segment s, D_{is} is the variable representing the position on the in-state demand curve for crop i at segment s, U_{ir} is the area under the out-of-state demand curve for crop i at segment r, E_{ir} is the variable representing the position on the out-of-state demand curve for crop i at segment r, P_f is the cost of purchase of input f, J_f is the supply of purchased input f, Δ_i is the marketing and packing cost (per farm unit) from the farm to the retail level for crop i, and M_i is the farm units of crop i marketed.

The Constraints

The model used in this study includes several constraints to balance resource use and output distribution. A simplified version of the Oklahoma sector model used here is given in table 1. Each constraint in the model is represented by a row in this table.

Commodity balance equations ensure that total quantity marketed does not exceed total production, and that quantity demanded does not exceed total amount marketed. The equations include the amounts produced of each commodity, whether consumed locally or sold outside the state. Commodity balances are expressed as follows:

Table 1. Simplified Tableau for the Oklahoma Sector Model

	Activities or Columns					
Balances/Rows	Production X_i	Input Supply J_f	Marketing M_i	In-State Demand D_{is}	Out-of-State Demand E_{ir}	RHS
Resources	a_{ki}					$\leq b_k$
Input Transfers	a_{fi}	-1				≤ 0
Farm-Level Yield	$-Y_i$		1			≤ 0
Retail-Level Yield			$-m_i$	G_{is}	H_{ir}	≤ 0
In-State Convex				1		≤ 1
Out-of-State Convex					1	≤ 1
Objective Function		$-P_f$	$-\Delta_i$	W_{is}	U_{is}	Max

Notes: RHS represents the right-hand-side component; a_{ki} and a_{fi} are requirements of resource k and purchased input f per acre of crop i, respectively; Y_i is farm-level yield for crop i; m_i is retail unit per farm unit for crop i; G_{is} and H_{ir} are the quantities associated with in-state and out-of-state demands at each segment of demand for crop, respectively; P_f is the cost to purchase input f; Δ_i is marketing and packing cost of farm to retail level for crop i; and W_{is} and U_{is} are the areas under the in-state and out-of-state demand curves, respectively.

$$-Y_i X_i + M_i \leq 0$$

and

$$-m_i M_i + \textstyle\sum_s G_{is} D_{is} + \sum_r H_{ir} E_{ir} \leq 0,$$

where Y_i is the farm-level yield for crop i, X_i is the acres of crop i, m_i is the retail units per farm unit for crop i, G_{is} is the quantity associated with in-state demand at different demand segments for crop i, H_{ir} is the quantity associated with out-of-state demand at different demand segments for crop i, and the remaining expressions are as previously defined.

Input balance equations ensure that the level of input usage does not exceed the supply for each input. Input balances are expressed as follows:

$$\textstyle\sum_i a_{fi} X_i - J_f \leq 0 \qquad \forall f \text{ inputs},$$

where a_{fi} denotes the requirements of purchased input f for crop i (per acre).

Resource constraints ensure that the amount of resources used by the agricultural sector is less than or equal to the available amount. These constraints are expressed as follows:

$$\textstyle\sum_i a_{ki} X_i \leq b_k \qquad \forall k \text{ resources},$$

where a_{ki} is the requirement of resource k for crop i (per acre), and b_k is the amount of resource k available.

Nonnegativity constraints are included to guarantee that all activities in the model have a nonnegative value. These constraints are expressed as follows:

$$X_i \geq 0, \quad J_f \geq 0, \quad D_{is} \geq 0, \quad \text{and}$$
$$E_{ir} \geq 0 \quad \forall\, i, f, s, r.$$

Demand convexity constraints force the model's solution to lie on the demand curve. There is a convexity constraint for in-state demand equation (1) and out-of-state demand equation (2). The convex combination for each crop must not exceed unity, and is written in the following manner:

$$\left.\begin{array}{ll} (1) & \sum_s D_{is} \leq 1 \\ (2) & \sum_r E_{ir} \leq 1 \end{array}\right\} \quad \forall\, i \text{ crops}.$$

Activity Components

The Oklahoma sector model contains columns of activities to describe production, input supply, marketing, in-state demand, and out-of-state demand. Each activity in the model is represented by a column in table 1. The columns relate the resource and input use to the marketed output that is used to meet in-state and out-of-state demand. The input/output coefficients are given in table 1.

