THE ECONOMIC POTENTIAL OF EXPANDING OKLAHOMA'S FRESH FRUIT AND VEGETABLE INDUSTRY

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CHAPTER I

INTRODUCTION

Oklahoma's current agricultural recession has stimulated the search for other enterprises as alternatives to the traditional Oklahoma enterprises, wheat and cattle. Fresh fruits and vegetables have been suggested as alternative crops for many Oklahoma farmers. These crops would help Oklahoma farmers diversify their enterprise mix and reduce the risk associated with specializing in a few traditional enterprises.

Currently, there are relatively few fruit and vegetable producers in Oklahoma and most of the local market is supplied by out-of-state producers. Furthermore, the potential market for fresh fruits and vegetables is expanding and it is expected that consumption of fresh fruits and vegetables will increase substantially in the next few years (Cook, 1989).

Compared with other northern states in the region, Oklahoma has a relatively long growing season, an abundance of good land and a sufficient supply of water. These characterisitcs make the production of several fresh fruits and vegetables in Oklahoma possible (Schatzer et al., 1986). Based on previous research (Schatzer et al., 1986 and Henneberry and Willoughby, 1989b), there seems to be a good potential for Oklahoma growers to expand their production of certain fresh fruits and vegetables in the commercial wholesale market.

Problem Statement

Fresh fruit and vegetable production in Oklahoma is limited and characterized by many growers with relatively small acreage scattered over a large area. Direct marketing channels like farmers' markets, roadside stands, and pick-your-own are used by many of Oklahoma's small growers (Henneberry and Willoughby, 1989a). The expansion of fresh fruit and vegetable production in Oklahoma is perceived as a risky business. This perception makes many growers reluctant to expand their production. The high degree of risk associated with fruit and vegetable production stems from the following factors:

1. Fresh fruit and vegetable prices are relatively volatile which leads to unstable returns.

2. Fruit and vegetable buyers are usually reluctant to buy from local growers, because they have a bad perception about the quality and continuity of local produce.

3. Oklahoma producers may lack the expertise or experience needed to attain the level of efficiency needed to compete with other regions.

4. The current U.S. market for fresh fruits and vegetables seems to be dominated by a few states, California, Florida and Texas.

5. Oklahoma lacks a developed and integrated marketing institution able to handle a large volume of fresh produce.

6. Oklahoma's weather is not ideal for certain fresh fruits and vegetables, which affects yield and quality of produce.

Improvements in the cooperation of farmers could contribute positively to some of the problems faced by Oklahoma growers. This cooperation may attract additional Oklahoma farmers to fresh fruit and vegetable production and lead to an increase in the production of fresh fruits and vegetables in Oklahoma.

Objective

The general objective of this research is to explore the potential for expansion of certain vegetable crops in Oklahoma. The research begins by describing and analyzing the present structure of Oklahoma's fresh fruit and vegetable industry. Alternative marketing channels used by Oklahoma producers, such as direct marketing, processing, and commercial wholesale will be discussed. This discussion will enable us to identify the major problems facing Oklahoma producers.

Improvement in the organization of growers such as the establishing of several cooperative associations will be discussed. The impact of hypothetical improvements, that might result from better organization, in yield, costs, and demand will be simulated. A comparative static analysis of the impacts of these improvements will be conducted. The effects of these improvements on the production of selected vegetables will be estimated. The impact on revenue and consumers' and producers' surplus will be evaluated. The vegetables which will be examined are: tomatoes, green peppers, cucumbers, cabbage, muskmelon, sweet corn, and squash.

Methodology

A modified quadratic sector model will be constructed to determine Oklahoma potentials in the production of the selected fresh vegetables. The sector model will be designed to maximize the sum of consumer and producer's surplus subject to the given constraints.

The development of this type of model started with Samuelson's (1952) famous article in which he provided the basic methodology by maximizing the area under the demand curve minus total cost subject to a set of constraints. Takayama and Judge (1964a, 1964b) expanded the work to quadratic programming approach. During the 1970s and 1980s, the sector programming approach was widely used to examine various agricultural policies and issues (Adams et al., 1977; Epperson et al., 1984, 1987).

In this study a modified version of the quadratic linear programming approach will be used. The modified sector model will place more emphasis upon the demand side where the impact of simulated changes in various parameters will be examined. Moreover, the model will focus mainly upon in-state demand, and only seven fresh vegetables will be analyzed.

After constructing the model and collecting the data, the model will be validated. Validation will be achieved by obtaining a base solution for the model which will be used as a benchmark for comparison with other scenarios. The base solution will be used to conduct a comparative static analysis for the impact of various simulated changes in yield, cost, labor use, and demand. The impact of these simulated changes on the fresh vegetable industry in Oklahoma can be evaluated by examining changes in cultivated area, revenue and welfare.

Organization of Study

An overview of the Oklahoma fresh fruit and vegetable industry will be presented in the next chapter. Also, various marketing channels used by Oklahoma producers will be described. In Chapter III, a literature review of related studies pertaining to this research are presented, and the general structure of programming models in agriculture is outlined. Chapter III also discusses the theory of the cooperative with particular emphasis on the cooperative association in agriculture.

Chapter IV contains the structure of the Oklahoma agricultural sector model. Data sources and assumptions are given in this Chapter. A comparative static analysis of various simulated scenarios and their implications are presented and discussed in Chapter V. Finally, the summary, conclusions and limitations of the study are discussed in Chapter VI.

CHAPTER II

OKLAHOMA FRESH FRUIT AND VEGETABLE INDUSTRY

In this chapter the current state of Oklahoma's fresh fruit and vegetable industry will be examined. Estimates of Oklahoma's production, acreage, consumption levels, and marketing outlets used to sell fresh fruits and vegetables will be discussed. This discussion will help us to understand the various aspects of the fresh fruit and vegetable industry in Oklahoma and will enable us to use these current levels as a base for examining potential future expansion.

Fresh Fruit and Vegetable Production in Oklahoma

Fruit and vegetable production is relatively new to many Oklahoma growers, and the production of such crops is mainly characterized by small acreage. Fresh fruit and vegetable growers in Oklahoma are a diverse group of individuals. Most of them grow fruits and vegetables as a supplemental crop to complement traditional crops like wheat and cotton (Schatzer et al., 1986).

The agricultural recession of the 1980s has caused many Oklahoma farmers to examine alternative crops such as fresh fruits and vegetables. This shift to alternative crops was stimulated by the high income potential associated with the production of fresh fruits and vegetables and by the need for Oklahoma farmers to diversify agricultural activities.

In 1989 it was estimated that the total acreage under fresh vegetable production in Oklahoma was approximately 56,000 acres (Motes, 1989). Cash receipts from vegetable production was estimated to be $37,229,000 in 1987. This amounts to 5.3 percent of the value of all crops harvested in Oklahoma during 1987 (Willoughby and Henneberry, 1989a). Table I contains estimates of acreage and values for selected produce items in Oklahoma.

The fresh fruit and vegetable industry in Oklahoma is dominated by a large number of small growers with only a few years of industry experience. Most growers cultivate small acres of fresh fruits and vegetables. A growers' survey conducted by Oklahoma State University in 1989 showed that over 35 percent of Oklahoma growers have less than 5 years of experience in fruit and vegetable production. Moreover, nearly 78 percent of Oklahoma growers reported their operation as being individually owned, 52 percent grew fruit and vegetables part-time and nearly 53 percent are involved in the production of more traditional crops. The majority of respondents reported producing fruits and vegetables on less than 5 acres of land (Henneberry and Willoughby, 1989a). Table II lists the distribution of Oklahoma growers by acreage size.

Oklahoma's fresh fruit and vegetable industry is highly seasonal and concentrated mainly in the summer months. This seasonality is due to Oklahoma's climate and is an important factor in analyzing Oklahoma's fresh fruit and vegetable industry.

Seasonality in production is important to Oklahoma growers as it provides them with location and timing advantages in wholesale markets such as Dallas and other major midwestern markets. For instance, a recent market window analysis shows that specific Oklahoma fruits and vegetables, (corn, muskmelon and watermelons), have good marketing opportunities in markets such as Dallas, Chicago, and St. Louis (Kang and Henneberry, 1990).

TABLE I

ESTIMATION OF SELECTED OKLAHOMA FRUITS AND VEGETABLES: ACRES AND VALUES 1989

Item	Acres	Value ($1,000)
Asparagus	675	945
Beans	4,000	2,200
Broccoli	100	200
Cabbage	600	1,100
Corn	7,200	6,840
Cucumber	600	1,200
Eggplant	10	20
Greens (mixed)	3,000	1,200
Muskmelon	2,800	3,080
Okra	600	1,800
Onion	100	200
Paprika	-	-
Pea	50	40
Southern Pea	18,000	2,160
Pepper	550	1,155
Potato	1,200	1,650
Pumpkin	1,100	1,210
Radish	100	400
Spinach	2,600	1,950
Sweet Potato	1,250	3,000
Tomato	700	3,150
Turnip	250	600
Watermelon	9,000	3,780
Squash	1,700	3,060

Source: J. Motes, Department of Horticulture, Oklahoma State University.

TABLE II

FRUIT AND VEGETABLE ACREAGE AND DISTRIBUTION AS REPORTED BY THE GROWER'S SURVEY 1988

Acres	Percentage of Producers
0.1 - 1	25.7
1.1 - 5	30.3
5.1 - 15	14.7
15.1 - 25	7.3
25.1 - 50	6.4
50.1 - 100	5.5
100.1 - 250	3.7
250.1 - 500	3.7
Over 500	2.8

Source: S. Henneberry and C. Willoughby, (1989a).

A major obstacle facing Oklahoma growers is the high degree of risk associated with the production and marketing of fresh fruits and vegetables. While potential income in the fresh produce industry is high, there are many risk factors involved in such industry. For instance, the production of horticultural crops in Oklahoma is usually associated with a variety of insect, disease, weed, and other weather related problems (Schatzer and Tilley, 1985). Moreover, fruit and vegetable production tends to be labor intensive, which means that a relatively higher level of labor per acre is required for production and harvesting. Thus, there is a potentially higher loss in the case of a bad crop. However, as Oklahoma growers expand, diversify, and gain more experience, it is expected that a lower degree of risk will be associated with the production of fruits and vegetables in Oklahoma.

Overview of Fresh Fruit and Vegetable Consumption Trends

Various studies on consumer demand suggest that fresh fruit and vegetable consumption in the United States has increased during the 1970s and 1980s. Compared to other food items, fresh produce consumption is considered one of the fastest growing segments in the U.S. (Henneberry and Charlet, 1990). This increase is mainly due to consumers becoming more health conscious, rising disposable incomes, and the year around availability of many varieties. Between 1973 and 1981 average per capita consumption of fresh fruits increased by 15 percent, while per capita consumption of vegetables increased by 8.7 percent. During the same period, consumption of tomatoes increased by 10 percent, lettuce by 12 percent, and green peppers by 24 percent (USDA, 1983). The increase in consumer demand for fresh fruit and vegetable continued well into the late 1980s (Henneberry anc Charlet, 1990). In 1987 it was estimated that the retail sales of fresh fruits and vegetables in the U.S. was nearly $26 billion (Cook, 1989).

A major factor contributing to the increase in the demand for fresh fruits and vegetables is the changing age structure of the American population. By the year 2000 it is estimated that 54 percent of consumer expenditure on food will be made by people in the 35-to-54 year age group (Cook, 1989). Consumers over 35 are more likely to be health conscious and consume more fruit and vegetables in their diet. Thus, fruit and vegetable consumption is expected to increase significantly as the American population structure changes.

The growth of the food service market, such as hotels, restaurants, and nursing homes is an important factor which contributed to the recent increase in the demand for fresh fruits and vegetables in the U.S. It is estimated that 35 to 40 percent of the total volume of fresh fruits and vegetables consumed in the U.S. is now distributed through food service channels, and it is expected to reach 50 percent by 1995 (Cook, 1989).

This surge in the consumer interest in horticultural crops is considered to be a major driving force behind many changes in the fresh produce industry. At the consumer level, retail outlets responded to these changes by expanding their produce department and adding more variety to promote sales. On the wholesale level more changes are needed to deal with these recent developments.

The Marketing Channels

Knowledge of the various market channels in Oklahoma is needed for several reasons. First, it is important to understand the various aspects of the fresh fruit and vegetable industry in Oklahoma. Second, fresh fruits and vegetables are highly perishable and their prices are volatile, which makes their production a risky business. Placing more emphasis upon understanding marketing institutions in Oklahoma might reduce the degree of risk associated with fresh fruit and vegetable production. Third, growers need to produce for specific market channels, therefore, it is necessary to examine in some detail the most common marketing channels in Oklahoma.

The marketing outlets used by Oklahoma growers can be classified into three major channels: the processing channel, the direct-to-consumers channel, and the commercial wholesale channel. Direct-to-consumer marketing outlets are the main outlets used by most Oklahoma growers. In addition, Oklahoma growers produce fruits and vegetables for processing plants and for the commercial wholesale market.

A growers' survey conducted by Oklahoma State University in 1989 showed that 24 percent of the participating growers used farmer markets. Seventeen percent used roadside stands, and 14 percent used pick-your-own operations. A significant number of growers use indirect marketing outlets with 11 percent selling to grocery stores and restaurants and 16 percent using wholesale outlets (Henneberry and Willoughby, 1988). Table III shows the distribution of marketing outlets used by Oklahoma growers.

TABLE III

PERCENTAGE OF MARKETING OUTLETS USED BY FRUIT AND VEGETABLE PRODUCERS IN OKLAHOMA

Outlets Used	Outlet Usage	Usage (Weighted by Quantity Marketed)
Farmer's Market	36.2	24.3
Roadside Stand	31.9	16.6
Terminal Market	2.6	.5
Broker/Wholesaler	25.9	16.3
Grocery/Restaurant	29.3	10.7
Processor	10.3	5.1
Pick-your-own	22.4	13.9
Other	23.3	12.8

Source: Henneberry and Willoughby, (1988).

The Processing Market Channel

Processing refers to the canning and freezing of fresh produce to preserve it for an extended period of time. It is often proposed as a supplement or an alternative to other marketing channels.

In the United States, a major proportion of fresh produce is processed. In 1985, 56.6 percent of the total U.S. commercial vegetable production was processed; processed fruits accounted for about 66.5 percent (Buckley et al., 1988).

The processing industry in the U.S. is dominated by a few large firms (with several large processing plants), and many other small processing firms (Rhodes, 1983). Many of these processing firms contract their supplies before planting time. Normally, the processor and producer will specify the acres to be planted, variety, production practices, quality, and delivery time in the contract prior to planting. The contract between processors and producers might also specify a lower price for lower quality produce.

To guarantee a certain volume and continuity of supplies, processors usually prefer to contract with large, established groups of growers. It is estimated that processors in the U.S. and Oklahoma contract for about 60 percent of their needs, buy 30 percent on the open market, and grow 10 percent themselves (Willoughby and Henneberry, 1989).

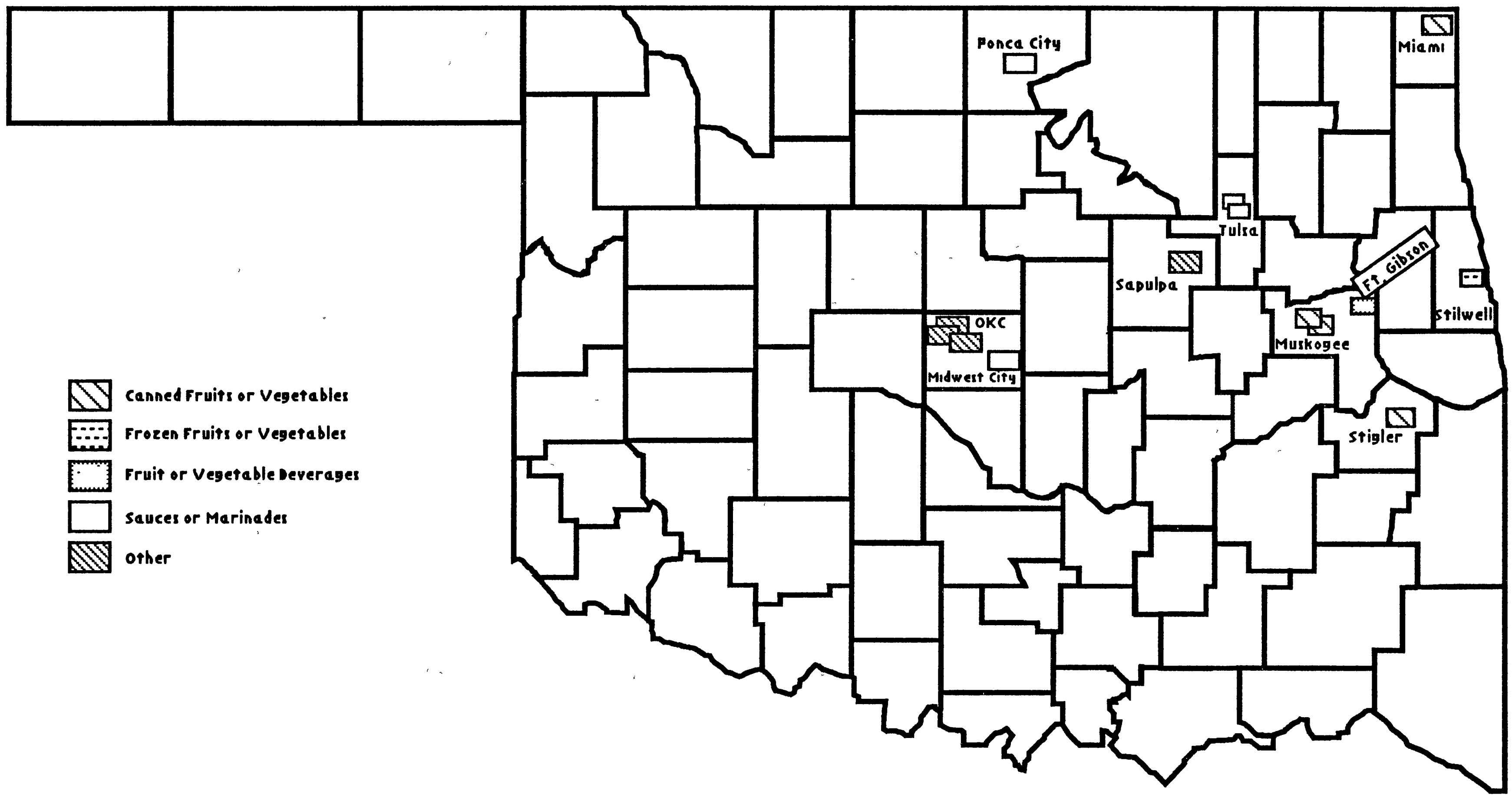
Processing firms are normally located where the production is concentrated. Locating near production areas allows processing firms to minimize procurement costs and to monitor production practices and time. This explains why most of the processing industry is concentrated on the West Coast and in Florida.

At the national level, the four major vegetables processed are: tomatoes, sweet corn, snap beans, and green peas. The four crops account for about 88 percent of total processed vegetables in the U.S. Tomatoes account for more than one-third of total processed vegetables in the U.S. (Tilley et al., 1984).

Processed products are usually packaged as national brands or as chain store brands. These brand names are usually well known and create barriers-to-entry for new processors wanting to enter the market. Therefore, to enter the processing market, new processors must either contract with chain stores or try to develop their own brand name. Another important barrier-to-entry for new processing firms is the size of the processing plant. To achieve a competitive cost per unit, processing plants must be of a certain size to benefit from economies-of-scale.

The Processing Industry in Oklahoma. The relatively small population of Oklahoma may limit local demand for fresh fruits and vegetables grown in Oklahoma. The processing outlet however could be considered as an important alternative channel to be used in expanding the commercial production of selected horticultural crops in Oklahoma. Currently, there are 14 fruit and vegetable processing firms in Oklahoma, and Oklahoma growers have access to other processing plants in the surrounding states (Henneberry and Willoughby, 1989a). Figure 1 illustrates the locations of processing plants in Oklahoma and the products they handle. Spinach, southern peas, butter peas, greens, squash, and potatoes are the primary vegetables produced for processing in Oklahoma. A small amount of tomatoes are processed in southeastern Oklahoma.

Fruits and vegetables processing could lead to higher acreages for Oklahoma. However, the various problems associated with the fruit and



Source: Henneberry and Willoughby, 1989a.