Production activities (X_i) describe the production of the seven crops under study. Each production activity represents the various levels of input requirements, resource use, and a yield per acre. For simplicity, input/output coefficients (a_{kt} and a_{ft}) are assumed to be the same for all growers in Oklahoma. Since most of the inputs are available in Oklahoma, the assumption of a perfectly elastic input supply seems reasonable (i.e., all amounts can be purchased at the given price).

Input supply activities (J_f) represent the demand for inputs required in the production process. Two groups of inputs (labor and irrigation activities) are incorporated into the Oklahoma sector model. Labor is measured in man-hour equivalents and shows actual time required per acre for each crop. Irrigation is measured in acre-inches in the model and corresponds to the usage of water required per acre for each crop. Production inputs such as land, labor, machinery, and fertilizer are available to Oklahoma growers, and shortages are not expected to occur as production expands. Thus, the assumption of a perfectly elastic factor supply seems reasonable for those inputs. Input usage of seeds, transplants, fertilizer, herbicides, pesticides, and machinery services is included in the cost within the production activity block in the model, and not in the input supply activity column.

Marketing and packing activities (M_t) reflect the transfer of crops from the farmgate level to the retail level. Normally, marketing and packing activities are included within the production activity block. However, in the Oklahoma sector model, marketing and packing activities are incorporated under a separate activity column for each crop. These activities enable us to examine the impacts of various changes in marketing activities on the fresh vegetable industry in Oklahoma.

In-state and out-of-state demand activities represent the demand for each crop. Commodity demand functions constitute an important part of the agricultural sector model. By incorporating demand functions into the model, the equilibrium price is determined endogenously through the interactions of demand and supply. Fresh vegetables in Oklahoma are produced mainly for local markets. However, some of these crops (such as watermelons, corn, and beans) are sold in large quantities outside Oklahoma; thus, the model allows for sale of all crops outside the state.

Both the in-state and out-of-state demand activities are generated from linear price-dependent demand curves. In reality, however, demand functions are not linear—which would make them difficult to incorporate into the objective function. To segment demand functions and incorporate them directly into the objective function, Hazell and Norton proposed a five-step grid linearization technique. These steps are described below.

Step 1. Obtain the parameter values of the own-price elasticity of the demand for each crop (ε_t), the initial price (P_t), and the initial quantity (Q_t).

Step 2. Calculate the intercept (α_t) and the slope (β_t) of the linearized inverse (price-dependent) demand function (3):

$$(3) \quad P_t = \alpha_t - \beta_t Q_t .$$

It follows that

$$(4) \quad \beta_t = -\frac{dP_t}{dQ_t} .$$

Elasticity is calculated as

$$(5) \quad \varepsilon_t = \frac{dQ_t}{dP_t} \times \frac{\overline{P}_t}{\overline{Q}_t} .$$

Substituting (4) into (5), we derive

$$(6) \quad \varepsilon_t = -\frac{1}{\beta_t} \times \frac{\overline{P}_t}{\overline{Q}_t} .$$

Solving for β_t and α_t will give the slope and the intercept of the demand function:

$$\beta_t = -\frac{P_t}{\varepsilon_t Q_t};$$

$$\alpha_t = P_t + \beta_t Q_t > 0.$$

Step 3. Establish the relevant range of the demand function. To accomplish this, the lower (P_t^L) and upper (P_t^U) prices are determined. Following the Hazell and Norton procedure, these two prices are measured by 50% and 200% of the base price, respectively. The lower and the upper prices are translated to the quantity axis. The calculations for the lower and upper prices are $.5P_t$ and $2P_t$, respectively. Translating to the quantity axis yields the following:

$$Q_i^L = \frac{\alpha_i - P_i^L}{\beta_i} \quad \text{(lower quantity)}$$

and

$$Q_i^U = \frac{\alpha_i - P_i^U}{\beta_i} \quad \text{(upper quantity).}$$

Step 4. Choose the number of segments for the demand curve so that the length of segments can be determined. Normally, 11 segments are used for such segmentation (Stoecker and Li). The segment length is calculated as follows:

$$K_i^L = \frac{Q_i^U - Q_i^L}{n - 1},$$

where K denotes the segments and n represents the number of segments. The quantities at each segment of the demand curve can then be calculated:

$$\begin{aligned} Q_{i0} &= Q_i^L, \\ Q_{i1} &= Q_i^L + K_i, \\ Q_{i2} &= Q_i^L + 2K_i, \\ &\cdot \\ &\cdot \\ &\cdot \\ Q_{i10} &= Q_i^L + 10K_i = Q_i^U. \end{aligned}$$

Step 5. The value of the area under the linear demand curve (W_i) for each segment is calculated as

$$W_{is} = \alpha_i Q_{is} - .5B_i Q_{is}^2,$$

where s denotes the segment number.

Data

Data were collected from several sources. Data problems were encountered during the early stages of model building, and suitable solutions were found in most of the cases. Since the data sets came from different sources, they were verified to check for possible inconsistencies. If any inconsistency was found, it was corrected and the model was adjusted to achieve consistency before proceeding to the next stage.

Two main groups of data were collected for the model: micro level and macro level. The micro-level production data include costs, returns, and planting and harvesting time periods for the seven crops in Oklahoma. The macro-level data include crop areas, available resources, price, and demand statistics. Land restraints were assumed to be nonbinding in the production of horticultural crops in Oklahoma. This is a reasonable assumption since Oklahoma has an abundance of suitable agricultural land.

Activity budgets constitute a major part of Oklahoma's sector model, as they contain requirements for the production of each of the seven vegetable crops. For instance, each of the activity budgets specifies the various inputs used, yields, and other costs per acre.

Enterprise budgets for most of Oklahoma's crops are prepared annually at Oklahoma State University (Schatzer and Motes). The activity data used in this study are taken from the enterprise budgets for small irrigated farms. These types of farms are appropriate for the model used here because they reflect the common horticultural practice in Oklahoma. Labor, machinery, fertilizer, and other types of variable inputs are the main resources used in vegetable production in Oklahoma and constitute a major component in the analysis. Activity data in the model are presented in physical units and in value terms. For example, eight man-hours of labor per acre are needed to transplant tomatoes, and the wage rate is estimated to be \$4.50 per hour. Thus, the transplant labor cost is estimated to be \$36 per acre.

Demand-related data are incorporated within the sector model to estimate social welfare functions. The Hazell and Norton segmented demand procedure, described earlier, is used to model demand for fresh vegetables. This procedure allows direct estimation of the area under the demand curve (social welfare), as well as the associated quantities consumed for each demand segment.

The parameter values needed for the procedure are: initial price, initial quantity, and the own-price elasticity for each crop. Price elasticities were obtained from Huang and from Epperson, Tyan, and Huang. Initial prices in the model are estimated using the Dallas terminal market prices and the activity budget prices for 1989. Initial quantities were calculated from data published by the U.S. Department of Agriculture (USDA). To calculate the initial state quantities, the time periods in which Oklahoma produces horticultural crops were used, and the quantities demanded in these periods were estimated. Out-of-state sales are incorporated into the model in the out-of-state activity columns to account for quantities sold outside the state. Initial out-of-state quantities of crops were estimated by the total quantity of these crops produced in Oklahoma minus the quantity demanded by Oklahoma consumers during harvesting periods. These quantities were then used with the prices and elasticities to develop the out-of-state demand activities.

Results

The Oklahoma sector model in this study uses the 1989 base year data as a benchmark. As illustrated in table 1, the rows in the model include the objective function, resource constraints, input balances, commodity balances, and the convex combination constraints. The columns include production activities, input supply activities, marketing activities, and the segmented demand activities. The Oklahoma sector model was estimated using a linear programming approach.