Figure 1. Location and Products Handled by Fruit and Vegetable Processors in Oklahoma, 1988-1989

vegetable processing industry may limit its expansion. For instance, the hot growing conditions in summer and pest infestation can lead to lower quality for crops like tomatoes, sweet corn, green beans, and sweet peas. Many new Oklahoma growers lack the necessary experience needed to grow the quality of product required by processors.

Direct-to-Consumer Marketing Channel

Outlets where growers deal directly with consumers are in the direct-to-consumer marketing channel. Only a small percentage of fresh fruits and vegetables in the U.S. are channeled through direct-to-consumer outlets. Over 90 percent of consumer demand is channelled through commercial retail outlets (Weimer et al., 1987).

In recent years, direct marketing outlets have become more popular with consumers in many parts of the country. Freshness and price are cited as the most important reasons why many Oklahoma consumers chose to shop at direct marketing outlets (Moesel and Tilley, 1985). Moreover, both consumers and producers feel they benefit by using direct marketing outlets since they by-pass all middlemen in the marketing channel. At the growers' level, direct marketing outlets are used by many Oklahoma producers, and they are considered the most important outlets by many Oklahoma producers.

Currently, various direct marketing outlets are used to sell fresh produce all over the U.S. In Oklahoma, roadside stands, farmers markets and pick-your-own are the most prominent outlets. Other direct marketing methods such as truck stops, buying clubs, and consumer cooperatives are used to sell Oklahoma fresh produce.

Pick-your-own Marketing Outlet. At a pick-your-own outlet, customers come directly to the field and harvest for themselves. The pick-your-own method is usually preferred by people who like to select fresh quality produce at a relatively low price. Many growers use the pick-your-own outlet to supplement their other direct and non-direct outlets. Moreover, it is preferred by growers as it saves them considerable harvesting and post-harvesting costs.

Pick-your-own operations were popular in the northeastern region of the U.S. during the depression years of the 1930s and after World War II. During these recession periods, fresh fruit and vegetable prices were relatively low and growers could not obtain a price high enough to pay for harvesting and packing costs. To provide some return toward costs invested, many growers opened their fields to consumers to pick their own fruits and vegetables. Pick-your-own proved to be a successful method, and since the 1930s and 1940s the pick-your-own operation has spread to other parts of the U.S. and became a supplementary marketing outlet for many growers.

In the pick-your-own operation fruits and vegetables may be sold by weight, volume, or count pricing. Competitive pricing is an important factor for the success of such operations, thus growers should take into consideration prices charged by other outlets. Quality, crop diversity, distance from urban centers, and effective advertising are all important factors which must be taken into consideration by growers. In Oklahoma, many pick-your-own operations are located near major urban centers such as Oklahoma City and Tulsa. Such operations are used by some Oklahoma farmers, especially producers of fruits and berries (Henneberry and Willoughby, 1989b).

The drawback to a pick-your-own operation is that commercial producers can not rely on such operations to market large quantities of produce. Moreover, for small growers consumers might not come at the same time the fruit is ripe, which will cause the loss of some crop and lower the return. Also, many customers are selective when they harvest for themselves which may lower the yield per acre.

Farmers' Markets. A farmers' market is a type of direct-to-consumer marketing outlet where growers gather at a designated place to sell their produce. Normally, in such operations local growers get together to benefit from marketing activities such as advertising and from sharing other marketing costs. Consumers come to such markets to take advantage of the relatively low prices and fresh quality produce.

Farmers' markets can be established and operated by a group of farmers, community interest groups such as the Chamber of Commerce, or by government organizations. These markets can be permanent and open all year around such as Oklahoma City farmers' market or can be seasonal for a specific time of the year. Weather conditions and the length of the growing season will determine the times the farmers' market is open. Normally, the main purpose for establishing such markets is to give local growers a new marketing outlet and to provide consumers with locally grown fresh quality fruits and vegetables at a reasonable price.

Location, prices, freshness, and quality are important factors to be considered when establishing farmers' market. For instance, farmers' markets should be close to urban areas, and be conveniently located for all participating growers. Furthermore, a wide variety of fresh produce items should be available at the market throughout the operating season.

In Oklahoma, farmers' markets are considered important outlets for many fruits and vegetable growers. Many of these markets are located in and around urban areas such as Oklahoma City and Tulsa. Based upon the Oklahoma

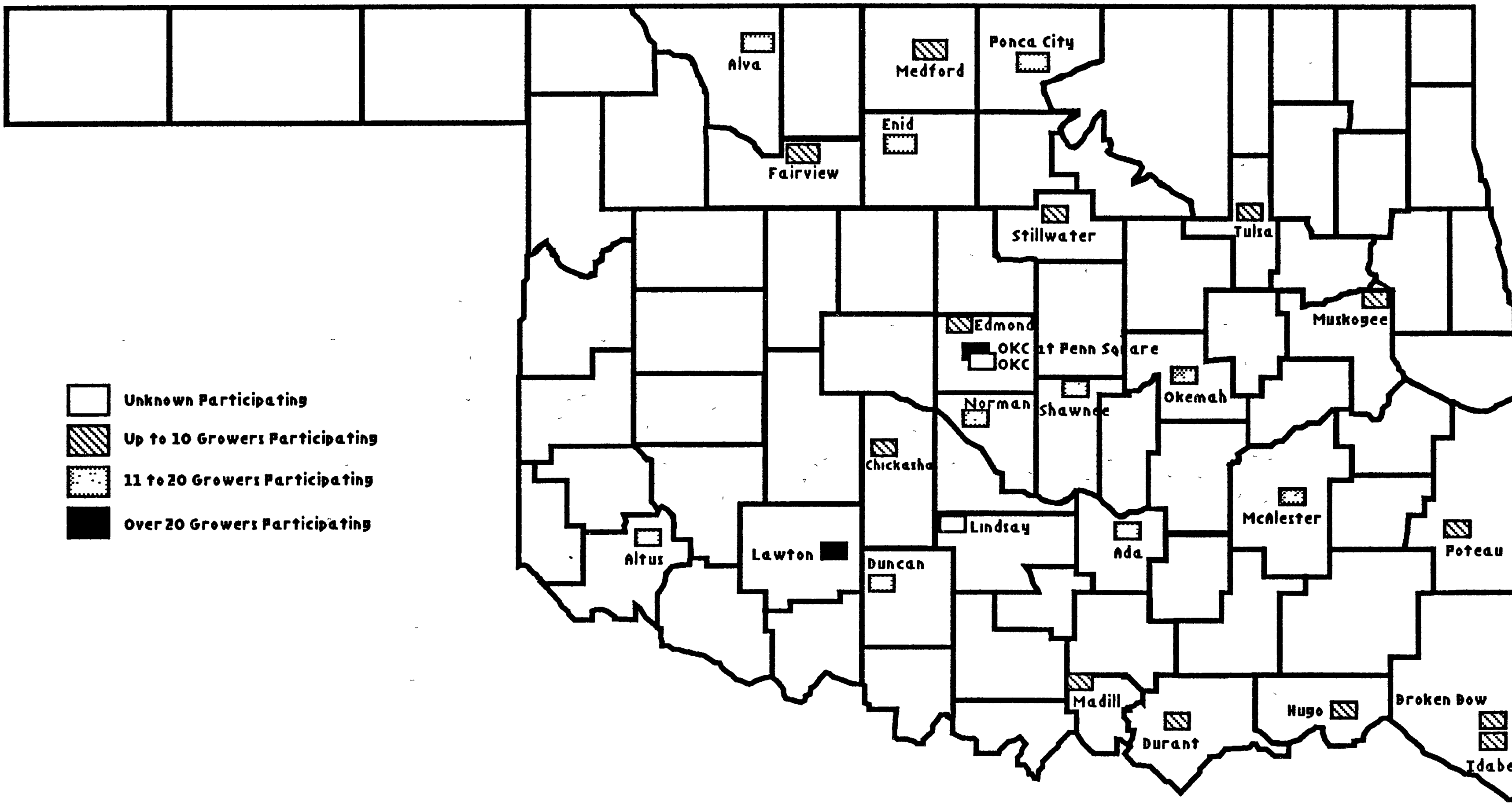
Department of Agriculture Statistics, there were 27 farmers' markets operating in Oklahoma in 1988 (Henneberry and Willoughby, 1989a). Figure 2 shows farmers' markets locations and type in Oklahoma.

Roadside Stands. The roadside stand is a direct marketing outlet where growers operate stands near busy roads and sell locally grown fruits and vegetables directly to consumers. These stands are open during the harvest season especially in the summer months when fresh produce is sold at these stands. With the increased use of automobiles in the 1930s and 1940s, roadside stands became popular in many parts of the U.S.

In Oklahoma, roadside stands are common and they are usually located close to the producer's operation on main roads, where traffic is heavy. The roadside stands are used by many small Oklahoma growers to sell their fruits and vegetables and to generate some extra income for their families. For Oklahoma consumers, it is considered a convenient way to buy fresh quality produce at a reasonable price.

Location is the most important factor in determining the success of such marketing operations. Roadside stands should be located on a busy road, easily visible from a distance and should have enough parking space for stopping customers.

Pick-your-own operations, farmers' markets and roadside stands are important marketing outlets in Oklahoma. Their profit potentials should be examined. A major problem in analyzing the direct markets is the lack of data available on them in Oklahoma. Accurate data on prices, quantities and production cost related to direct marketing outlets in Oklahoma are not available. Small producers who usually use these outlets have different production cost and do not include the cost associated with post-harvest



Source: Henneberry and Willoughby, 1989a.

Figure 2. Farmers' Markets Locations and Grower Participation in Oklahoma, 1988

handling. Also, data published by the USDA reflect only commercial wholesale prices and quantities in selected markets and do not necessarily reflect direct marketing outlets' prices and quantities.

The Commercial Wholesale Marketing Channel

Fresh fruits and vegetables can be marketed indirectly through non-direct outlets, the commercial wholesale market. It is estimated that the commercial marketing outlets supply over 90 percent of the demand for fresh fruit and vegetables in Oklahoma (Willoughby and Henneberry, 1989).

The commercial market for the fruit and vegetable industry consists of a complex system of institutions. This system includes marketing firms, brokers, jobbers, terminal markets, institutional wholesalers, cooperatives, retail stores, and food service institutions. Figure 3 illustrates the structure of the fresh fruit and vegetable marketing system, and demonstrates the importance of the commercial marketing channel. Consumers are the driving force in this channel so they are at the top of the system.

Retail Outlets and Food Service Institutions. Below the consumers in the commercial wholesale channel are the retail stores and institutional outlets. They consist of supermarket chains, local grocery stores, restaurants, and fast food chains. Other potential outlets include institutions such as hospitals, schools and hotels. These outlets usually require frequent low volume deliveries of a variety of produce items, and they normally negotiate prices, quantities and quality directly with the suppliers.

In recent years, restaurants and fast food chains have become important outlets for fresh fruits and vegetables. Many of them have added or expanded their existing salad bars to satisfy the increasing number of health conscious

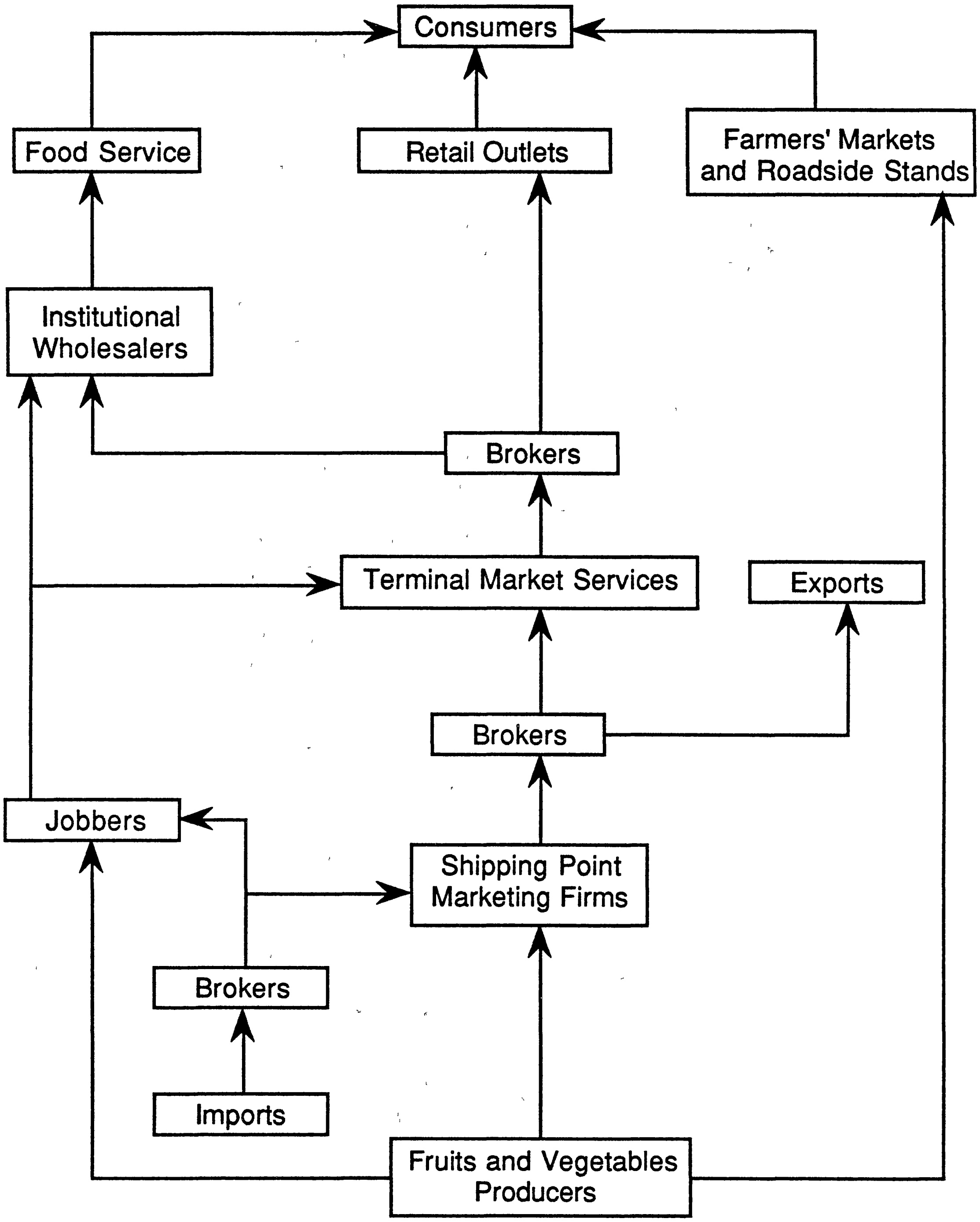


Figure 3. The Structure of Oklahoma Fresh Fruit and Vegetable Marketing System

consumers. Thus, these important outlets are essential to the future expansion of the fresh fruit and vegetable industry in Oklahoma. In short, being aware of the needs of restaurants and fast food chains could be an important source of profit since these institutions satisfy a major portion of consumer demand.

Institutional Wholesalers. Institutional wholesalers act as middlemen in the fresh fruit and vegetable industry. They purchase large quantities of produce from growers or other dealers, then distribute it to retail outlets, food service institutions and other wholesalers. Fruit and vegetable wholesalers may accept orders from retail outlets, then organize their buying activities to supply their clients. To meet their clients' demand, wholesalers prefer to have reliable sources of supply, thus, they might contract with growers to supply them with certain crops.

Brokers. Brokers are another type of middlemen in the produce industry who work to facilitate the movement of fresh fruits and vegetables between producers and buyers. There are two types of brokers who work in the produce industry (Lloyd et al., 1988): buying brokers who arrange sales between terminal markets and retailers and selling brokers who arrange sales between local growers and terminal market buyers. Brokers may never take title or possess the product and only act as a selling agent and take a percentage as commission. Consequently, they usually try to locate quality produce at fair prices for both buyers and sellers.

Jobbers. Jobbers usually work to facilitate the exchange in the wholesale market and may buy and sell from any one in the produce market. Normally, one of the jobbers' main activity is to buy fruit and vegetables in bulk, and package it to fit the need of their customers. Moreover, jobbers might specialize in selling fruits and vegetables in small quantities to independent grocery stores and other food service outlets.

Terminal Markets. Terminal markets are assembly and distribution centers for fresh fruits and vegetables which are located in large metropolitan areas. They normally consist of a large number of merchants who are concentrated into one selling area. From these terminal markets fresh fruits and vegetables are distributed by various marketing agents to the surrounding areas.

The Dallas terminal market is the closest large terminal market to Oklahoma. Moreover, the Dallas market is considered an important outlet by many Oklahoma growers. Other terminal markets such as Houston, Kansas City and St. Louis are used to meet the demand for fresh fruits and vegetables in Oklahoma.

In recent years many chain outlets and food service institutions have started to buy directly from the producer-shippers, thus eliminating many middlemen. The increase in such activities has led to the decline in the importance of terminal markets. This increase in direct purchases may explain the recent decrease in terminal market numbers in the United States (Rhodes, 1983).

In the above marketing system, it is clear that retail and food service outlets are the main channels for the flow of fresh fruits and vegetables. It is estimated that over 76 percent of fresh produce is sold through various retail outlets and another 22 percent is sold through the food service outlets in the U.S. (McLaughlin and Pierson, 1983).

In Oklahoma, most of the locally grown fruits and vegetables is marketed through direct outlets. A large percentage of the produce that is marketed through the non-direct market goes through retail stores. A buyers survey conducted by Oklahoma State University shows that 33 percent of Oklahoma's fruits and vegetables goes to retail stores, and over 50 percent goes to institutional outlets such as restaurants and hospitals (Henneberry and Willoughby, 1989a). Table IV lists buyers of Oklahoma fruits and vegetables by type of business.

Commercial Market Requirements in Oklahoma. Commercial market outlets normally have a relatively higher level of quality standard than direct marketing outlets. Several strict marketing requirements must be met for fresh fruits and vegetables to be accepted in the wholesale markets. These requirements usually include: freshness, long shelf-life, packing requirements, consistent supplies, and good physical appearance (Weimer and Hallam, 1988).

Low quality fruits and vegetables will not be accepted by most commercial buyers. In a survey of produce buyers in Oklahoma, nearly 75 percent of those buyers said they would refuse to accept delivery of low quality fruits and vegetables. Moreover, marketing agreements were used by 14.3 percent of the buyers to settle quality discrepancies while 6.7 percent expressed their willingness to accept the disputed produce at a lower price (Henneberry and Barron, 1990). Over 67 percent of the respondents cited quality as the most important criteria they take into consideration when buying fresh fruits and vegetables.

To succeed in the commercial market, Oklahoma growers are expected to provide many of the packing, handling, information, and transportation services that are currently performed at the wholesale or retail levels. The establishing of fresh fruit and vegetable packing facilities could be an effective way for Oklahoma producers to enter the commercial fresh fruit and vegetable market.

TABLE IV

BUYERS OF OKLAHOMA PRODUCE BY
TYPE OF BUSINESS

Business	Percentage
Grocery Store/Supermarket	33.0
Restaurant	29.5
Hospital/Nursing Home	23.8
Wholesale Distributor	4.8
Hotel/Inn/Resort	2.2
School/College	1.8
Broker	1.8
Other	3.1

Source: Henneberry and Willoughby, 1989a.

Table V lists the most important criteria used by Oklahoma produce buyers when purchasing their supplies.

Fresh fruits and vegetables are highly perishable, therefore special equipment must be used to keep them fresh for a longer period. For instance, cooling equipments is usually used by commercial producers to remove the field heat from the crop and an icing machine is used to prepare certain heat sensitive commodities such as broccoli and green onions. Other crops such as tomatoes and green peppers are sensitive to icing, thus, other types of cooling equipment should be used to keep them fresh.

Packing requirements are strict and should meet certain specifications so that fresh fruits and vegetables will stand long transportation and stacking in warehouses. Physical appearance of fresh fruits and vegetables is another important factor. It is recommended that producers invest enough resources to make sure that their product meets commercial marketing requirements. Likewise, uniformity in appearance is an important factor, thus producers should devote some time to sorting and sizing their produce.

To meet these requirements, producers need to invest a considerable amount of capital, time and effort in washing, sorting, grading, packing, and cooling. These activities may necessitate the purchase of capital items, such as cooling and grading equipment. For many Oklahoma producers, it is not economical to invest in such costly equipment. Therefore, the establishment of cooperative associations may make it possible for many Oklahoma small growers to benefit from such facilities.