Base Year Model Results

Because the model is not highly constrained in resource use, some discrepancies exist between the base model solution and the observed base year data. Results of the base model solution are presented in the first column of tables 2, 3, and 4. The objective function is maximized at the level of $38.2 million (table 4) and reflects the sum of consumers' and producers' surplus. The producer revenue is calculated by multiplying price times the quantity that corresponds to the equilibrium segment for each crop. In-state and out-of-state quantities are added to calculate producer revenue, which amounted to $19.97 million for the base year solution (table 3).

Activity levels are reported in planted acres. Cabbage, muskmelon, and squash areas are underestimated by the model. Nevertheless, cucumber, sweet corn, and tomato areas in the base solution are very close to the observed areas (table 2). The solution reveals that the total available land is not fully used, and there are slack acres in all periods of production. This reflects closely the current state of Oklahoma agriculture and is considered to be a realistic outcome for such a model.

Base Year Model Validation

Model validation refers to the ability of the model to reproduce actual base year values. Also, validation can identify possible inconsistencies in data and model structure. Finally, the validation procedure can be used to evaluate the model's predictive ability to simulate various policy changes.

Validation begins with a series of comparisons of model results with the observed actual values of the variables. Normally, simple comparisons are made and measures of deviations are calculated. A common measure that has been used by most researchers to evaluate the fit of sector models is the percentage absolute deviation (PAD). Hazell and Norton suggest the following rule for evaluating the performance of a sector model: A PAD of 15% or more indicates the model may need some correction, a PAD below 10% is good, and a PAD of 5% would be exceptional.

Validity of the Oklahoma sector model is evaluated using the PAD measure. Results of the observed and simulated crop areas in table 2 indicate that the PAD for the Oklahoma sector model used in this study is around 5%, which represents a good to exceptional fit. This result is evidence of the validity of the Oklahoma sector model to simulate different policy scenarios.

Comparative Static Analysis

Comparative static analysis represents a simulation of the sector's response to a specific change or a combination of changes. The values of the parameters and exogenous variables are changed one at a time, and the cause and effect relations in the model are then traced out. The base model solution is gradually adjusted to reflect various realistic alternate sets of assumptions.

Despite its hypothetical nature, this type of analysis provides useful information about the possible direction and magnitude of changes which are expected to occur. The model solution under each alternate set of assumptions represents a market equilibrium in which all adjustments within the system have been fully worked out.

Six alternative static equilibrium simulations

Table 2. Base Solution and Percentage Change in Area Planted to Selected Vegetables in Oklahoma Under Alternative Yield, Costs, and Demand Assumptions

Crop	Base Solution	1989 Observed Area	Change from Base Solution Value: 15% Increased Yield	15% Decreased Production Cost	15% Decreased Marketing Cost	15% Decreased Labor Hours	Previous Four Changes Combined	15% Increased Demand
	(acres)		(percent)					
Tomatoes	735	700	5.7	4.5	2.9	5.9	15.1	33.7
Green Peppers	433	467	16.6	8.3	6.5	6.5	24.5	37.2
Cucumbers	500	510	15.0	5.6	2.8	2.8	18.2	36.2
Cabbage	459	510	15.0	7.0	3.5	2.6	18.5	55.3
Muskmelons	2,021	2,240	9.5	26.1	9.0	6.7	30.8	128.4
Sweet Corn	5,995	6,120	5.7	9.4	4.0	1.7	15.0	63.0
Squash	1,242	1,360	9.2	5.1	3.1	1.1	16.2	53.2
Total	11,385	11,907	8.0	11.3	4.7	3.0	18.6	73.0

Table 3. Base Solution and Percentage Change in Producers' Revenues for Selected Vegetables in Oklahoma Under Alternative Yield, Costs, and Demand Assumptions