Another important requirement for Oklahoma growers to succeed in the commercial market is to be able to provide stable and steady supplies of various commodities. Cooperative associations in Oklahoma could play an

TABLE V

THE MOST IMPORTANT CRITERIA THAT OKLAHOMA BUYERS CONSIDER WHEN PURCHASING FRESH FRUITS AND VEGETABLES

Criteria	Percentage of Respondents
Consistent quality year-round	67.2
Price	11.5
Year-round availability	7.7
Promotional appeal	3.3
Shelf life	2.7
Dependable deliveries	2.7
Dependable volume of supply	1.1
Size uniformity	1.1
Convenience	.5
Organically grown	.5
Packaging	0.0
Service	0.0
Other	1.6

Source: Henneberry and Willoughby, 1989a.

important role in coordinating the activities of Oklahoma producers, thus guaranteeing a steady and stable supply of several crops. Moreover, the establishment of several packing and shipping facilities by these cooperatives could be an important factor which may help more Oklahoma growers to break into the commercial market. The packing and shipping facilities are expected to provide Oklahoma growers with important marketing related services such as washing, grading, packing, cooling, shipping, and selling.

CHAPTER III

THEORETICAL BACKGROUND AND LITERATURE REVIEW

Sector Programming

Agricultural sector programming is a term used to describe a wide range of formal analytical work used to study the agricultural sector. It involves setting up a model for the agricultural sector which determines levels of various activities such as production and factor supply. Normally, the objective function of a sector model will reflect the goals of the agricultural policy such as maximizing welfare, revenue or output.

Programming models in agriculture are an effective mean of economic analysis, as they provide a suitable framework for organizing quantitative information about the supply side of the agricultural sector. Normally, these types of models are used to perform different kinds of sensitivity analysis and parametric variations. This analysis generates response functions that are implicit in the models. Another important use for such models is to estimate the effect of various changes in agriculture, such as, the introduction of new crops, technological changes, marketing improvements, and land reform (Hazell and Norton, 1986).

Since the early fifties, sector programming has been used extensively in modeling agricultural activities. Since then, sectoral programming has received increased emphasis by economists and policy makers. The increased use of programming models in agriculture can be explained by several factors (Kutcher and Scandizzo, 1981):

1. The difficulties of estimating cost and production functions econometrically and obtaining the data series that will give a reasonable degree of freedom for econometric analysis

2. Technological alternatives in agriculture production are numerous and discrete. Therefore, they fit naturally into this type of framework

3. Mathematical programming framework can be used to conduct different policy analysis and the effect of different scenarios can be estimated through changing specific variables in the model

4. The development of powerful computers facilitates large-scale applications in the agricultural sector. This development opened up new opportunities for the construction of large-scale models which reflect more closely the sector being modeled.

Theoretical Setting

Sector programming is a distinct type of analysis as it contains elements from microeconomic theory such as production functions, and elements of macroeconomic as it covers the whole agricultural sector. It can include all sources of supply and demand for various products in the agricultural sector. Demand and supply for various products are aggregated at a suitable level, such as regionally or nationally. Also, a sector model can include international trade if it is relevant to the sector in question. In general, sector models, do not include all factors of production since certain factors may not be used in that particular sector. Only economy-wide general equilibrium models will cover all domestic factors. As for the agricultural sector models, they normally include some-specific factors like land, farm labor, water, or fixed capitol.

Hazell and Norton (1986) point out that a sector programming model should contain the following elements:

1. The economic behavior of producers, such as their objective, and their decision rule on output composition. For instance, in the agricultural models the growers objectives are normally to maximize profit and minimize risk level.

2. The production functions or technological sets available to growers, whether it is exogenous or endogenous. Normally, production functions differ from region to region and from one group of farmers to another. A small farmer may use different production technology than large farmers. This differentiation in production technology is important to make the model as realistic as possible.

3. Resource endowments available in the sector to be studied. For example, in the agricultural sector these endowments refer to land, labor, irrigation supplies, livestock, machineries, and other important agricultural factors.

4. Market environment specifications, which will determine the type of market form such as perfect competition or monopoly. To simplify and facilitate such analysis, most models assume linear demand functions. Normally, demand functions in sector models are negatively sloped and refer to all demands for the products of the agricultural sector and not all demand by farming household. This distinction is important as it is necessary to derive the demand curves facing the growers in the sector, but not demand curves of the household in that sector. Also, processing and marketing activities are normally included in agricultural sector models and they often vary by product.

5. Policy specifications, such as input and output subsidies, import quotas, and tariffs which are used within the system.

Based on the above mentioned elements, a sector model is assumed to have many variables which are highly inter-dependent. These variables will make it suitable for analyzing agricultural problems and issues such as the impact of external and internal changes on the agricultural sector.

The Structure of the Agricultural Sector Model

To construct an agricultural sector model, the starting point usually is to define the different regions and choose the representative farm for the country under the study. For example, the production side of the model might include two types of farm to reflect the traditional (small) and commercial (large) farming activities. The above process is affected by the objective of the research and by the availability of data. Resource endowment should be determined and production technologies must be specified. In the case of the agricultural sector, these resources might include land, labor, machinery, livestock and irrigation supplies. After that the model is arranged in a simple matrix form, which shows relations between various variables in the agricultural system.

Following Hazell and Norton (1986) the basic structure of the agricultural sector model may be expressed by the following system of equations:

Objective Function. The general form of the objective function may be expressed as follows:

$$\text{Max } \Pi = \sum_i (\alpha_i - .5B_iQ_i)\, Q_i - \sum_i C(S_i) \qquad (3\text{-}1)$$

$$\begin{bmatrix}\text{Sum of producer and}\\ \text{consumer surplus}\end{bmatrix} = \begin{bmatrix}\text{Area under the}\\ \text{demand curve}\end{bmatrix} - \begin{bmatrix}\text{Area under the}\\ \text{supply curve}\end{bmatrix}$$

Subject to the following constraints:

$$Q_i - S_i \leq 0 \text{ for all commodities } i \qquad (3\text{-}2)$$

$$\sum_i a_{ji}X_i \leq b_j \text{ for all resources } j \qquad (3\text{-}3)$$

$$Q_i, S_i \geq 0 \qquad (3\text{-}4)$$

where $C(S_i)$ is the cost of commodity i, α is the intercept and B is the slope of the demand function. Equation (3-2) states that sales of commodity i, Q_i, must not exceed its production, S_i. Equation (3-3) states that resource j required for the production activities X_i, can not exceed its availability b_j, and equation (3-4) states the non-negativity condition.

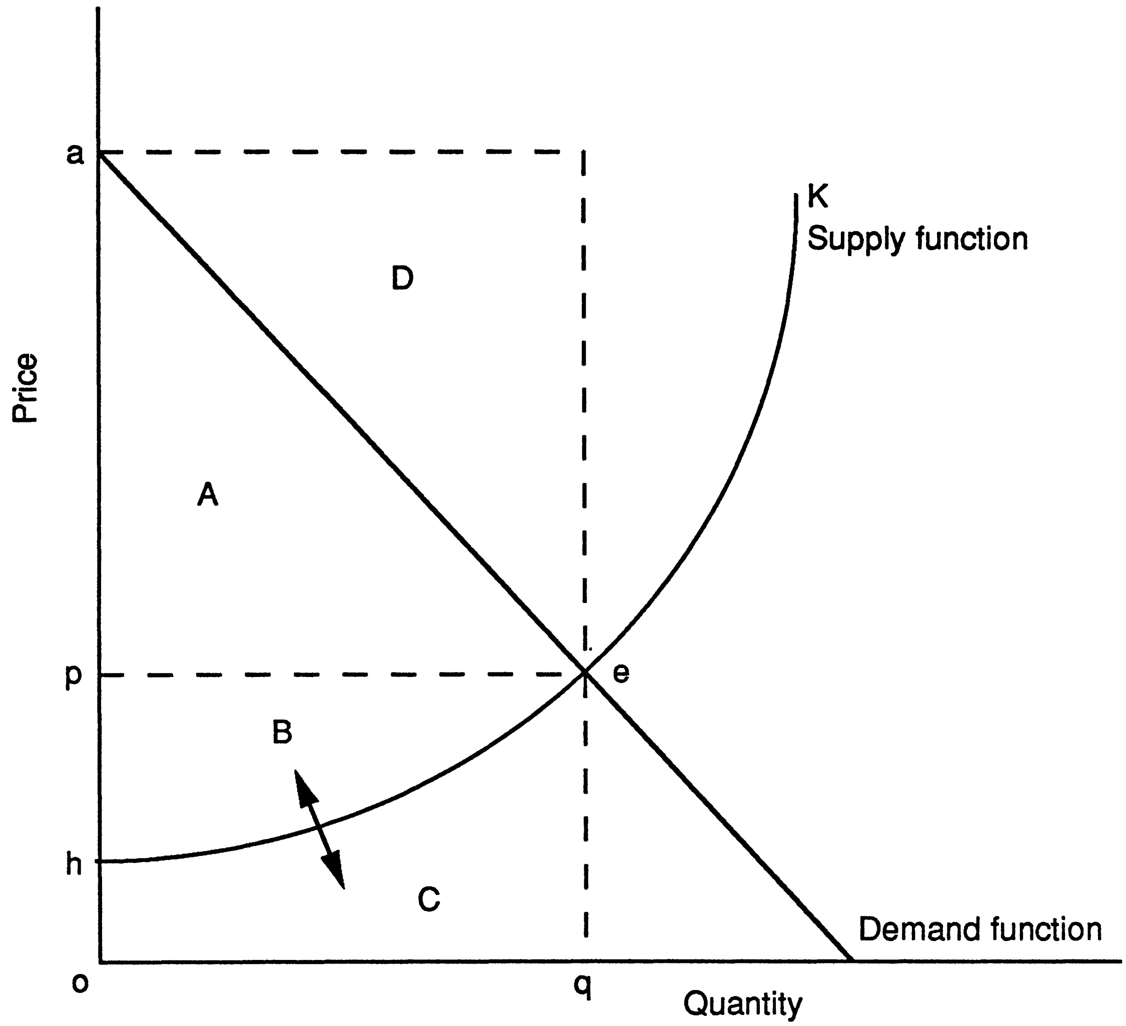
Following the Hazell-Norton explanation, the derivation of the objective function is illustrated geometrically in Figure 4. The total area under the demand curve may be decomposed into three parts:

1. Consumer surplus represented by triangle A
2. The producer gross revenue represented by rectangle B
3. The area under the supply curve which represents the total cost and denoted by C. The area A is the triangle ape; area B is defined as opeq; and area C is the irregular shape oheq. Area B includes area C but the two enter the objective function with opposite signs. Producer surplus is B - C and the objective function to be maximized is A + B - C. The value of this objective function can be expressed as follows:

$$\Pi = A + B - C \qquad (3\text{-}5)$$

$$\Pi = \frac{1}{2}\,(oa - op)\,oq + (op)\,(oq) - C \qquad (3\text{-}6)$$

$$\Pi = \frac{1}{2}\,(a - p)\,q + (p)\,(q) - C \qquad (3\text{-}7)$$



Source: Hazell and Norton, 1986

Figure 4. The Derivation of the Objective Function Geometrically

This basic expression holds for any price-quantity pair that lies on the demand curve. Therefore, the objective function for good i becomes:

$$\Pi_i = \frac{1}{2} (a_i - p_i) q_i + p_i q_i - C (q_i) \qquad (3\text{-}8)$$

Assuming a linear demand function, the inverse demand function can be written as:

$$p_i = a_i - B_i q_i \qquad (3\text{-}9)$$

Where a_i is the intercept and B_i is the slope of such function. Combining (3-9) and (3-8) yields the following equation:

$$\Pi_i = \frac{1}{2} [a_i - (a_i - B_i q_i)] q_i + (a_i - B_i q_i) q_i - C (q_i) \qquad (3\text{-}10)$$

$$\Pi_i = \frac{1}{2} (B_i q_i) q_i + (a_i - B_i q_i) q_i - C (q_i) \qquad (3\text{-}11)$$

Rearranging (3-11) gives us the final form for our objective function:

$$\Pi_i = (a_i - \frac{1}{2} B_i q_i) q_i - C (q_i) \qquad (3\text{-}12)$$

Commodity Balances. Commodity balance equations contain commodities produced and consumed locally, where the quantity demanded of any commodity must not exceed what is produced of such commodity. Commodity balances can be expressed as follows:

$$- Y_i X_i + \sum_s G_{is} D_{is} \leq 0 \text{ for all i} \qquad (3\text{-}13)$$

where Y_i is the yield for commodity i, X_i is the activity level and G_{is} denotes the quantity demanded of good i over segments s. The letter s refers to the number of segments in the demand curve. The sum of D_{is} represents the convex combination constraint for commodity i which must not exceed unity in value.

Convex Combination Constraints. Convex combination constraints are the choice variables regarding the position on the demand curve. The convex combination constraints force the model's solution to be located on or below the demand curve. But any point below the demand curve will be inefficient because a greater value of Π can be attained with the same quantity by moving to a point on the demand curve. Therefore, the convex combination constraint effectively dictates that the model's optimal solution will lie on the demand curve, provided of course, it is feasible to do so (Hazell and Norton, 1986).

The convex combination constraint may be expressed as follows:

$$\sum_s D_{is} \leq 1 \qquad (3\text{-}14)$$

[The sum of the variable D_{is} over s must not exceed unity.]

Resource Constraints. Resource constraints ensure that the amount of resources, such as labor, land, and capital used by the sector is less than or equal to the amount available.

$$\sum_i a_{ji} X_i \leq b_j \text{ for all } j \qquad (3\text{-}15)$$

Where a_{ij} is the technical coefficient which determines the amount of resource j needed for crop i activity X_i, and b_j is the amount of resource j, available.

Input Balances Equations. Input balance equations show various inputs purchased in the agricultural sector and equates usage levels with supply for all inputs.

$$\sum_i a_{fi} X_i - J_f \leq 0 \qquad (3\text{-}16)$$

where a_{fj} is the input-output coefficients for input f in crop i and J_f is the amount available of purchased input f.

Non-negativity Constraint. Non-negativity constraints ensure that all activities in the model have positive values.

$$X_i, D_{is}, J_f, \geq 0 \qquad (3\text{-}17)$$

After building the model, the next step is to validate the model and test its credibility.

Model Validation

Model validation refers to the testing of the credibility of the solution derived from the model. The credibility of the model solution is an important part in the model building process as policy makers must be convinced that the model structure approximates the actual situation. Moreover, the model responses to various changes must be within a reasonable range. An important factor determining the credibility of a model is how close the model reflects the actual situation.

In the literature there are no standard validations procedures to be followed. However, Gass (1983) points out that the measurement of a model's validity depends on the real world aspect being analyzed, the type of model being used, who is asking the questions, and who will interpret the results.

Normally, the main purpose of a sector model is to simulate the response of an interdependent system to various policy changes. Therefore, a validation procedure which serves such general purpose seems to be important for the credibility of such models. Also, programming models validation in the literature is usually targeted to the variables which are important to the purpose of the model. However, in a highly interrelated agricultural system, it might be misleading to base the reliability of the model solely on the above mentioned variable.

Gass (1983) presents a comprehensive analysis for the validation procedure of simulation models. This procedure can be summarized as follows:

1. Data verification to verify the correctness of the data and technical coefficients, and to evaluate how realistic the assumptions of the model are. For example, the model's technical coefficients should represent the average farmer in the sector to be studied. Moreover, market environment depicted by the model should be as close to reality as possible. Kutcher (1983) suggests using special tests like the marginal cost test to verify how realistic the model is. The marginal cost test tests whether the marginal cost equals the marginal revenue. If the test shows otherwise, this means that the market environment is not perfect competition as assumed in the model and the structure of the model should be changed to reflect the actual situation.

2. "Calibration" is the ability of the model to reproduce the actual base year prices and quantities. The model is considered valid if it generates information acquired from the real world. Calibration tests usually consist of capacity, input level, production, and price tests (Gass, 1983).

3. Testing the predictive ability of the model in the real world before using the model for any simulation. Testing the predictability can be done by updating the resource constraints, changing different cost items, changing the demand function, or changing government policies. After this, the impact of such changes on different variables in the model can be evaluated. Given the structure of such models, it is more feasible to perform these tests, then compare the result with the reported actual values of different variables.

After comparisons are made and deviations are calculated, the model is evaluated. There is no consensus on the best statistic to be used in evaluating the goodness of fit of sector models. However, most researchers have used measures such as the mean absolute deviation (MAD) or the percentage absolute deviation (PAD).

Hazel and Norton (1986) suggest the following measures for evaluating performance of a sector model: a PAD below 10 percent is good, a PAD of 5 percent would be exceptional, and a PAD of 15 percent or more indicates the model may need some corrections. After corrections are made and the model is validated, the next step is to perform various simulations as needed.

Simulation Analysis

Simulation is a common procedure used in agricultural sector analysis to evaluate agricultural policies under different circumstances. Naylor et. al., (1968) defines it as a flexible procedure which involves setting up a model of a real situation and performing different experiments on it. These experiments are conducted by changing the value of the parameters and exogenous variables one at a time, then the cause and effect relations in the sector are traced out. Considerable caution is required when interpreting the results of these type of experiments.

Simulation models can be classified based upon their incorporation of the time factor and their treatment of other variables. A static model does not account for time and only reflects the system at a particular point of time. A dynamic model takes time into consideration and reflects the system over time.

Law and Kelton (1982) state several advantages to the simulation procedure. These advantages include the ability to evaluate the performance of an existing system under a variety of operating conditions. Also, simulation models can account for stochastic variables and multiple time periods.

Literature Review

The use of mathematical programming to simulate market behavior in agriculture has been used extensively since the early fifties. The literature contains several types of agricultural sector programming models. These programming models can be classified according to different criteria. They can be classified based upon their level of aggregation (regional, national or multiple country), by the time dimensions of the model (static or dynamic), or by the methodological approach used in the formulation of product supply and demand (exogenous or endogenous prices) (Cakmak, 1987).

Price Exogenous Models

Price exogenous programming models include the restrictive assumption of fixed market prices or quantities, thereby ignoring the inter-relationships of aggregate price and quantity (McCarl and Spreen, 1980). This assumption implies that demand is exogenously determined outside the model.

Price exogenous linear programming models have been widely used to predict crop production and to assess the impact of policy changes in the agricultural sector. Heady and Egbert (1959) constructed the first detailed agricultural sector model for the United States. Their model was simple and attempted to explain the pattern of wheat production and distribution in the United States. The model's objective was minimizing costs of production and transportation to satisfy national demand, plus export demand. To achieve this objective, the U.S. was divided into 104 homogeneous producing areas and 10 consuming regions. A base solution was obtained and different hypothetical changes were simulated.

Evindson, Heady and Srivastava (1975) addressed farm size and its location and how these affect productivity and efficiency. They distinguished between three classes of farm sizes in each area. The results of their study showed a comparative advantage in production for large farms over small farms.

Stoecker and Khatikam (1982) developed a national crop model for Thailand. The purpose of this model was to provide a basis for analysis of alternative crop production level technologies in relation to livestock production and production in non-agricultural sector.

Although, price exogenous models can be used for different types of economic analysis, their objective function specification might fail to simulate the existing market condition. Thus, they might not generate a solution close to the observed data. Endogenous price models allow the solution to be more closely related to the market equilibrium.

Price Endogenous Models

Price endogenous models are based upon the method which was first suggested by Enke (1951) to simulate market equilibrium under perfect competition conditions. In the price endogenous sector models, input and output prices as well as quantity of factors used may be incorporated into the model through demand and supply functions. The parameters of domestic demand functions are determined econometrically and are subsequently included in the programming model. Income and population changes are exogenous to this type of model. Product supplies are determined by the resource availability constraints and profit maximization behavior of growers.

Risk behavior of growers could be accounted for in such models by incorporating it into the objective function.

Samuelson (1952) provided the basic methodology for such models by maximizing the area under the demand curve minus total cost subject to a set of constraints. Takagama and Judge (1964a, 1964b) introduced a quadratic programming formulation with endogenous prices and extended Samuelson's concept to trade between spatially separated markets.

A significant development in this work was attained in the 1970s by Duloy and Norton (1975, 1983). They extended the analysis to simulate the behavior of a complete agricultural sector for Mexico. Hazell and Scandizzo (1974) modified the Duloy and Norton method by emphasizing the importance of risk and incorporating it into their model. To facilitate solution for this type of quadratic programming model, Duloy and Norton (1975) used a grid linearization technique to approximate the demand functions by piecewise linear segments. Furthermore, Hazell (1979) developed a method to incorporate continuous upward sloping input supply functions that use a grid linearization technique similar to that used by Duloy and Norton in the demand functions.

During the 1970s and 1980s price endogenous sector programming models were used to conduct various empirical work in agriculture. Simmons and Pomareda (1975) used a sector model to examine the effect of changes in certain economic factors on the production and timing of specific crops. Adams et al. (1977) used a modified version of Takayama and Judge's model to conduct a comparative static analysis for the impact of energy cost increase on the production mix of crops in California. Epperson and Tyan (1984) used a linear programming model to examine the impact of a simulated reduction in fruit and vegetable supplies from California and Florida on production potential in the southeast region. Weimer and Hallam (1988) developed a quasi-spatial substitution model to examine Iowa's potential to expand in the commercial wholesale market for selected produce items.

The importance and applications of modelling the agricultural sector is clear. Price endogenous models are more common in agricultural sector programming, and fresh fruit and vegetable prices and quantities are not fixed in Oklahoma. Thus, these types of models appears most appropriate for examining the impact of marketing institution improvements in Oklahoma. A major marketing institution improvements in Oklahoma would be the establishing of a cooperative association for Oklahoma growers.

Theory of Cooperatives and Cooperative Associations in Agriculture

Cooperative associations are a common form of organization for small fresh fruit and vegetable growers in the U.S. They are most common in the northeast, great lakes, and the pacific states, and they could be a valuable alternative for Oklahoma producers.

Cooperatives are a form of business organization that are democratically controlled by their member-owners and provide their members with various services. Helmberger and Hoos (1965) define cooperatives as voluntary associations organized by agricultural producers to aid them in improving their income position, and help them in getting better terms of sales, or to provide other types of service. This role for the farmers' cooperative continues to receive widespread public support except for the cases of illegal practices on the part of farmer cooperatives as set out in the Capper-Volstead Act (Christy, 1987).

The Capper-Volstead Antitrust Act of 1922 exempted cooperative organizations and does not consider their formation as a violation of the federal antitrust law. To qualify for such exemption, cooperative members must be agricultural producers and the cooperative organization must be democratically organized and must operate for the benefit of its members (Mischler, 1957). Thus, under this act, a cooperative organization might be able to acquire some sort of market power, which would enhance its bargaining position.

Within some commodity markets, cooperatives have acquired a major share of the markets (i.e. dairy). Whether the growth in cooperative size and market share provides cooperatives with too much market power remains an empirical question. However, Galbraith identified several structure characteristics which limit their market power (Christy, 1987).

1. Cooperatives are a loose association of individuals
2. Cooperative associations rarely include all the producers of a product
3. Cooperatives cannot control the production of all members
4. Cooperatives have less than absolute control over the decision to sell

Therefore, it seems very unlikely that cooperative associations can attain an excessive level of market power in agricultural markets.

Historical Background

Agricultural cooperatives in the United States originated out of a dissatisfaction among farmers with the way their special needs were being met in the free market system (Beierlein et al, 1986). During the 1910s and 1920s, and as a reaction to this situation, farmers grouped together and started to form agricultural cooperatives. Since then, cooperative has become an accepted policy alternative to remedy agricultural market failures.

Cooperative associations in fruits and vegetables first started in California and Utah during World War I, and later the idea spread to other parts of the country. These early associations have served as a model for the cooperatives which were established later. A big surge in cooperative organization was started during and after World War II, and the number of cooperative organizations increased sharply. Tables VI through VIII show for 1987 the number of farm cooperatives, their membership, their business volume by state, and the growth in their market share. These figures cover all types of agricultural cooperatives, such as, fruit, grain and beef. Fruit and vegetable cooperative associations are mainly concentrated in the mid-atlantic, great lakes, and pacific states. They are most common in the production of peaches, pears, apples, cherries, grapes, olives, strawberries, tomatoes, peas, corn, peppers, and other vegetables (Stern and Anderson, 1986).

Principles of Cooperatives

The cooperative movement has an explicit set of principles, derived from the Rochdale pioneers, which are often used to explain cooperatives. The Rochdale pioneers established the use of cooperative principles in England in 1844. These principles can be summarized as follows (Bateman et al., 1979a and 1979b).

1. Membership of a cooperative should be voluntary. It should be open to all persons who can make use of its services and are willing to accept the responsibilities of membership.

2. Cooperatives are democratic organizations. They should be managed by persons elected or appointed in a manner agreed by the members.

TABLE VI

FARMER COOPERATIVE NUMBERS, MEMBERSHIP AND BUSINESS VOLUME BY STATE, 1987

State	Headquartered in State	Memberships in State	Business Volume
	Number		Mil. Dol.
Alabama	77	84,736	652.7
Arizona	14	63,880	421.9
Arkansas	94	73,922	1,132.2
California	209	78,286	6,413.8
Colorado	70	39,673	477.8
Connecticut	5	4,556	172.1
Delaware	5	17,257	83.3
Florida	53	32,729	1,608.4
Hawaii	29	4,140	89.1
Idaho	55	39,424	525.1
Illinois	261	244,109	3,240.9
Indiana	71	170,881	1,617.2
Iowa	322	257,715	4,472.7
Kansas	218	194,766	1,880.6
Kentucky	76	248,529	755.3
Louisiana	64	16,354	506.2
Maine	7	9,769	155.9
Maryland	21	72,420	452.3
Massachusetts	12	8,111	504.9
Michigan	88	85,070	1,542.1
Minnesota	519	370,660	4,398.1
Mississippi	131	86,017	757.7
Missouri	91	177,328	1,753.5
Montana	109	38,439	307.3
Nebraska	210	164,182	1,964.9
New Jersey	18	10,353	300.3
New Mexico	13	4,078	42.3
New York	170	84,178	2,109.4
North Carolina	31	101,692	566.5
North Dakota	371	150,095	1,910.0
Ohio	134	134,754	2,317.9
Oklahoma	134	86,625	823.8
Oregon	51	41,075	860.4
Pennsylvania	76	71,856	1,679.9
South Carolina	13	25,048	177.0
South Dakota	215	154,495	923.4

TABLE VI (Continued)

State	Headquartered in State	Memberships in State	Business Volume
Tennessee	95	138,179	619.6
Texas	346	125,304	2,142.6
Utah	32	17,090	366.5
Vermont	16	8,741	354.4
Virginia	97	219,575	841.6
Washington	108	50,518	1,499.0
West Virginia	43	67,679	128.3
Wisconsin	300	293,384	4,167.8
Wyoming	18	8,129	51.4
Other States	22	64,198	1,097.7
United States	5,109	4,439,999	59,166.3

Source: Farmer Cooperative, June 1989.

TABLE VII

THE GROWTH OF MARKET SHARE FOR AGRICULTURAL COOPERATIVES (1952-1986)

Crop Type	Number of Cooperatives	Market Share Percent		
		1952	1983	1986
Dairy Products	418	43%	77%	78%
Grain & Soybeans	2,275	35%	36%	41%
Cotton	487	10%	31%	35%
Fruits & Vegetables	52	15%	19%	18%
Livestock & Wool	583	14%	11%	8%
Poultry & Eggs	63	6%	8%	8%
All Farm Products	3,514	20%	30%	31%

Source: USDA Farmers Cooperative Statistics, Agricultural Cooperative Service, Washington, D.C. Nov. 1987.

TABLE VIII

NUMBER, MEMBERSHIP, AND BUSINESS VOLUME OF FARM COOPS IN THE U.S., SELECTED YEAR, 1970-1987

Year	Number of Coops	Number of Members	Business Volume ($1,000)
1970	4,834	3,102,745	18,388,420
1973	4,897	3,117,980	25,110,774
1976	4,658	2,811,853	39,402,165
1979	3,825	2,530,733	53,668,810
1981	3,743	2,452,219	70,161,551
1983	3,647	2,307,630	61,709,412
1987	5,109	4,439,999	59,166,300

Sources: 1. Stern and Anderson (1986).
2. Farmer Cooperative, June 1989.
3. USDA Farmers Cooperative Statistics, Agricultural Cooperative Service, 1985.

3. Share capital should receive only a strictly limited rate of interest, if any.

4. Surplus or savings, arising out of cooperative operations belong to the members of that cooperative and should be distributed equally among its members.

5. Cooperatives should make provisions for the education of members, employees, and the general public, in the principles and techniques of cooperation.

6. To best serve its members and their communities, cooperatives should co-operate with other cooperatives at local and national levels.

Objectives and Functions of Cooperative Associations

The main objective of a fruit and vegetable cooperative association is to enhance terms of trade for its members so that net return to members for any given level of output is maximized. Furthermore, the price received by members must be at least as high as that received by non-members. In such cooperatives, the major emphasis is usually placed on attaining a higher price, setting quality standards, grading procedure, and so forth.

Other objectives of fruit and vegetable cooperatives might include curtailing certain unfair buying policies of buyers, which discriminate among different growers. Such discriminating policies might include, poor grading practice, and improper weighing procedures, whereby high quality produce may not receive the price it deserves (LeVay, 1983).

Among other purposes of a cooperative are negotiating contract terms for its members, and using its bargaining power to try to enhance returns to its members. To be an effective bargainer, a cooperative must prepare for negotiations by collecting and analyzing all kinds of necessary data, such as prices, sales, shipments, inventories, and so forth. During negotiation with the buyers-processors, proposals and counter proposals are discussed until a final contract is reached. Contract terms usually include price structure for crops of various grades and varieties, grades and methods of grading, time and method of payment, and place of delivery. Moreover, the contract may specify costs of services provided by processors, specification of acceptable qualities and condition of crops, hauling allowances, methods of cultivation, and methods of settling disputes between growers and buyers-processors, (McBride, 1986).

The cooperative organization might collect and disseminate relevant information on marketing conditions and participate in research on different aspects of fruit and vegetable industry. Furthermore, they may supply members with service of cooperatively owned machines, and lobby on behalf of growers at governmental and legislative levels.

Membership and Management of a Cooperative

Membership agreements are very important for cooperative associations. Through membership agreements, the cooperatives will gain control of the produce and work to improve terms of trade for their members. In most cases, membership agreements are agency-type contracts, where the growers appoint the cooperative as their exclusive sale agent for specific crops and for a given period of time. In short, the grower must market his commodity through the cooperative and the cooperative must approve the terms of sale.

To gain more control of a member's crop, cooperatives might refer to product pooling. Pooling is referred to the organization of members production into similar groups of products, then distributing payments according to member participation in the specified pool. In a large cooperative, usually it is impractical and inefficient to segregate products by ownership. Under pooling, a cooperative adds net revenues from sale of a pool of products. After a portion of shared costs is deducted, the sum is distributed in proportion to each member's pool contribution. Contributions can be measured in terms of physical volume, market value, or other agreed valuation of raw products delivered (Buccola and Subaei, 1985).

Fresh fruit and vegetable cooperatives seldom use pooling. However, processed fruit and vegetable and dairy cooperatives do often use pooling methods. Usually, the pools are formed for each year's production and returns to members are paid out over one or two years as the crop is sold with the final payment coming after the pool has been liquidated (Falk, 1988).

Since fruit and vegetable cooperatives handle several crops, they have to solve the problem of how to allocate pooled earnings to various products. One solution is to pay competitive market price for produce then distribute any additional earnings as an equal percentage of price among all commodities. Another method is to maintain a separate pool for each commodity (Buccola and Subaei, 1985).

Non-member producers may use a marketing cooperative to market their products, but they can not vote in such cooperatives. Moreover, to qualify for tax exemption, cooperatives can not have a greater volume of non-member business than member business. Specifically the proportion of business with non-member may not exceed 15 percent of the cooperative business volume (Stern and Anderson, 1986).

New members must be approved by the board of directors and the board will not accept those growers whose financial interest are in conflict with the cooperative's members.

Voting rights vary from one cooperative to another, it can be based upon a one vote per member or based on volume of patronage. Patronage could be measured by tonnage in case of fruit and by acres planted in the case of vegetable cooperatives.

Cooperative members usually elect the board of directors who then assume the responsibility and authority to operate and direct the cooperative. The board is usually given all powers of the cooperative, subject to the bylaws and articles of incorporation. These powers include the ability to enter into contract, incur debts, appoint agents, etc. The board is also authorized to appoint a president, vice-president, secretary, and other executive members.

Although, the final authority rests with the cooperative board of directors, the powers are usually executed by managers and other employees. Normally, cooperative managers and employees duties will include; participating in negotiation with buyers-processors, recruiting new members for the cooperative, collecting and analyzing data, and maintaining good public relations (Vitaliano, 1983).

Financial Aspects of Cooperatives

Financial needs of fresh fruit and vegetable marketing cooperatives are modest in comparison with the need of processing cooperatives, because their services will be relatively inexpensive. Such cooperatives are usually financed by retaining a percentage of member's gross proceeds. This portion is normally determined by bylaws of the cooperative, and could be in the range of .5 to 1.5 percent in the case of vegetables (Helmberger and Hoos, 1965). However, these retains do not necessary indicate the real cost to members. The figures might be the maximum amount which could be collected from members. Thus, any surplus left will be returned to members as a patronage refund.

Other ways to finance a marketing cooperative would be by charging a membership fee, initial investment by the founding members, annual dues, buyers service charge, and loans (Rhodes, 1983). The buyers service charge refers to payments made by buyers to marketing cooperatives for their services in providing stable supply through contact with various growers.

Cooperative Marketing Strategy

Normally, agricultural marketing cooperatives consider large food corporations to be their main competitors. Newly formed marketing cooperatives might be too small or not strong enough to compete with giant marketing firms, so they must be careful when entering new markets. In evaluating their competitive position, cooperatives must know their own strengths and weaknesses and the strength and weaknesses of their competitors.

A key element of cooperative marketing strategy is the creation of brand names which will be well known in the market. Cooperatives may purchase their brand name from another entity, usually a private company or another cooperative. It is probably more feasible for a new cooperative to purchase a brand franchise and the associated marketing organizations than to develop its own. This fact is because the launching of a new brand would cost millions of dollars in consumer advertising and promotion and there is no guarantee that such new brands will succeed. Table IX lists some of the major brand names used by cooperatives to market their agricultural products.

TABLE IX

MAJOR BRAND NAMES USED BY COOPERATIVES
TO MARKET AGRICULTURAL PRODUCTS

Fruits & Juice	Vegetables	Dairy	Grain & Nuts
Cranapple	Brooks	Challenge	Blue Ribbon
Donald Duck	Calavo	Crown	Blue Diamond
Libby	Comstock	Dairigold	Diamond
Ocean Spray	Great Lakes	Dairylea	Hinod Rice
Sunkist	McKenzie's	Flav-O-Rich	Riceland
Sun Maid	Redpack	Hood	3-Minute
Sun Sweet	Sacramento	Land O' Lakes	
Tree Top	S & W	Lake to Lake	
Welch's		Prairie Farms	

Source: U.S. Department of Agriculture, Cooperative Brands of Processed Foods. Agricultural Cooperative Service, June 1985.

Aggressive distribution efforts are an important part of a successful marketing strategy in a new cooperative. Being relatively small, new cooperatives could not afford large scale organizations of their own. Consequently, most new cooperatives rely heavily on well established brokers to move their products.

Pricing policy is another important part of marketing strategy for a successful marketing cooperative. An important objective of new cooperatives is normally to supply their market with quality produce at a competitive price. Also, advertising and promotion is used by cooperatives to promote their products. In addition to traditional advertising methods, cooperatives may use other non-traditional methods such as participating in community agricultural fairs and other social events.

CHAPTER IV

AGRICULTURAL SECTOR MODEL FOR OKLAHOMA

Structure of the Model

A sector model of the Oklahoma vegetable industry has been developed to evaluate alternative scenarios. The basic structure of the Oklahoma model is similar to the sector model developed by Duloy and Norton in 1983. The Oklahoma model is a sector-wide model in the sense that it describes total Oklahoma supply and use of seven vegetable items. It is a one period model. The year 1989 is used as the base year. The production side of the sector model is decomposed into submodels for each of the seven crops. Activity budgets for small farms are used in this model since vegetable production in Oklahoma is characterized by small acreage.

On the demand side, consumer demand is regarded as price dependent, thus market clearing commodity prices are endogenous to the model. Demand segment variables, along with associated convex combination constraints are used in the model.

The objective function in the Oklahoma model is defined as the maximization of producers' and consumers' surplus. Activities for product sold outside Oklahoma are incorporated into the model. The inclusion of these activities will account for large quantities of certain crops sold outside Oklahoma.

Model Assumptions

The model assumes that consumers and producers are price takers and operate in a perfectly competitive environment, while market clearing is assumed in output and factor markets. This assumption is similar to the current situation in the fresh vegetable industry in Oklahoma, since it is dominated by many small producers. The above formulation will enable us to evaluate the sector-wide effects of various agricultural policies. Moreover, the impact of other exogenous changes, such as the introduction of cost saving methods or forming a marketing cooperative can be evaluated. Given that data are limited and to facilitate the analysis, demand curves are assumed to be linear. Table X defines the symbols used in the model description.

The Objective Function

The objective function used in the model is a quadratic function and maximizes the area between linear demand and supply curves. The maximand consists of the sum of consumers' and producers' surplus.

The main components of the objective function can be illustrated geometrically as shown in Figure 5. The linear demand functions used are of the following form:

$$P = \alpha - BQ \qquad (4\text{-}1)$$

where α is the intercept term and B is the slope coefficient. The supply functions exhibit constant average cost with rising production, due to fixed yields as production expands. The objective function is the algebraic sum of the value of area under the demand curve, minus total cost. Normally, the total cost will cover all types of cost such as purchased inputs, marketing cost, and fixed cost. The mathematical form of the objective function can be written as follows:

TABLE X

DEFINITION OF NOTATIONS USED IN THE MODEL

Symbol	Description
Π_{is}	Net social welfare for crop i at segment s.
W_{is}	Area under in-state demand curve for crop i at segment s.
U_{ir}	Area under out-of-state demand curve for crop i at segment r.
Y_i	Farm level yield for crop i.
P_f	Cost of purchase for input f.
G_{is}	Quantities associated with in-state demand at different segments for crop i.
H_{ir}	Quantities associated with out-of-state demand at different segments for crop i.
a_{fi}	Requirements of purchased input f for crop i (per acre).
a_{ki}	Requirement of resource k for crop i (per acre).
b_k	Amount of resource k available.
Δ_i	Marketing and Packing cost farm to retail level unit for crop i (per farm unit).
i	Crop type.
k	Resource type.
s	In-state demand segments.
r	Out-of-state demand segments.
X_i	Acres of crop i.
M_i	Farm units of crop i marketed.
m_i	Retail unit per farm unit for crop i.
D_{is}	Choice variable regarding position on in-state demand curve for crop i at segment s.
J_f	Supply of purchased input f.
E_{ir}	Choice variable regarding position on out-of-state demand curve for crop i at segment r.