Crop	Base Solution	Change from Base Solution Value: 15% Increased Yield	15% Decreased Production Cost	15% Decreased Marketing Cost	15% Decreased Labor Hours	Previous Four Changes Combined	15% Increased Demand
	($1,000)	(percent)					
Tomatoes	4,877.46	5.7	4.5	2.9	5.9	15.1	33.7
Green Peppers	1,067.64	16.4	8.1	6.2	6.2	24.2	36.9
Cubumbers	1,252.50	15.0	5.6	2.8	2.8	18.2	36.2
Cabbage	795.22	15.0	7.0	3.5	2.6	18.5	55.3
Muskmelons	4,037.96	9.5	26.1	9.0	6.7	30.8	128.4
Sweet Corn	5,395.50	5.7	9.4	4.0	1.7	15.0	63.0
Squash	2,546.10	9.2	5.1	3.2	1.1	16.2	53.2
Total	19,972.38	8.4	10.6	4.6	4.0	19.2	69.8

Table 4. Base Solution and Percentage Change in Consumers' and Producers' Surplus for Selected Vegetables in Oklahoma Under Alternative Yield, Costs, and Demand Assumptions

		Change from Base Solution Value					
Crop	Base Solution	15% Increased Yield	15% Decreased Total Cost	15% Decreased Marketing Cost	15% Decreased Labor Hours	Previous Four Changes Combined	15% Increased Demand
	($1,000)	(percent)					
Tomatoes	9,602.74	5.7	4.6	2.9	5.9	15.2	33.8
Green Peppers	3,532.82	16.4	8.1	6.3	6.3	24.2	36.9
Cucumbers	4,614.21	15.0	5.5	2.7	2.7	25.0	36.1
Cabbage	1,648.25	15.0	6.8	3.4	2.5	18.4	55.1
Muskmelons	5,750.05	9.5	25.7	8.7	6.4	32.1	127.8
Sweet Corn	8,050.09	5.7	9.2	3.9	1.5	16.1	62.8
Squash	4,972.53	9.2	4.9	3.0	0.9	16.0	54.2
Total	38,170.69	9.2	9.3	4.3	3.9	18.8	67.3

were conducted. The impacts on area planted, producers' revenues, and consumers' and producers' surplus were estimated. Results of the adjustments to the sector model are traced out for the following alternate assumptions: (*a*) 15% increase in yield; (*b*) 15% decrease in per acre production cost; (*c*) 15% decrease in per unit marketing cost; (*d*) 15% saving in labor use; (*e*) combined effects of increased yield, cost reduction, and labor savings; and (*f*) 15% increase in demand.

These assumptions were based on the objectives (noted in the introduction) of multifarmer marketing organizations or cooperatives. To test the sensitivity of the model to various hypothetical changes in the above assumptions, a 10% and a 20% change, in addition to the 15% change, were simulated. Results show that tomatoes, cucumbers, and squash were less sensitive than other crops to the variations. That is, the changes in acreage, revenues, and consumers' and producers' surplus at the 10% and 20% change levels were not statistically significant at the 5% level compared to the 15% change. To avoid repetition, the results of the hypothetical changes (other than 15%) are explained only for production costs. Results from other simulations (10% and 20%) are similar, in terms of direction of change, to the results from production costs.

Increased Yields

A 15% increase in yield is simulated based on the assumption that an improvement in production and marketing institutions, such as forming a cooperative or other multifarmer marketing organization, will help Oklahoma growers to increase yields. Increased yield is assumed to occur because marketing organizations provide member growers with information regarding the type of crop suitable for each type of soil. Moreover, marketing associations can collect and disseminate information on various aspects of cultural practice and the correct timing for planting, irrigation, pest control, and harvesting of various crops.

Results show a significant change in acreage, revenue, and surpluses compared to the base solution (tables 2, 3, and 4). Green peppers, cucumbers, and cabbage showed the highest relative increase in acreage, revenue, and surplus. The overall increase in cultivated acres was 8%, and the total increase in acreage was approximately 900 acres (table 2). The sum of the consumers' and producers' surplus increased by 9.2% compared to the base year solution (table 4). The overall increase in revenue was at a lower level and amounted to 8.4% (table 3). This represents a total increase in revenue of $1.7 million, and a surplus of $3.5 million.