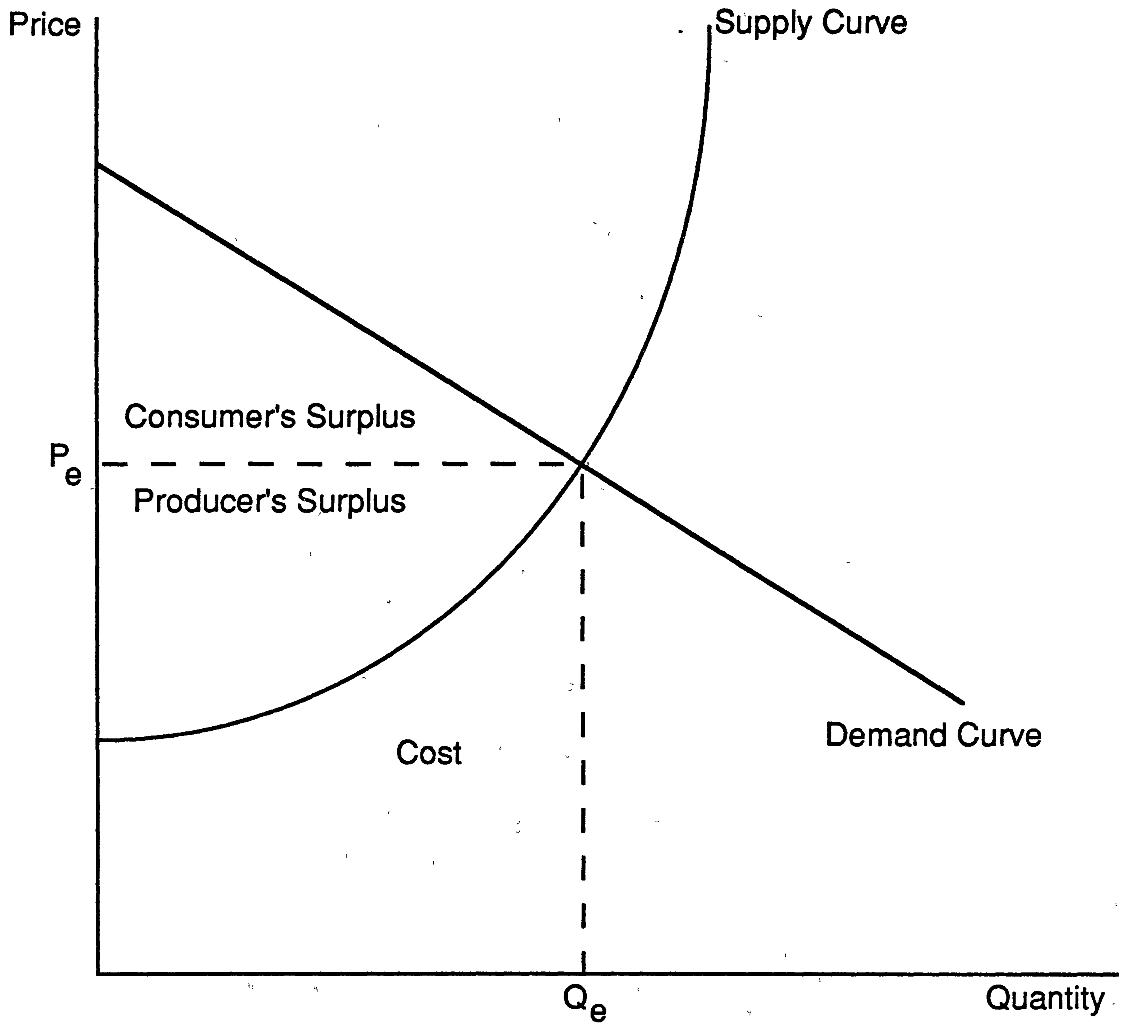


Figure 5: Consumers' Surplus, Producers' Surplus, and Total Cost

$$\text{Max } \Pi = \sum_i \sum_s W_{is} D_{is} - \sum_f P_f J_f - \sum_i \Delta_i M_i + \sum_i \sum_r U_{ir} E_{ir} \tag{4-2}$$

$$\begin{bmatrix}\text{Maximize consumers'}\\ \text{plus producers' surplus}\end{bmatrix} = \begin{bmatrix}\text{Area under in-}\\ \text{state demand curve}\end{bmatrix} - \begin{bmatrix}\text{Cost of}\\ \text{purchased inputs}\end{bmatrix} - \begin{bmatrix}\text{Marketing and}\\ \text{packing cost}\end{bmatrix} + \begin{bmatrix}\text{Area under out-of-}\\ \text{state demand curve}\end{bmatrix}$$

<u>Commodity Balances</u>

Commodity balances include the amounts produced of each commodity whether consumed locally or sold outside the state. Commodity balances are expressed as follows:

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

$$-\begin{bmatrix}\text{Production balance}\\ \text{at farm gate level}\end{bmatrix} + \begin{bmatrix}\text{Marketed}\\ \text{production}\end{bmatrix} \leq 0 \tag{4-3a}$$

$$- m_i M_i + \sum_s G_{is} D_{is} + \sum_r H_{ir} E_{ir} \leq 0 \tag{4-3b}$$

$$-\begin{bmatrix}\text{Total production}\\ \text{at retail level}\end{bmatrix} + \begin{bmatrix}\text{In-state}\\ \text{Consumption}\end{bmatrix} + \begin{bmatrix}\text{Out-of-state}\\ \text{sales}\end{bmatrix} \leq 0$$

The out-of-state variable is added to the commodity balances to account for the amount sold outside Oklahoma.

<u>Input Balances</u>

Input balance equations equate the level of input usage with the supply for each input. Normally, input balances are written as follows:

$$\sum_i a_{fi} X_i - J_f \leq 0. \tag{4-4}$$

$$\begin{bmatrix}\text{Amount of purchased}\\ \text{input used}\end{bmatrix} - \begin{bmatrix}\text{Supply of}\\ \text{purchased input}\end{bmatrix} \leq 0$$

Resource Constraints

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

$$\sum_i a_{ki} X_i \leq b_k \text{ for all k resources} \qquad (4\text{-}5)$$

$$\begin{bmatrix}\text{Amount of} \\ \text{resource used}\end{bmatrix} \leq \begin{bmatrix}\text{Available} \\ \text{resources}\end{bmatrix}$$

Non-negativity Constraints

To guarantee that all activities in the model have a non-negative value. This condition must be specified as follows:

$$X_i, D_{is}, J_f, E_{ir} \geq 0 \text{ for all i, f, s and r} \qquad (4\text{-}6)$$

Demand Convexity Constraints

The demand convexity constraints force the model's solution to lie on the demand curve. There is a convexity constraint for in-state demand (4-7) and out-of-state demand (4-8). The convex combination for each crop must not exceed unity, and is written as follows:

$$\sum_s D_{is} \leq 1 \text{ for all i crops} \qquad (4\text{-}7)$$

$$\sum_r H_{ir} \leq 1 \text{ for all i crops} \qquad (4\text{-}8)$$

$$\begin{bmatrix}\text{Sum of demand} \\ \text{segments}\end{bmatrix} \leq \begin{bmatrix}1\end{bmatrix}$$

Activity Components of the Model

The Oklahoma sector model contains various types of activities to describe production, marketing, input supply, output demand, and out-of-state demand activity. These activities are shown in schematic tableau format in Table XI. Each activity in the model is represented by a column in the tableau. The production activity columns have yield entries (Y_i) in the commodity balance rows, and resource requirements (a_{ki}) in the resource constraint rows, where (k) denotes the resource type. Also, the intersections of the demand activity columns and the commodity balance rows are the quantities demanded in the local market.

Production Activities (X_i)

The core of the model consists of production activities. As shown in Table XI, the model contains many activities to describe the production of the seven crops under study. Each production activity defines various levels of input use, marketing costs, and a yield per acre. Tables XIII to XIX show labor and other input charges per acre for the 1989 base year which are used in the sector model.

For simplicity, input-output coefficients are assumed to be the same for all growers in Oklahoma. Since most of inputs are available in Oklahoma, the assumption of perfect elasticity for the input supply seems reasonable (all amounts can be purchased at the given price).

Seasonality in production is accounted for by specifying a time range for each crop. The time range will determine not only the production timing, but also constitute factor demand activities. Table XII shows planting and harvesting ranges for the selected horticultural crops in Oklahoma that will be

TABLE XI

SIMPLIFIED TABLEAU FOR OKLAHOMA SECTOR MODEL

Balances "Rows"	Activities or "Columns"					
	Production X_i	Marketing M_i	Input Supply J_{if}	In-State Demand D_{is}	Out-of-State Demand E_i	RHS
Input Balances	a_{fi}		-1			≤ 0
Farm Level Commodity Balances	$-Y_i$	1				≤ 0
Retail Level Commodity Balances		m_i		1	1	≤ 0
Resource Constraints	a_{ki}					$\leq b_k$
In-State Convex Combination				1		≤ 1
Out-of-State Convex Combination					1	≤ 1
Objective Function		$-\Delta i$	$-P_f$	$f(D_i)$	$f(E_i)$	Max

Note: See Table X for explanation of notation in the tableau.

TABLE XII

PLANTING AND HARVEST SEASONS FOR SELECTED CROPS IN OKLAHOMA

Crop	Planting Range	Harvest Range	Range Used in the Study
Tomatoes	Apr. 2-Apr. 29	June 16-Aug.19	Apr. 1-Aug. 30
Bell Peppers	Apr. 2-Apr. 29	June 11-Aug.26	Apr. 1-Aug. 30
Cucumber	Apr. 2-July 29	June 4-Oct. 28	Apr. 1-Oct. 30
Cabbage (Fall)	Sept. 3-Sept. 30	Oct. 8-Nov. 20	Aug. 1-Nov. 30
Cantaloupe	Apr. 2-June 30	July 9-Oct. 21	Apr. 1-Sept. 30
Sweet Corn	Mar. 12-May 13	June 4-Aug. 5	Mar. 1-Aug. 30
Squash	Apr. 2-July 29	June 11-Oct. 28	Apr. 1-Oct. 30

Source: Schatzer et al., 1986.

TABLE XIII

ACTIVITY BUDGET FOR SMALL IRRIGATED FARM - TOMATOES, 1989

Item	Units	Price	Quantity	Value
Variable (operating) costs:				
Herbicide	Acre	3.15	1.00	3.15
Fertilizer	Cwt.	8.80	3.35	29.48
Potash	Lbs.	.08	100.00	8.00
Rntfertsprd/acre	Acre	1.00	2.00	2.00
Transplant	ThpL	50.00	5.00	250.00
Transplant Labor	Hr.	4.50	8.00	36.00
Stakes	Each	.25	834.00	208.50
Twine	Lbs.	1.25	30.00	37.50
Staking, Tieing & Hoeing Labor	Hr.	4.50	259.00	1039.50
Insecticide, Bact. & Fungicide	Acre	34.65	8.03	278.40
Nitrogen	Lbs.	.17	50.00	8.50
Lugs	lugs	.68	840.00	571.20
Harvest Labor	Hr.	4.50	202.00	909.00
Mktg. & Grading	lugs	.75	840.00	630.00
Capital (annual)	Dol.	.118	418.661	49.19
Labor charges	Hr.	4.50	21.13	95.09
Fuel & repairs	Acre			91.18
Total variable costs	Acre			4282.68
Fixed Costs:				
Machinery	Acre			237.81
Irrigation				87.75
Total fixed costs	Acre			320.56
Total costs	Acre			4603.24

Source: Schatzer et al., 1989.

TABLE XIV

ACTIVITY BUDGET FOR SMALL IRRIGATED FARM -BELL PEPPERS, 1989

Item	Units	Price	Quantity	Value
Variable (operating) costs:				
Herbicide	Acre	3.15	1.0	3.15
Fertilizer	Cwt.	8.80	3.50	30.80
Rntfertsprd/acre	Acre	1.00	2.00	2.00
Transplant	ThpL	40.00	12.00	480.00
Transplant Labor	Hr.	4.50	15.00	67.50
Insecticide, Bact. & Fungicide	Acre	23.9	5.72	136.80
Hoeing Labor	Hr.	4.50	12.00	54.00
Nitrogen	Lbs.	0.170	50.00	8.50
Cartons	Cart	1.20	300.00	360.00
Harvest Labor	Hr.	4.50	120.00	540.00
Mktg. & Grading	Cart.	1.00	300.00	300.00
Capital (annual)	Dol.	0.118	200.516	23.56
Labor charges	Hr.	4.50	15.118	68.03
Fuel & repairs	Acre			75.64
Total variable costs	Acre			2149.98
Fixed Costs:				
Machinery	Acre			271.549
Irrigation				50.140
Total fixed costs	Acre			334.92
Total costs	Acre			2484.56

Source: Schatzer et al., 1989.

TABLE XV

ACTIVITY BUDGET FOR SMALL IRRIGATED FARM - CUCUMBER, 1989

Item	Units	Price	Quantity	Value
Variable (operating) costs:				
Herbicide	Acre	24.00	1.00	24.00
Seed	Lbs.	14.00	1.50	21.00
Fertilizer	Cwt.	8.80	3.50	30.80
Rntfertsprd/acre	Acre	1.00	2.00	2.00
Insecticide	Acre	6.60	4.00	26.40
Hoeing & labor	Hr.	4.50	12.00	54.00
Herbicide	Acre	3.150	1.00	3.15
Nitrogen	Lbs.	0.170	50.00	8.50
Cartons	Cart.	1.20	300.00	360.00
Harvest Labor	Hr.	4.50	90.00	405.00
Mktg & Grading	Cart.	1.00	300.00	300.00
Capital (annual)	Dol.	0.118	26.517	3.12
Labor charges	Hr.	4.50	10.191	45.86
Fuel & repairs	Acre			69.75
Total variable costs	Acre			1353.57
Fixed Costs:				
Machinery	Acre			171.948
Irrigation	Acre			78.000
Total fixed costs	Acre			249.95
Total costs	Acre			1603.52

Source: Schatzer et al., 1989.

TABLE XVI

ACTIVITY BUDGET FOR SMALL IRRIGATED FARM - FALL CABBAGE, 1989

Item	Units	Price	Quantity	Value
Variable (operating) costs:				
Herbicide	Acre	3.150	1.00	3.15
Fertilizer	Cwt.	8.80	3.00	26.40
Rntfertsprd/acre	Acre	1.00	3.00	3.00
Transplant	ThpL	30.00	16.500	495.00
Transplant Labor	Hr.	4.50	18.00	81.00
Nitrogen	Lbs.	0.170	80.00	13.60
Insecticide	Acre	12.150	4.00	48.60
Carton	Cart.	1.180	450.00	531.00
Harvest Labor	Hr.	4.50	112.50	506.25
Mktg. & Grading	Cart.	1.350	450.00	607.50
Capital (annual)	Dol.	0.118	120.970	14.21
Labor charges	Hr.	4.50	12.211	54.95
Fuel & repairs	Acre			37.30
Total variable costs	Acre			2441.96
Fixed Costs:				
Machinery	Acre			219.295
Irrigation	Acre			43.875
Total fixed costs	Acre			263.17
Total costs	Acre			2705.13

Source: Schatzer et al., 1989.

TABLE XVII

ACTIVITY BUDGET FOR SMALL IRRIGATED FARM - MUSKMELON, 1989

Item	Units	Price	Quantity	Value
Variable (operating) costs:				
Herbicide	Acre	327.15	1.00	27.150
Fertilizer	Cwt.	8.80	3.00	26.40
Rntfertsprd/acre	Acre	1.00	2.00	2.00
Seed	Lbs.	6.00	2.00	12.00
Insecticide	Acre	12.150	4.00	48.60
Nitrogen	Lbs.	0.170	60.00	10.20
Hoeing & labor	Hr.	4.50	8.00	36.00
Cartons	Cart.	1.780	370.00	473.60
Harvest Labor	Hr.	4.50	148.00	666.00
Mktg. & Grading	Cart.	1.00	370.00	370.00
Capital (annual)	Dol.	0.118	75.994	8.93
Labor charges	Hr.	4.50	11.293	50.82
Fuel & repairs	Acre			95.17
Total variable costs	Acre			1806.30
Fixed Costs:				
Machinery	Acre			196.238
Irrigation	Acre			82.875
Total fixed costs	Acre			279.11
Total costs	Acre			2085.41

Source: Schatzer et al., 1989.

TABLE XVIII

ACTIVITY BUDGET FOR SMALL IRRIGATED FARM - SWEET CORN, 1989

Item	Units	Price	Quantity	Value
Variable (operating) costs:				
Seed	Lbs.	3.00	10.00	30.00
Herbicide	Acre	15.00	1.00	15.00
Fertilizer	Cwt.	8.80	3.50	30.80
Rntfertsprd/acre	Acre	1.00	2.00	2.00
Nitrogen	Lbs.	0.170	70.00	11.90
Hoeing Labor	Hr.	4.50	30.00	135.00
Insecticide	Acre	6.60	9.00	59.40
Crates	Crat.	1.250	180.00	225.00
Harvest Labor	Hr.	4.50	30.00	135.00
Mktg. & Grading	Crat.	0.550	180.00	99.00
Capital (annual)	Dol.	0.118	30.403	3.57
Labor charges	Hr.	4.50	10.509	47.29
Fuel & repairs	Acre			65.42
Total variable costs	Acre			742.39
Fixed Costs:				
Machinery	Acre			186.719
Irrigation	Acre			68.25
Total fixed costs	Acre			254.97
Total costs	Acre			997.36

Source: Schatzer et al., 1989.

TABLE XIX

ACTIVITY BUDGET FOR SMALL IRRIGATED FARM - SQUASH, 1989

Item	Units	Price	Quantity	Value
Variable (operating) costs:				
Herbicide	Acre	30.00	1.00	30.00
Seed	Lbs.	22.00	4.00	88.00
Fertilizer	Cwt.	8.80	3.00	26.40
Rntfertsprd/acre	Acre	1.00	2.00	2.00
Insecticide	Acre	6.60	6.00	39.60
Hoeing Labor	Hr.	4.50	24.00	108.00
Nitrogen	Lbs.	0.170	30.00	5.10
Cartons	Cart.	0.99	500.00	495.00
Harvest Labor	Hr.	4.50	200.00	900.00
Mktg. & Grading	Cart.	1.00	500.00	500.00
Capital (annual)	Dol.	0.118	73.80	8.67
Labor charges	Hr.	4.50	10.159	45.72
Fuel & repairs	Acre			64.39
Total variable costs	Acre			2312.87
Fixed Costs:				
Machinery	Acre			176.954
Irrigation	Acre			68.25
Total fixed costs	Acre			245.20
Total costs	Acre			2558.07

Source: Schatzer et al., 1989.

used in this study. Inputs such as labor, land, and water are specified on a monthly basis.

Labor is the most important input in the production activities. It is measured in man-hour equivalents and shows actual time required per acre for each crop.

Marketing and Packing Activities (M_i)

Marketing and packing activities play the role of transferring crops from the farm gate level to the retail level. Normally, marketing and packing activities are enclosed within the production activity block. However, in the Oklahoma sector model, marketing and packing activities are incorporated under separate activity columns. The inclusion of marketing and packing activities in separate columns will enable us to use the model to examine the impact of various changes in marketing activities on the fresh vegetable industry in Oklahoma. Table XI shows how marketing and packing activities are incorporated separately into the model.

The algebraic form for commodity balance in the model is as follows:

$$- m_i M_i + \sum_s G_{is} D_{is} + \sum_r H_{ir} E_{ir} \leq 0 \text{ for all i crops} \qquad (4\text{-}9)$$

where m_i is the output of the joint marketing and packing activity per unit of raw crop from producers, and Mi is the corresponding activity level. Marketing and packing costs are denoted by Δ_i in Table XI where i indicates crop type.

The timing of marketing periods also reflects the seasonality of Oklahoma's horticultural activities, as illustrated in Figures 6 to 12. Previous studies conducted at Oklahoma State University were used to estimate these marketing periods (i.e. Schatzer and Motes, 1989; Sleper et al., 1984; Falk, 1988).

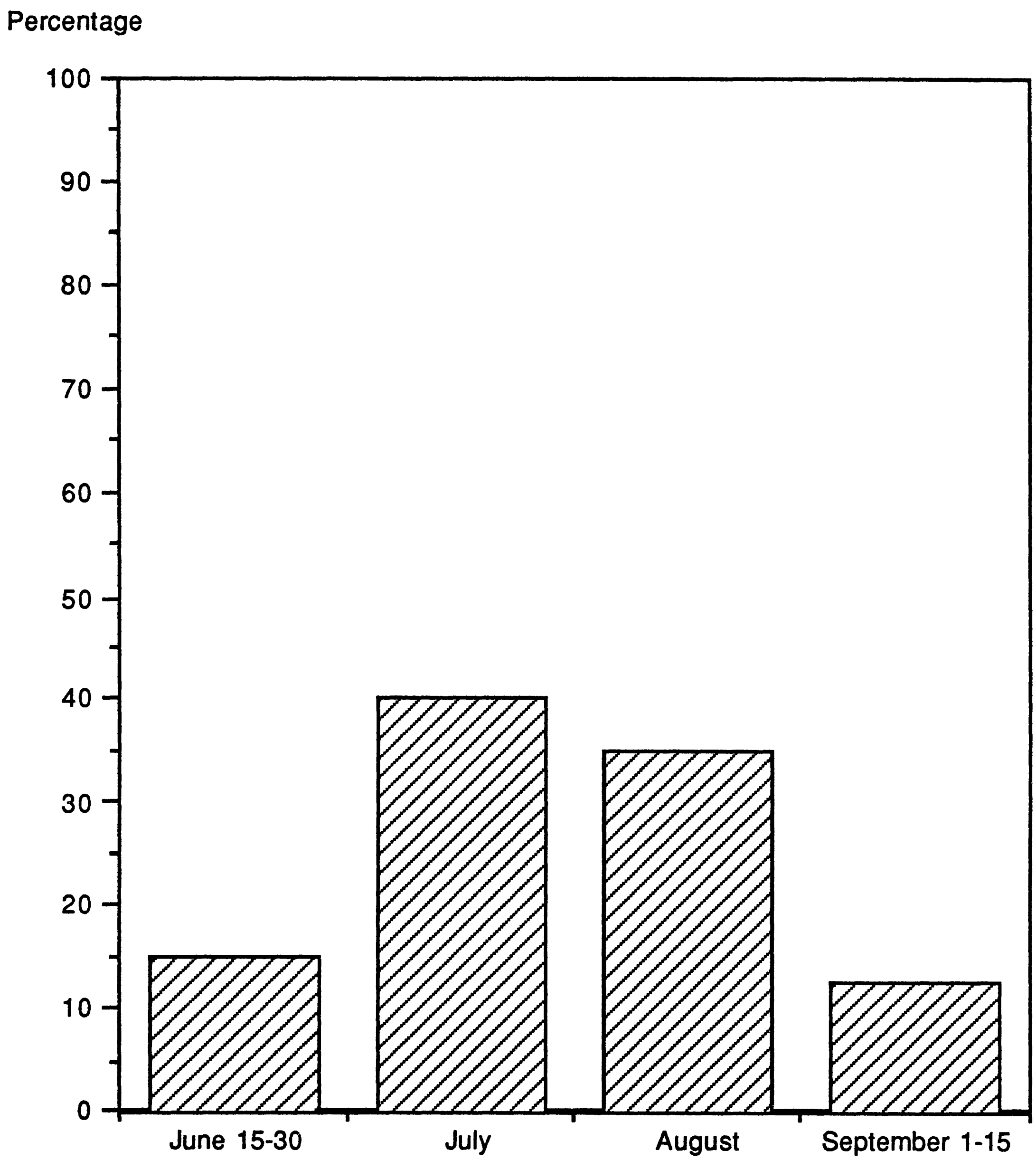


Figure 6. Tomatoes Estimated Marketing Periods

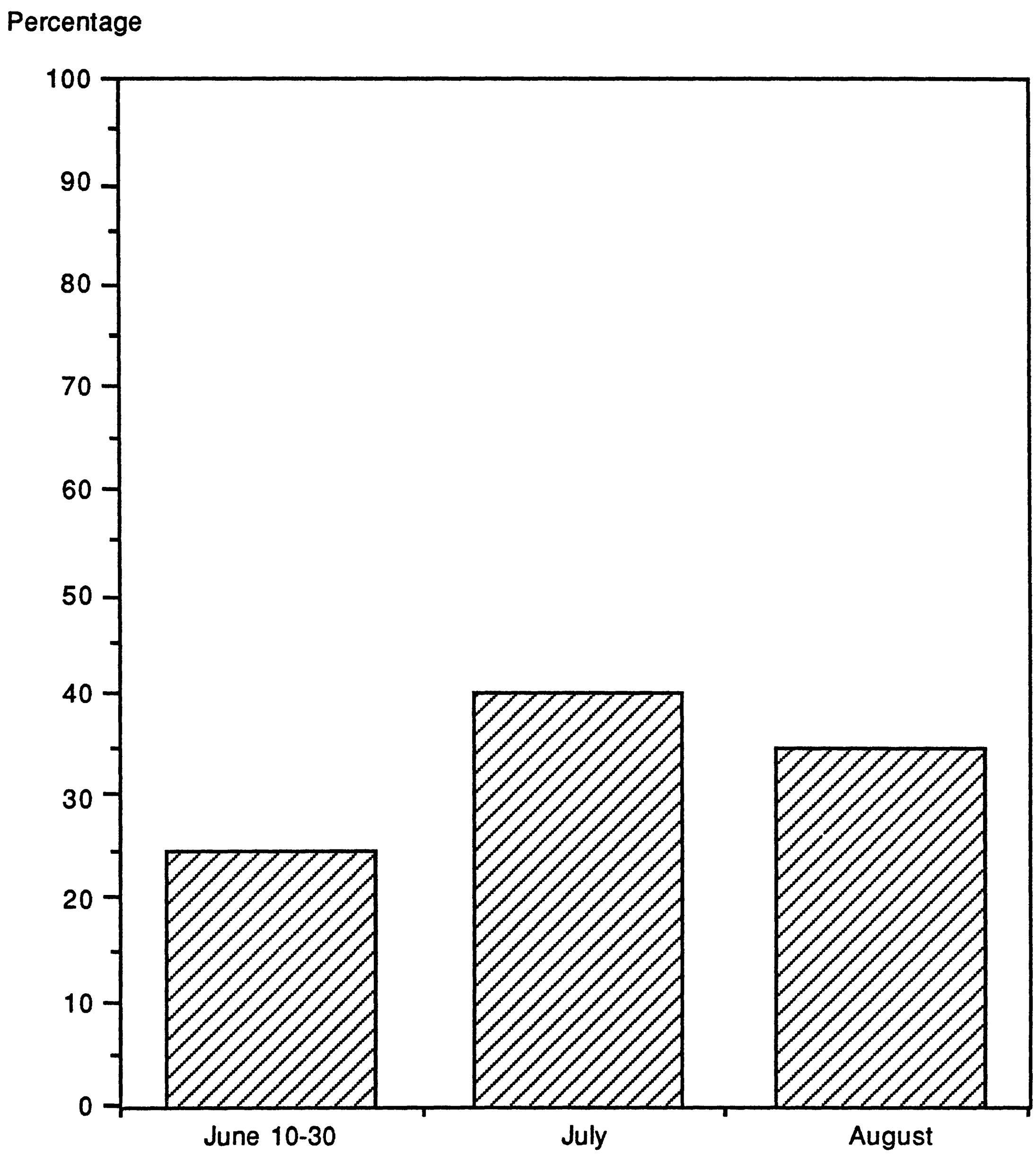


Figure 7. Green Peppers Estimated Marketing Periods

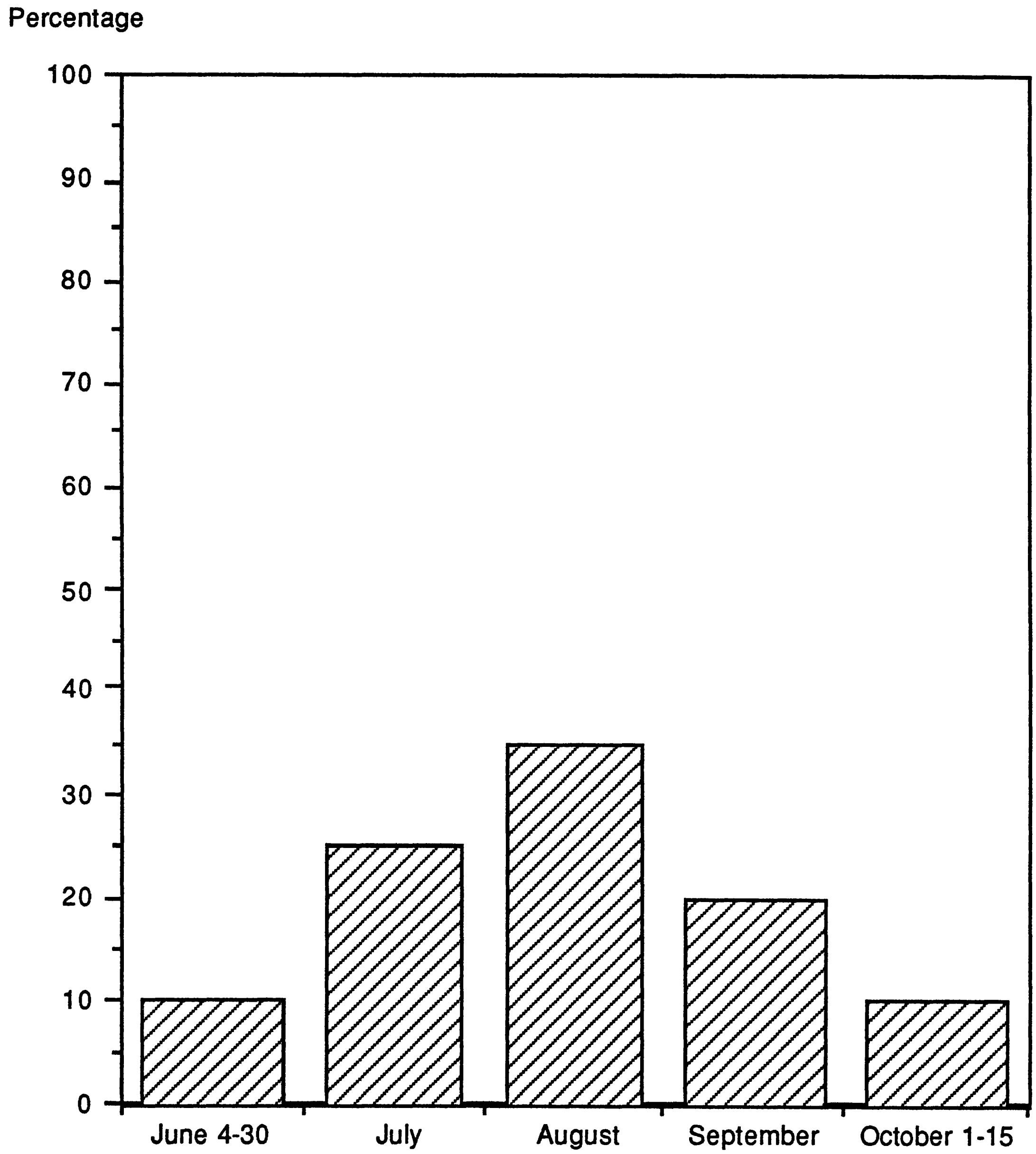


Figure 8. Cucumber Estimated Marketing Periods

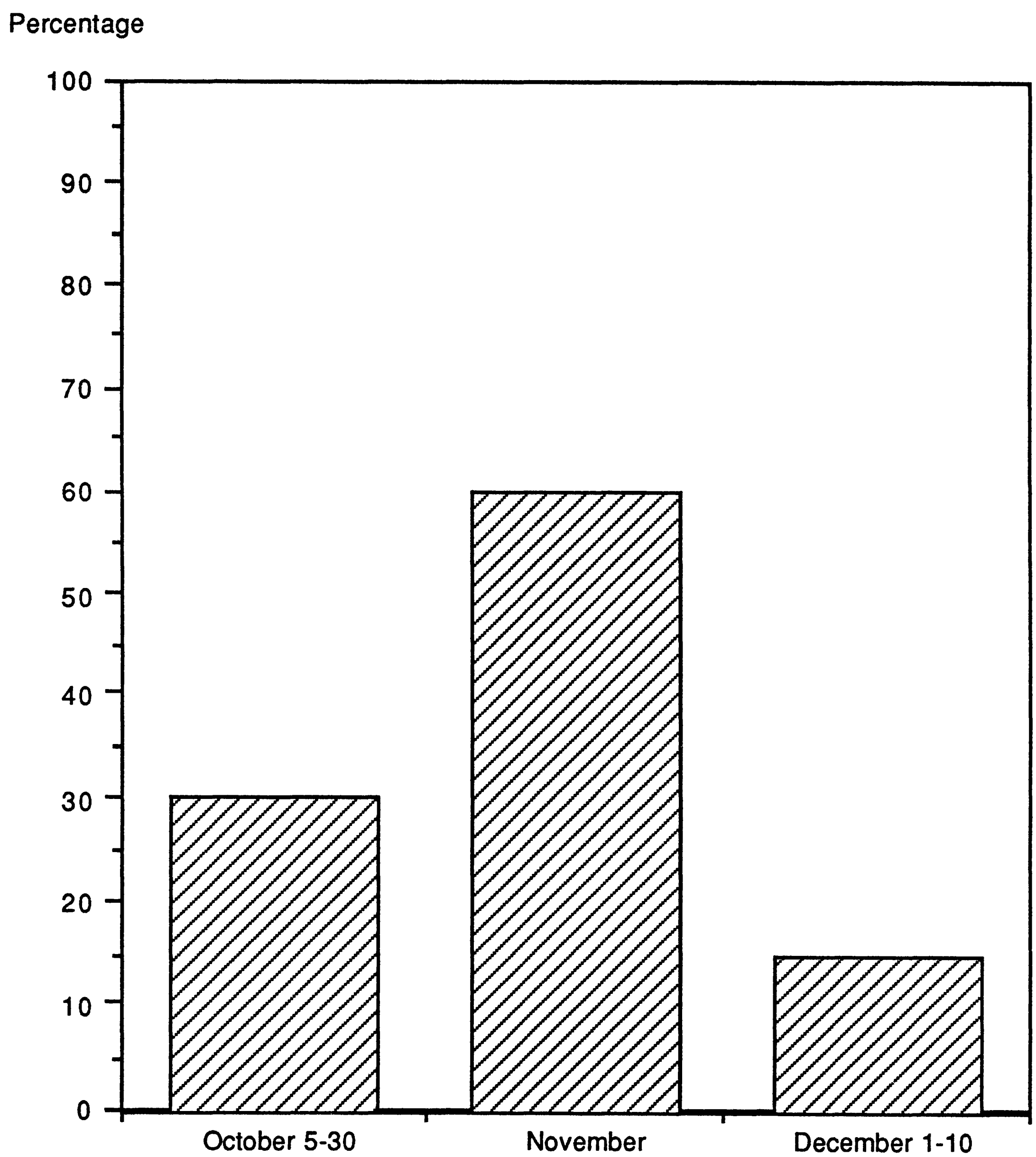


Figure 9. Cabbage Estimated Marketing Periods

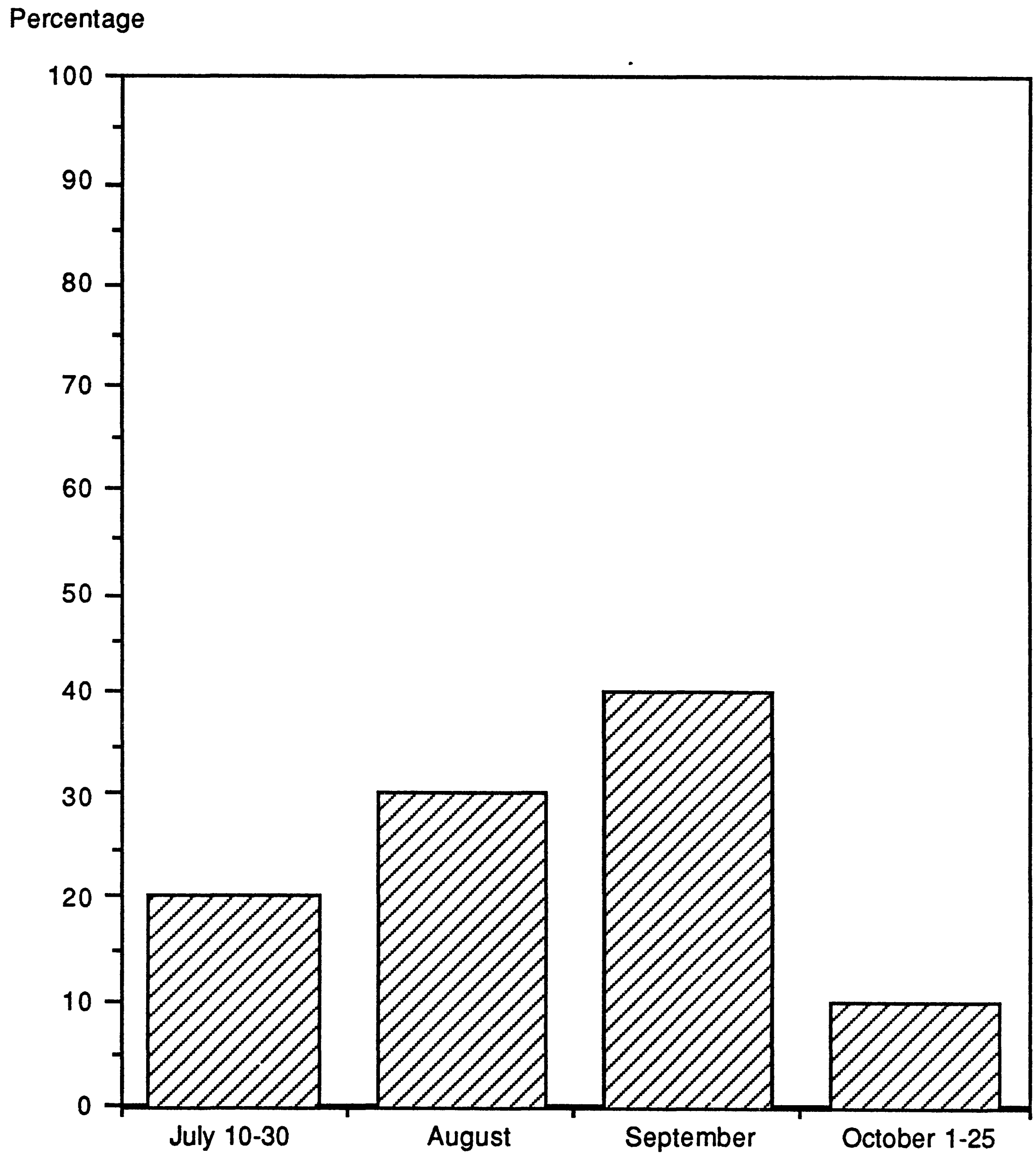


Figure 10. Muskmelon Estimated Marketing Periods

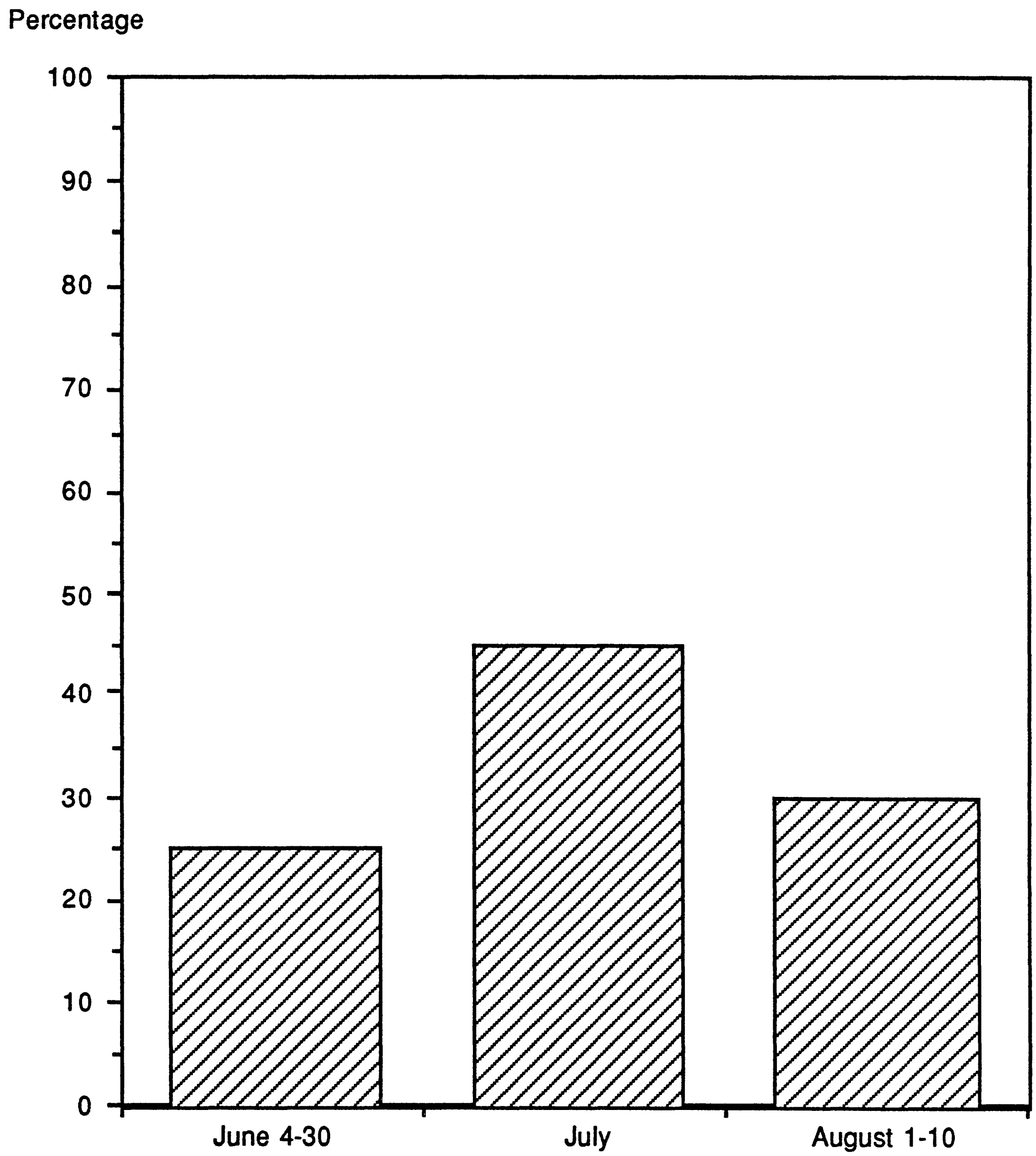


Figure 11. Sweet Corn Estimated Marketing Periods

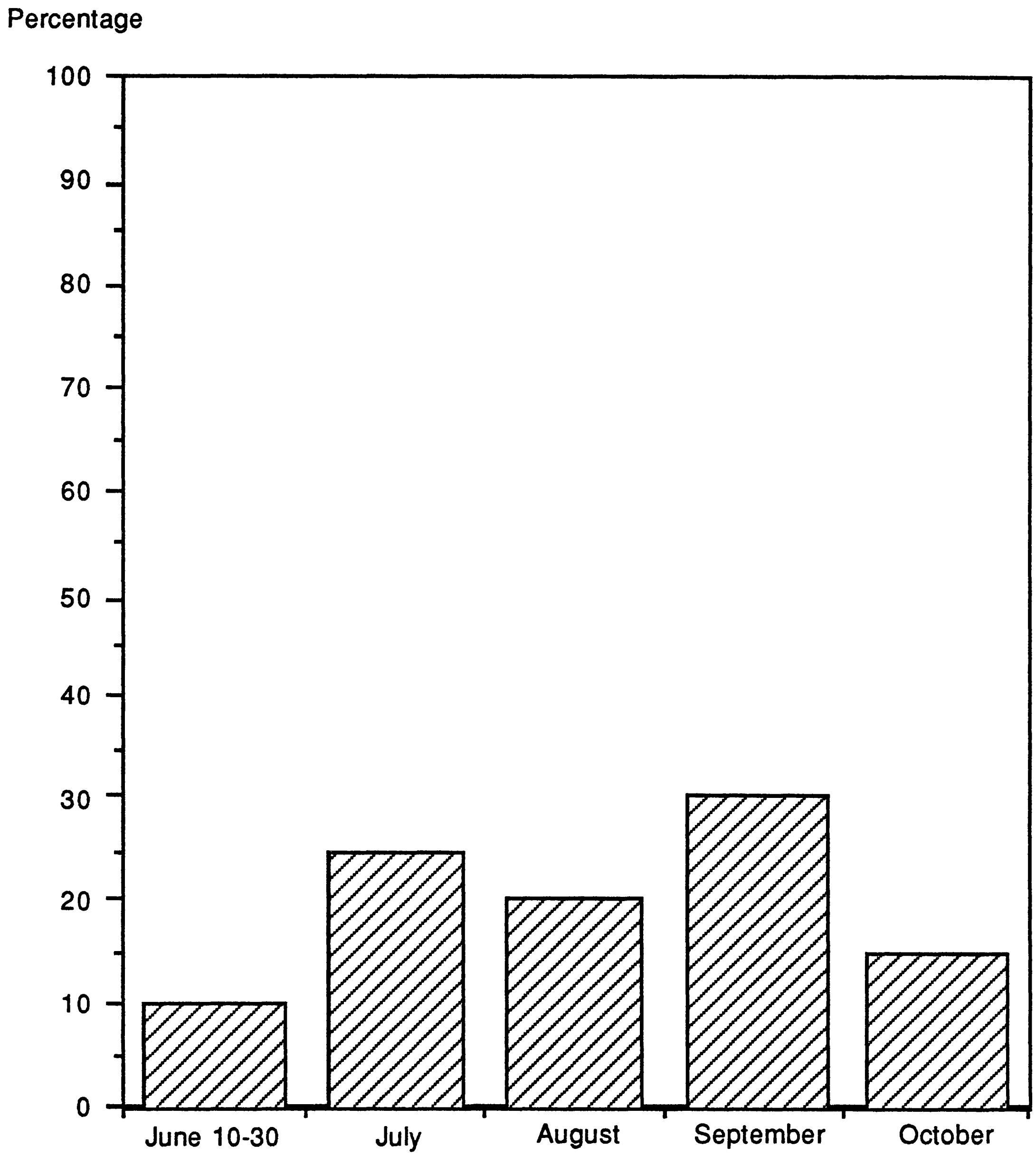


Figure 12. Squash Estimated Marketing Periods

Factor Supply Activities (J_f)

Production factors such as land, labor, machinery, and fertilizer are available for Oklahoma growers, and shortages are not expected to occur as production expands. Thus, the assumption of perfect elasticity of factors supply seem reasonable. Factor demands are determined by crop production activities in the model. Factor costs are denoted by P_f in Table XI and enter the objective function with negative signs.

Two groups of inputs (labor and irrigation activities) are incorporated in the Oklahoma sector model. Irrigation hours in the model correspond to the usage of water in actual irrigation activities. Other inputs usage such as fertilizer, herbicide, pesticide, and machinery services, are included in the cost within the production activity block in the model.

In addition to the above inputs, seeds and transplant costs are included in the production activity block as production costs, and they are specified for each activity unit.

Product Use

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. Within the state demand activities and out-of-state demand activities are generated by linear demand curves, and are incorporated within the activity component of the model.

Demand Activities (E_{ir})

Commodity demand functions constitute an important part of the agricultural sector model. By incorporating demand functions in the model we are able to determine the equilibrium price endogenously through the interaction of the demand and supply. In reality, demand functions are not linear which would make them difficult to incorporate in the objective function. However, Hazell and Norton (1986), proposed a grid linearization technique to segment demand functions and incorporate the result directly into the objective function. Five steps are used to linearize the demand function.

First, obtain the parameter values of the own price elasticity of the demand for each crop (ε_i), the initial price (P_{io}) and the initial quantity (Q_{io}).

Second, calculate the intercept (α_i) and the slope (B_i) of the linearized inverse demand function:

$$P_i = \alpha_i - B_i Q_i \text{ is the inverse demand function} \quad (4\text{-}10)$$

$$B_i = -\frac{dP_i}{dQ_i} \quad (4\text{-}11)$$

$$\varepsilon_i = \frac{dQ_{io}}{dP_{io}} \frac{P_{io}}{Q_{io}} \quad (4\text{-}12)$$

$$\varepsilon_i = -\frac{1}{B_{io}} \frac{P_{io}}{Q_{io}} \quad (4\text{-}13)$$

$$B_i = \frac{P_{io}}{\varepsilon_i Q_{io}} \quad (4\text{-}14)$$

$$\alpha_i = P_{io} + B_i Q_{io} > 0 \quad (4\text{-}15)$$

Third, establish the relevant range of the demand function. To do that lower (P_{io}^L) and Upper (P_{io}^U) prices are determined. Following Hazell and Norton procedure, these two prices are measured by 50 percent and 200 percent of the base price, respectively. The lower (P_{io}^L) and the upper (P_{io}^U) prices are translated to the quantity axis. The calculation is as follows:

Lower Price: $P_{io}{}^{L} = .5\ P_{io}$ (4-16)

Upper Price: $P_{io}{}^{U} = 2\ P_{io}$ (4-17)

Lower Quantity: $Q_i{}^{L} = \frac{\alpha_i - P_i{}^{U}}{B_i}$ (4-18)

Upper Quantity: $Q_i{}^{U} = \frac{\alpha_i - P_i{}^{L}}{B_i}$ (4-19)

Next, choose the number of segments for the demand curve so that the length of segments can be determined. Normally, eleven segments are used for such segmentation (Stoecker and Li, 1988). The segment length is calculated as follows:

$$K_i = \frac{Q_i{}^{U} - Q_i{}^{L}}{n - 1} \qquad (4\text{-}20)$$

Where K denote the segments and n stands for the number of segments. The quantities at each segment of the demand curve can be calculated as follows:

$$Q_{i0} = Q_i{}^{L}$$

$$Q_{i1} = Q_i{}^{L} + K_i$$

$$Q_{i2} = Q_i{}^{L} + 2\ K_i$$

.

.

.

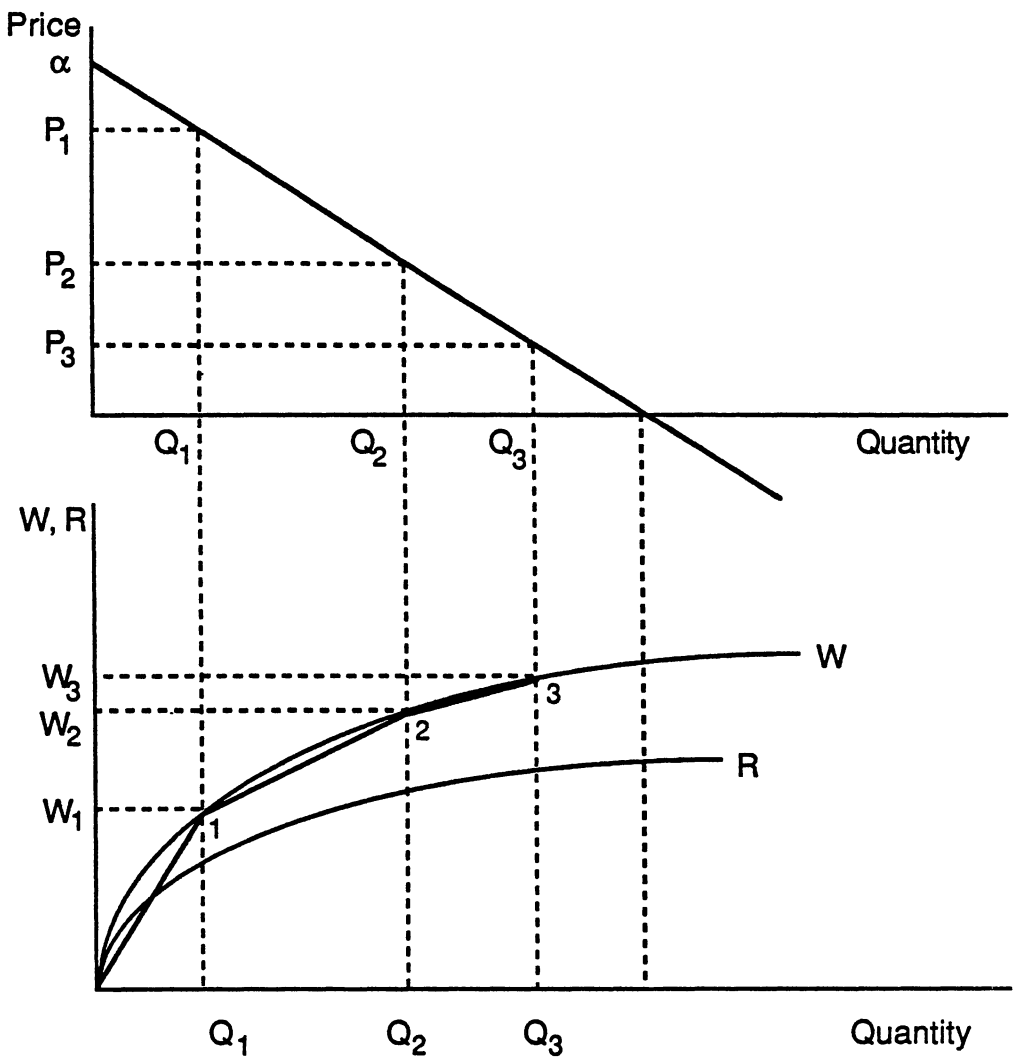
$$Q_{i10} = Q_i{}^{L} + 10\ K_i = Q_i{}^{U} \qquad (4\text{-}21)$$

Finally, the value of (Wi) the area under the demand curve for each point are calculated from the first right side term of equation (3-12)

$$W_{is} = \alpha\ Q_{is} - .5\ B_i\ Q_{is}{}^{2} \qquad (4\text{-}22)$$

where the (s) denotes the segment number.

It is clear that the demand function, the revenue function, and the social welfare function (objective function) are closely related. Figure 13 is drawn to explain the relationship between these three functions. The line (ad) is a linear demand curve and the curve (W) is the social welfare function associated with



Source: Hazell and Norton, 1986

Figure 13. Relationship Between Demand Functions, the Total Revenue Function and the Social Welfare Function

such demand curve. Points 1, 2, and 3 are chosen on W curve. The corresponding values of W_{is}, R_{is} and prices are found on the vertical axis, and the associated quantities are found on the horizontal axis.

An illustrative example of the demand segmentation procedure is provided below for in-state tomatoes demand in the Oklahoma sector model. The same procedure is used for out-of-state demand.

Step 1. $\varepsilon = -.558$

$P_o = 7.9$ (dollar/carton)

$Q_o = 600.85$ (thousand cartons)

Step 2. $B = -\frac{P_{io}}{\varepsilon Q_i} = 0.0235$

$\alpha = P_o + BQ_o = 22.047$

Step 3. $P^L = .5\, P_o = 3.95$

$P^U = 2\, P_o = 15.8$

$Q^L = \frac{\alpha - P^U}{B} = 265.335$

$Q^U = \frac{\alpha - P^L}{B} = 768.607$

Step 4. Establish the length of segments between points on the demand function as follows:

$K = \frac{Q^U - Q^L}{11 - 1} = 50.33$

thus, the quantities at each point are:

$Q_0 = Q^L = 265.335$

$Q_1 = Q^L + K = 315.662$

$Q_2 = Q^L + 2K = 365.989$

.

.

.

$Q_{10} = Q^L + 10K = 768.607$

Step 5. The corresponding points on the objective function are;

	Point 0	Point 1	Point 2	---	Point 10
Q_i	265.335	315,662	365.989	---	768.607
W_i	5021.148	4786.499	6492.212	---	9940.959

Data Description in the Model

At the data organization stage, the main purpose was to construct a data base which will permit various policy simulation scenarios using the model. This stage required several sets of data which were collected from different sources. Data problems were encountered during the early state of model building, and suitable solutions were found in most of the cases.

Since the data sets came from different sources, it was necessary to verify it for possible inconsistencies in quantities which entered the model such as area, yield, and demand. If any inconsistency was found, it was corrected and the model was adjusted to achieve consistency before proceeding to the next stage.

The data collected for this model can be classified into two main groups: micro and macro level data. The micro level production data include cost and returns, and planting and harvesting ranges for various horticultural crops in Oklahoma. The macro level data include crop areas, available resources, prices and demand statistics.

Activity Budgets