Decrease in Production Costs

Forming a marketing organization can result in cost savings for member owners. A marketing organization may supply its members with various inputs needed for cultivation, harvesting, and marketing. Moreover, a member can use the machines owned by the marketing organization. Clearly, the member benefits provided by such marketing associations can result in a cost savings for Oklahoma growers.

For purposes of this study, a 15% decrease in production costs is simulated. The impact of reducing costs by 15% was more significant than the 15% increase in yields. The overall increase in acreage was 11.3%, or 1,282 acres (table 2). Revenue increased by 10.6%, or $2.1 million (table 3), and total surplus increased by 9.3%, or $3.6 million (table 4). The most significant increases in terms of acreage were in muskmelon, which can be justified by the relatively high muskmelon elasticity of demand.

To test the sensitivity of the model to various hypothetical changes in grower production costs, simulations were performed for both a 10% and a 20% change in production costs. Results indicate that tomatoes, cucumbers, and squash are less sensitive to variation in production costs. Other crops, such as green peppers, cabbage, and muskmelons, were more sensitive to such variations. Under the 10% decrease in production costs, the overall increase in acreage was 6.3%, with muskmelons and sweet corn showing the greatest increase. Decreasing the production costs by 15% resulted in an overall increase in cultivated area of 11.3%. However, as production costs were further decreased by 20%, the overall increase in cultivated area rose to only 11.7%.

Decrease in Marketing Costs

An important objective of any farmer organization is to promote and facilitate the marketing of the organization's products. A successful collective marketing effort and joint marketing ventures for Oklahoma growers could lead to a significant reduction in marketing costs. Marketing costs were specified in a separate activity in the Oklahoma sector model. This specification makes it possible to examine the impact of changes in marketing costs on other variables in the sector model.

To examine the impact of a change in marketing costs, a 15% reduction in marketing margin is simulated. The results from this alternative showed a smaller change compared to the 15% yield increase and the 15% production cost decrease (tables 2, 3, and 4). The smaller increase in predicted revenues and cultivated area occurred because the absolute decrease in marketing costs was lower than the absolute decrease in production costs. The overall increase in cultivated area was 4.7% (table 2), with muskmelons showing the largest relative increase in acreage. The modest increase in tomato and cucumber acreage is due to the fact that marketing margins for these crops are relatively small. Moreover, the production costs for tomatoes are the highest among the selected crops.

Increases in revenue and surplus were modest when marketing costs were reduced by 15%. The overall increase in revenue was 4.6% (table 3), and the increase in consumers' and producers' surplus was 4.3% (table 4). The modest increase in revenue can be explained by the fact that the highest increases in acreage were among crops with relatively low returns—muskmelons and sweet corn.

Savings in Labor Use

Improvement in farmers' operations due to the formation of marketing organizations may lead to a savings in labor use at various stages of production and marketing. Labor savings can be a result of the adoption of modern methods in cultivation, harvesting, handling, or packing.

To examine the impact of such a change, a 15% reduction in labor use is simulated. Under this simulation, the largest relative increases in cultivated area occurred in muskmelons, green peppers, and tomatoes (table 2). The extensive use of labor in the production of these three crops is one of the main reasons behind such a large increase. Therefore, the adoption of labor-saving technologies in planting, harvesting, and packing can result in more savings for these labor-intensive crops. The overall increase in cultivated area was approximately 3% (table 2). However, this increase was not matched by proportional increases in revenue and surplus. Revenue increased by only 4% (table 3), and surplus increased by only 3.9% (table 4). Among the crops surveyed, muskmelons, green peppers, and tomatoes showed the highest relative increases in revenues and surplus.

Combining Increased Yield with Decreased Costs and Labor Use

The analysis under this alternative is concerned with the potential impact of combining three of the previous assumptions. The setup for such simulation consists of raising yields by 15% and decreasing the costs (production and marketing) and labor use by 15% each, compared to the base year solution. Harvesting costs are assumed to increase as yield increases. This hypothetical situation might correspond to the maximum expansion that can be achieved given a constant demand level.