Activity budgets constitute a major part of Oklahoma sector model, as they contain requirements for the production of each of the seven horticultural crops.

For instance, each of the activity budgets specifies the various input used, yields and other cost per acre.

Enterprise budgets for most of Oklahoma crops are prepared annually at Oklahoma State University (Motes and Schatzer, 1989). The activity data used in this study are taken from enterprise budgets for small irrigated farms. These types of farms are appropriate for such models because they reflect the common horticulture practice in Oklahoma. The budget data used are presented in Tables XIII to XIX.

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. The wage rate is estimated to be $4.50 per hour, thus the transplant labor value is estimated to be $36 per acre.

Land Use

Oklahoma has an abundance of good agricultural land which is suitable for the production of various horticultural crops. For instance, it is estimated that Oklahoma has approximately 11,050,000 acres which can be used in horticulture (Oklahoma Resource Inventory, 1984). Therefore, land restraints were judged to be nonbinding in the production of horticultural crops in Oklahoma.

Crop areas and yields in Oklahoma were taken from two major sources. First, the OSU Department of Horticulture prepares estimates annually. Second, the vegetables annual summary (USDA, various years) provides estimates of: acreage, yield, production, and/or value. These two sources were used to estimate the fruit and vegetable areas in Oklahoma which are listed in Table XX.

TABLE XX

ESTIMATED CROP AREA, AND YIELD
FOR SELECTED CROPS IN
OKLAHOMA, 1989

Crop	Area (acre)	Yield (units/acre)	Unit
Tomatoes	700	840	25 Lbs. Lugs
Bell Peppers	550	300	30 Lbs. Carton
Snap Beans	4000	12000	30 Lbs. Bus.
Cucumber	600	300	55 Lbs. Carton
Cabbage	600	450	500 Lbs. Carton
Sweet Potatoes	1250	300	50 Lbs. Basket
Cantaloup	2800	370	38 Lbs. Carton
Watermelon	9000	140	Cwt.
Sweet Corn	7200	180	45 Lbs. Crate
Squash	1700	500	20 Lbs. Carton

Source: Motes, Department of Horticulture, Oklahoma State University, 1989.

Resource Use

Quantities and proportions of resources used in the model are influenced by the type of technology in use. Normally, small mechanized farms are the common practice in horticultural production in Oklahoma (Schatzer et al., 1986). This farm type is reflected in the activity budgets. Labor, machinery, fertilizer, and other types of variable inputs are the main resources used in fruit and vegetable production in Oklahoma. These inputs constitute a major component in the data set of the model, and they are specified in Tables XIII to XIX.

Demand Data

Demand data were needed to estimate social welfare functions in the model. These data are incorporated within the sector model in the domestic activity columns. The segmented demand procedure is used to model domestic demand for fresh vegetables. The segmented demand procedures are explained in Hazell and Norton (1986) and Stoecker and Li (1988). This procedure allows direct estimation of the area under the demand curve (social welfare), and the associated quantities consumed for each demand segment.

The parameter values needed for the procedure are: the initial price, the initial quantity, and the own price elasticity for each crop. Initial prices in the model are estimated by using the Dallas terminal market prices and the activity budget prices for 1989. Initial quantities were calculated from data published by USDA (1983).

To calculate the initial in state quantities, the time periods in which Oklahoma produces horticultural crops were used and the quantities demanded in these periods were estimated. Table XII lists the time periods that were used for this estimation, which were taken from the activity budgets. The own price elasticities were taken from two sources. The values and sources for these parameters are reported in Table XXI.

Out-of-State Sales

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 are estimated by subtracting the total quality produced of these crops in Oklahoma from 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.

TABLE XXI

PRICE ELASTICITY OF DEMAND, WHOLESALE PRICE, AND CONSUMPTION FOR SELECTED CROPS IN OKLAHOMA, 1989

Crop	Elasticity	Price Dollar/Units	Consumption* (1000 Unit)	Unit
Tomatoes	- .5584	7.90	600.85	25 Lbs. Lug
Green Peppers	- .111	8.20	94.56	30 Lbs. Carton
Cucumber	- .198	8.35	132.63	55 Lbs. Carton
Cabbage	- .0385	3.85	221.54	50 Lbs. Carton
Cantaloupe	- 1.427	5.40	302.16	38 Lbs. Carton
Sweet Corn	- .89	5.00	165.7	45 Lbs. Crate
Squash	- .32	4.10	153.99	20 Lbs. Carton

Source: Elasticities were obtained from Epperson et al. (1981) and Hung (1985). Prices and consumption levels were obtained from USDA, ERS, "Food Consumption, Prices and Expenditures" (1983).

* Consumption levels calculation for various crops were based upon harvest periods in Oklahoma.

CHAPTER V

COMPARATIVE STATIC ANALYSIS AND EXPANSION POTENTIALS OF SELECTED OKLAHOMA CROPS

Introduction

The purpose of this Chapter is to report the results of simulation experiments conducted with the Oklahoma sector model constructed in the previous chapter.

Several changes in cost and demand will be simulated under various scenarios. These simulated changes are assumed to occur as a result of improvements in the business organizations used by Oklahoma fresh fruit and vegetables growers.

The establishing of cooperative associations can be considered as a major improvement to these business organizations. Forming such cooperatives can lead to a significant reduction in various cost items, and to an expansion in the quantity of demand for Oklahoma fresh fruits and vegetables.

There are several important aspects of farmer's business organizations, where a cooperative can improve upon the organization and increase its efficiency. The establishment of several packing and shipping facilities by such cooperatives can reduce the handling and marketing cost for its member growers. The packing and shipping facilities are expected to provide Oklahoma growers with important marketing related services such as washing, grading, packing, cooling and selling.

Cooperatives could negotiate contract terms for producers, thus enhancing terms of trade for its members. Also, cooperatives can play an educational role by collecting and disseminating information on correct horticultural practice, which may help increase the yield per acre. Cooperatives may supply members with the service of cooperatively owned machines, and provide them with quality seeds and plants, which can cut production and harvesting cost per acre.

These are some important ways where a cooperative can contribute to the improvement in the producer's return and may lead to the expansion of the fresh fruit and vegetable production in Oklahoma.

A comparative static analysis will be used to examine the impact of various simulated changes which are expected to result from the establishment of cooperative associations in Oklahoma.

Base Model

The 1989 base year data are considered as a benchmark for this research. A portion of the initial tableau of the Oklahoma sector model is presented in Table XXII. The rows contain four major elements; the objective function, resource constraints, commodity balances and the convex combination constraints. The columns contain production activities, marketing activities, factor supply activities and the segmented demand activities.