Results of this simulation show significant increases for all of the selected crops. The overall increase in cultivated area was about 18.6%, with muskmelons and green peppers showing the largest relative increases. Sweet corn showed the largest absolute change, with an increase in cultivated area of 900 acres compared to the base solution (table 2). Revenue increased by 19.2% compared to the base solution (table 3), which was less than the increase in acreage. This smaller relative increase may be due to the decrease in equilibrium price as the supply curves shift to the right. Consumers' and producers' surplus increased relatively more than revenue, i.e., by 18.8% (table 4).

Increase in Demand

Under the previous five alternative simulations, demand was assumed to be constant. Nevertheless, improvements in production and marketing institutions, such as the formation of farmers' cooperatives, are expected to have an impact on the demand for Oklahoma-grown fresh vegetables through promotion and other market development activities. To examine the impact of market expansion, a 15% increase in the base year demand was simulated.

The simulated change is a rightward shift in the demand curves for each crop. Results of this simulation show the largest increases in acreage, revenue, and surplus compared with other scenarios (tables 2, 3, and 4). Muskmelons reflected the highest increase in all three categories, followed by sweet corn. There is a relatively large area cultivated under these two crops compared to other crops. Generally, increase in demand is expected to have a larger impact on crops which have a larger area under planting and larger production levels. Moreover, planting and harvesting costs for these crops are relatively lower than for other crops, such as tomatoes and green peppers.

Increase in revenue was very significant for all crops, with an overall increase of 69.8% (table 3). Increase in the consumers' and producers' surplus was 67.3% (table 4), which is lower than the 73% increase in acreage (table 2). The total increase in consumers' and producers' surplus is estimated to be about $25.7 million.

Past studies on the economic impacts of marketing strategies used by agricultural cooperatives have been inconclusive. For example, cost/benefit studies of promotion programs for agricultural products have offered a wide range of (and even conflicting) results (Rhodes, p. 261). This makes the comparison of the results of this study with other studies difficult.

Summary and Concluding Remarks

The purpose of this study was to investigate the economic impacts of the expansion of the production of selected vegetable crops in Oklahoma that might result from the consolidation of the growers into cooperatives or other multifarmer marketing organizations. To achieve this objective, a sector programming model for Oklahoma was developed. The basic structure of the Oklahoma sector model included an objective function, production activities, demand activities, and commodity balances. The demand side of the model incorporated two submodels to reflect the difference between in-state and out-of-state demand. To incorporate demand into the model, the demand segmentation procedure was used. Moreover, the production side of the model included seven components representing the selected crops under investigation.

The model was subjected to a detailed validation procedure. Model validation refers to the ability of the model to reproduce actual base year values. In addition, the validation process can be used to justify the model's predictive ability to simulate various policy changes. The validation results supported the use of the model for simulation analysis.

In this study, the potential effects of hypothetical changes in yields, costs, and demand on planted acreage, producers' revenues, and consumers' and producers' surplus were analyzed. The Oklahoma sector model provides a framework for tracing the direct and indirect effects of these simulated changes. The changes are assumed to occur as a result of improvement in various production and marketing institutions used by Oklahoma vegetable producers. These improvements could be achieved through cooperative associations or other changes in the vegetable marketing channel.

Results of the comparative static analysis clearly indicate that changes in the demand side are more effective in increasing cultivated area, revenues, and welfare measured by consumers' and producers' surplus. Additionally, the supply side of the model appears to respond well to changes in the demand side. Therefore, activities that are aimed toward increasing demand for Oklahoma vegetables are expected to increase growers' incomes. These activities could include increased promotion and advertising of Oklahoma-grown vegetables and the establishment of more farmers' markets that promote local produce in various parts of the state. Whether the increases in income would offset the cost of these programs was beyond the scope of this study and was not analyzed here.

Results from the study suggest that improvements in the production and marketing institutions used by Oklahoma growers should be part of any policy aimed at expanding the fresh vegetable industry in Oklahoma. Both cooperative and noncooperative forms of grower organizations can be used to attain such improvements.

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