Results of the Base Model

Because the model is not highly constrained in resource use some discrepancies exist between the base model solution and the observed base year data.

TABLE XXII

A PORTION OF THE INITIAL TABLEAU OF THE OKLAHOMA SECTOR MODEL (BASE SOLUTION)

	Production Activities			Marketing Activities			Input Supply Analysis		Demand Activities			
Rows	Tomt	Pepr	Cucm ..	Mxttom	Mktpep	Mktcuc . .	Strig1	Strig 2...	Dtomt1	Dtomt2 ...	Dsqax	RHS
Objective Function							- 006	-.006	5,021.15	5,786	2,459 33	Maximize
Resource Use												<
Land 1												< 10,000
Land 2												< 10,000
⋮												
Irig 1												<0
Irig 2												<0
⋮												
Labr 1												<0
⋮												
Labr 12												<0
Costs												
Vcost	3,652.68	1,849.98	712 7									<0
Fcost	320.56	334.92	218 8									<0
Mktcost	630 00	300	120									<0
Yield												
Yldtom	-840			85								<0
Yldpep		-300			85							<0
⋮												
Commodity Balances												
Tombal				- 001					265 33	315.66		<0
Pepbal					- 001							<0
⋮												
Convexity Constraint												
Convtom									1	1 ···		<1
Convpep												<1
Convcuc												<1
⋮												

Results of the base model solution are presented in Table XXIII. The objective function is maximized at the level of $38,714,690 and reflects the sum of consumer and producer's surplus. Revenue is calculated by multiplying price time quantity that correspond to the equilibrium segment for each crop. In-state and out-of-state quantities are added to calculate revenue which amounted to $20,354,390 for the base year solution.

Activity levels are reported in acres. Cabbage, muskmelons and squash areas are under estimated by the model. However, cucumbers, sweet corn and tomatoes areas are very close to the observed base year area.

Resource use solution reveals that 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 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 process can be used to justify 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. Several statistical measures have been used to evaluate the goodness of fit of sector models. A common measure that has been used by most researchers is the percentage absolute deviation (PAD).

TABLE XXIII

BASE MODEL SOLUTION TO THE
OKLAHOMA SECTOR MODEL

Crop	Acreage	Revenue ($1,000)	Consumer and Producer's Surplus ($1,000)
Tomatoes	735	4,877.46	9,602.74
Green Peppers	433	1,067.64	3,532.82
Cucumbers	500	1,252.50	4,614.21
Cabbage	459	795.22	1,648.25
Muskmelons	2,021	4,037.96	5,750.05
Sweet Corn	5,995	5,395.50	8,050.09
Squash	1,242	2,546.10	4,972.53
Total	11,385	20,354.39	38,714.69

Hazell and Norton (1986) suggested the following rule for evaluating the performance of a sector model: a PAD of 15 percent or more indicates the model may need some correction, a PAD below 10 percent is good, and a PAD of 5 percent would be exceptional.

Validity of the Oklahoma sector model is evaluated using the percentage absolute deviation (PAD). Results of the observed and simulated crop levels are presented in Table XXIV. It is clear that the PAD for the specified test is around 5 percent and reflects a good 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 reaction to a specific change or a combination of changes. The value of the parameters and exogenous variables are charged one at a time, and cause and effect relations in the model are traced out. The base model solution is gradually adjusted to reflect various realistic scenarios.

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

The Oklahoma sector model is used to conduct six alternative static equilibrium simulations. Results of the adjustments to the sector model are traced out through the following scenarios:

1. 15 percent increase in yield,
2. 15 percent decrease in total cost,

TABLE XXIV

VALIDATION OF THE OKLAHOMA SECTOR MODEL
BY CULTIVATED CROP AREA (ACRES)

Crop	Observed Area* (1989)	Simulated Area	Absolute Deviation	Percentage Deviation
Tomatoes	700	735	35	5.0
Green Peppers	467	433	34	7.2
Cucumbers	510	500	10	1.9
Cabbage	510	459	51	10.0
Muskmelons	2,240	2,021	219	9.7
Sweet Corn	6,120	5,995	125	2.0
Squash	1,360	1,242	118	8.6
Value ($1,000)	20,585			
Total	11,907	11,385	592	4.9

* Adjusted to account for the loss between farm gate and retail market.

3. 15 percent decrease in marketing cost,
4. 15 percent saving in labor use,
5. combined effects of increased yield, costs reduction and labor saving.
6. 15 percent increase in demand.

The following discussion focuses on these six scenarios and examines their impact upon the results of the Oklahoma sector model.

Increased Yields

Under this scenario, a 15 percent increase in yield is simulated and the effects of this change are examined. Such simulation is based on the assumption that an improvement in business organizations as a result of forming a cooperative or other farmer's organizations will help Oklahoma growers to increase yield.

Cooperatives are more likely to provide member growers with information regarding the type of crop suitable for each type of soil. Moreover, cooperative associations can collect and disseminate information on various aspects of horticulture practice and the correct timing for planting, irrigation, pest control and harvesting various crops.

Results of this specific scenario are presented in Table XXV and show a significant change compared to the base solution. These results are simulated under the assumption that harvesting costs do not change as yield increase. However, an increase in harvesting costs by the same percentage will have some impact, especially in the case of tomatoes, cucumbers and muskmelon. This change would be due to the relatively high level of harvesting costs for these three crops.

Green peppers, cucumbers and muskmelon showed the highest relative increase in acreage, revenue and surplus. Tomatoes, on the other hand,

TABLE XXV

EFFECTS OF A 15 PERCENT INCREASE IN YIELD ON CULTIVATED AREA, REVENUE, AND SURPLUS

Crop	Acreage	Absolute Change From Base Solution	Percentage Change From Base Solution	Revenue ($1,000)	Consumer and Producer's Surplus ($1,000)
Tomatoes	777	42	5.7	5,156.17	10,151.47
Green Peppers	505	72	16.6	1,242.30	4,111.08
Cucumbers	575	75	15	1,440.37	5,307.04
Cabbage	528	69	15	914.76	1,896.02
Muskmelons	2,212	191	9.4	4,419.58	6,293.48
Sweet Corn	6,337	342	5.7	5,703.30	8,509.32
Squash	1,356	114	9.2	2,779.80	5,428.95
Total	12,290	905	7.9	21,656.28	41,697.36

showed the lowest level of change, relative to the rest of the crops. The overall percentage change in total change of all crops area was 7.9 percent. Revenue increased by 6.4 percent and surplus increased by 7.7 percent compared to the base solution. The sum of surplus showed a relatively higher level of increase than revenue. This result is probably due to the fact that the increase in yield will lower the equilibrium price causing an increase in consumer surplus. Moreover, the lower price implies a relatively lower revenue.

Decrease in Total Costs

Forming a cooperative can result in cost savings for member owners. A cooperative may supply its members with various inputs needed for cultivation, harvesting and marketing. Moreover, a cooperative member can use the cooperatively owned machines. This kind of service can result in a significant cost savings for Oklahoma growers.

Under this scenario, a 15 percent decrease in product cost is simulated. Results of this scenario are presented in Table XXVI. These results show a significant increase in the cultivated area for all crops. The largest increases were in muskmelons and sweet corn. These large increases are the result of the crops' relatively high elasticity of demand. These results suggest that muskmelons and sweet corn may be more suitable for Oklahoma producers than the other crops.

The overall increase in acreage was 11.3 percent. Revenue increased by an average of 8.5 percent and surplus increased by 7.8 percent. Revenue increased relatively higher than total surplus because lower costs are more likely to contribute directly to increasing the revenue.

TABLE XXVI

EFFECTS OF A 15 PERCENT DECREASE IN COSTS ON CULTIVATED AREA, REVENUE, AND SURPLUS

Crop	Acreage	Absolute Change From Base Solution	Percentage Change From Base Solution	Revenue ($1,000)	Consumer and Producer's Surplus ($1,000)
Tomatoes	768	33	4.5	5,096.45	10,040.00
Green Peppers	469	36	8.3	1,153.74	3,818.88
Cucumbers	528	28	5.6	1,322.64	4,867.32
Cabbage	491	32	7.0	850.66	1,760.86
Muskmelons	2,548	527	26.0	5,090.90	7,229.08
Sweet Corn	6,558	563	9.4	5,902.22	8,794.28
Squash	1,305	63	5.1	2,675.25	5,216.74
Total	12,667	1,282	11.3	22,091.86	41,727.16

To test the sensitivity of the model to various hypothetical changes in total costs, a ten and twenty percent change in total costs are simulated. Results of these simulations are presented in Tables XXVII and XXVIII. Tomatoes, cucumbers and squash were less sensitive to variation in total cost. Other crops such as green peppers, cabbage and muskmelons were more sensitive to such variations.

Under the ten percent decrease in total cost, the overall increase in acreage was 6.3 percent with muskmelon and sweet corn showing the biggest increase. Decreasing the total cost by fifteen percent resulted in an overall increase in cultivated area by 11.3 percent. However, as the total cost was further decreased by 20 percent, the overall increase in cultivated area was only 11.7 percent.

The incremental increase in cultivated area was insignificant at .4 percent. This is probably due to the dimishing return to scale in agriculture. As the production expands, more strains are put upon other institutions used by farmers which will limit the expansion potentials. Therefore, by comparing the results of the three simulated changes in costs, it appears that the 15 percent decrease in cost is relatively more effective and should be targed in the future.

Decrease in Marketing Cost

An important objective of any farmer organization is to promote and facilitate the marketing of the organization's products. A collective marketing effort and joint marketing ventures for Oklahoma growers can lead to a significant reduction in marketing cost. Marketing costs were specified in a separate row in the Oklahoma sector model. This specification makes it

TABLE XXVII

EFFECTS OF A 10 PERCENT DECREASE IN COSTS ON CULTIVATED AREA, REVENUE, AND SURPLUS

Crop	Acreage	Absolute Change From Base Solution	Percentage Change From Base Solution	Revenue ($1,000)	Consumer and Producer's Surplus ($1,000)
Tomatoes	756	21	2.8	5,016.81	9,883.12
Green Peppers	447	14	3.2	1,099.62	3,639.74
Cucumbers	514	14	2.8	1,287.57	4,738.25
Cabbage	475	16	3.4	822.93	1,703.48
Muskmelons	2,212	191	9.4	4,419.57	6,275.79
Sweet Corn	6,402	407	6.7	5,761.80	8,585.08
Squash	1,305	63	5.0	2,675.25	5,216.73
Total	12,111	726	6.3	21,083.55	40,042.19

TABLE XXVIII

EFFECTS OF A 20 PERCENT DECREASE IN COSTS ON CULTIVATED AREA, REVENUE, AND SURPLUS

Crop	Acreage	Absolute Change From Base Solution	Percentage Change From Base Solution	Revenue ($1,000)	Consumer and Producer's Surplus ($1,000)
Tomatoes	768	33	4.5	5,096.45	10,040.00
Green Peppers	476	43	9.9	1,170.96	3,875.87
Cucumbers	528	28	5.6	1,322.64	4,867.32
Cabbage	523	64	13.9	9,060.97	1,875.62
Muskmelons	2,548	517	26.5	5,090.90	7,229.08
Sweet Corn	6,558	563	9.4	5,902.22	8,794.28
Squash	1,317	75	6.0	2,699.85	5,264.70
Total	12,718	1,333	11.7	30,343.99	41,946.87

possible to examine the impact of changes in marketing costs upon other variables in the sector model.

To examine the impact a of change in marketing costs, a 15 percent reduction in marketing costs is simulated. Results of this scenario are presented in Table XXIX and show a smaller increase compared to the previous scenarios. The smaller increase under this scenario can be justified by comparing the reduction in cost under the previous two scenarios. Reduction in marketing costs were relatively smaller than the reduction in total production costs.

The overall increase in cultivated area was 4.7 percent with muskmelons showing the largest relative increase. Tomatoes and cucumbers showed the smallest relative increase. The modest increase in tomatoes and cucumbers is because marketing costs for these two crops are relatively smaller than muskmelons. Moreover, the production costs for tomatoes are the highest among these selected crops. Elasticity of demand should be considered as an important factor which influence the outcome of these scenarios. For instance, tomatoes have a relatively low elasticity of demand, while muskmelons have the highest elasticity of demand among these crops.

Changes in revenue and surplus were not significant compared to the other scenarios. The overall increase in revenue was 2.7 percent. The small increase in revenue is because the highest increases in acreage were among muskmelon and corn. Muskmelons and corn are characterized by a relatively lower return compared to other crops.

The overall increase in consumer and producer's surplus was 2.8 percent with muskmelons and green peppers showing the largest relative increase compared to the base year.

TABLE XXIX

EFFECTS OF A 15 PERCENT REDUCTION IN MARKETING COST ON CULTIVATED AREA, REVENUE, AND SURPLUS

Crop	Acreage	Absolute Change From Base Solution	Percentage Change From Base Solution	Revenue ($1,000)	Consumer and Producer's Surplus ($1,000)
Tomatoes	756	21	2.9	5,016.82	9,883.13
Green Peppers	461	28	6.5	1,134.06	3,753.74
Cucumbers	514	14	2.8	1,287.56	4,738.26
Cabbage	475	16	3.5	822.94	1,703.48
Muskmelons	2,202	181	10.6	4,399.60	6,247.43
Sweet Corn	6,235	240	4.0	5,611.50	8,361.14
Squash	1,281	39	3.1	2,626.05	5,120.80
Total	11,924	539	4.7	20,898.54	39,807.98

Saving in Labor Use

Improvement in farmers' operations due to the forming of cooperatives or other forms of business organization may lead to a savings in labor use at various stages of production and marketing. Labor savings can be as a result of the adoption of modern methods in cultivation, harvesting, handling or packing.

To examine the impact of such a change, a 15 percent reduction in labor use is simulated and the results of this simulation are presented in Table XXX. In terms of cultivated area, the largest increase occurred in the production of muskmelons, tomatoes and green peppers. In the case of tomatoes and green peppers, the increase is largely due to the extensive use of labor in these two crops. Also, muskmelons use a relatively higher level of labor than other crops, such as sweet corn or cabbage. Thus, the adoption of labor saving technology in cultivation, harvesting and packing, can result in more saving for the labor intensive crops, such as tomatoes and green peppers.

The overall increase in the cultivated area under this scenario was about three percent. Moreover, this increase in cultivated area was not matched by a proportional increase in revenue and surplus. Revenue increased by only two percent on average, and surplus increased by only 2.4 percent. Tomatoes and green peppers showed higher relative increases of 5.8 and 5.3 percent respectively.

Combining Increase in Yield With Decrease in Costs and Labor Use

The analysis under this scenario is concerned with the potential impact of combining three of the previous scenarios. The set-up for such simulation consists of raising the yield by 15 percent and decreasing the costs and labor

TABLE XXX

EFFECTS OF A 15 PERCENT SAVINGS IN LABOR USE ON CULTIVATED AREA, REVENUE, AND SURPLUS

Crop	Acreage	Absolute Change From Base Solution	Percentage Change From Base Solution	Revenue ($1,000)	Consumer and Producer's Surplus ($1,000)
Tomatoes	778	43	5.9	5,162.81	10,170.73
Green Peppers	461	28	5.6	1,134.06	3,753.74
Cucumbers	514	14	2.8	1,287.57	4,738.26
Cabbage	471	12	2.6	816.00	1,689.13
Muskmelons	2,157	136	6.7	4,309.69	6,119.75
Sweet Corn	6,096	101	1.7	5,485.50	8,173.39
Squash	1,255	13	1.0	2,572.75	5,016.86
Total	11,731	347	3.0	20,768.38	39,661.86

use by 15 percent compared to the base year solution. Harvesting costs are assumed to increase as yield increases. This hypothetical situation can correspond to the maximum expansion that can be achieved given the demand level stays the same.

Results of this scenario are presented in Table XXXI and show a significant increase for all the selected crops. The immediate effect of these changes will be an upward shift in the supply curve for each crop. This means an increase in cultivated area, revenue and consumer and producer's surplus.

The overall increase in the cultivated area was about 18.6 percent with muskmelons and green peppers showing the largest relative increases. The biggest absolute increase was in sweet corn, where the cultivated area increased by 900 acres compared to the base year. The least affected crops were cabbage and tomatoes. The relatively small increase in tomatoes cultivated area is probably due to the high level of variable costs in tomatoes production. Thus, a larger decrease in costs may be needed to induce a significant increase in tomatoes cultivated area.

Another important impact for this scenarios is with respect to revenue and surplus. Revenue increased by an average of 17 percent compared to the base solution. The relatively lower level of increase in revenue is due to the decrease in equilibrium price as the supply curves shift to the right.

The increase in consumer and producer's surplus was relatively larger than the increase in revenue. This increase is the result of higher consumer's surplus because the prices decrease as a result of the expansion in output.

TABLE XXXI

COMBINED EFFECTS OF COSTS DECREASE, YIELD INCREASE, AND LABOR SAVINGS

Crop	Acreage	Absolute Change From Base Solution	Percentage Change From Base Solution	Revenue ($1,000)	Consumer and Producer's Surplus ($1,000)
Tomatoes	846	111	15.1	5,614.06	11,059.69
Green Peppers	539	106	24.5	1,325.94	4,388.86
Cucumbers	591	91	18.2	1,480.45	5,768.07
Cabbage	544	85	18.5	942.48	1,950.93
Muskmelons	2,643	622	30.8	5,280.71	7,598.61
Sweet Corn	6,895	900	15.0	6,205.50	9,346.19
Squash	1,443	201	16.2	2,958.15	5,768.39
Total	13,501	2,116	18.6	23,807.29	45,360.74

Increase in Demand

Under the previous five scenarios, demand was assumed to be constant. However, improvements in business institutions such as the forming of farmer's cooperatives are expected to have an impact on the demand for Oklahoma grown fresh fruits and vegetables. To examine the impact of such possibilities, a 15 percent 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 specific scenario are listed in Table XXXII and as expected show the largest increase in acreage, revenue and surplus. The largest increase was in muskmelons followed by sweet corn. The relatively high elasticity of demand for muskmelons and sweet corn is one of the main factors behind the large increase. For instance, muskmelons followed by sweet corn have the highest elasticity of demand among the selected crops.

Another reason for such a large absolute increase in muskmelons and sweet corn acreage probably has something to do with the relatively large area cultivated by these crops. Moreover, planting and harvesting costs for these crops are relatively lower than other crops, such as tomatoes and green peppers.

Increase in revenue was very significant for all crops, with muskmelons showing the largest relative increase, followed by sweet corn and green peppers.

Surprisingly, the increase in consumer and producer's surplus was relatively lower than the increase in revenue. The shift in demand curves will result in a new equilibrium at a higher price level. This means a higher revenue and producer's surplus. However, the higher prices mean a lower consumer's surplus. This may explain why total surplus increases proportionally less than

TABLE XXXII

EFFECTS OF A 15 PERCENT INCREASE IN DEMAND ON CULTIVATED AREA, REVENUE, AND SURPLUS

Crop	Acreage	Absolute Change From Base Solution	Percentage Change From Base Solution	Revenue ($1,000)	Consumer and Producer's Surplus ($1,000)
Tomatoes	983	248	33.7	6,523.19	12,850.68
Green Peppers	594	161	37.2	1,461.24	4,836.70
Cucumbers	681	181	36.2	1,705.91	6,277.75
Cabbage	713	254	55.3	1,235.27	2,557.01
Muskmelons	4,616	2,404	108.7	9,222.77	13,096.33
Sweet Corn	9,772	3,777	63.0	8,794.86	13,104.25
Squash	1,903	661	53.2	3,901.15	7,667.24
Total	19,697	8,312	73.0	33,914.43	63,872.00

revenue and acreage. The overall increase in surplus was about 65 percent, which is significant.

Analysis of Acreage, Revenue and Surplus

Potential effects on acreage, revenue and consumer and producer's surplus of each of the six scenarios are listed in Tables XXXIII through XXXV. Among these scenarios, change in demand appears to have the most significant impact upon acreage, revenue and total surplus. For instance, a 15 percent increase in demand led to a total increase of 8,000 acres in cultivated area. This amounts to over a 70 percent increase from the base year solution.

Revenue and total surplus showed a significant increase under scenario six, too. Revenue increased by a relatively higher level than surplus, because of the increase in equilibrium prices as demand shifted.

Scenario five, which combines the effects of changes in costs, yields and labor use, showed significant results, too. However, the overall combined effect under this scenario is far less than scenario six. For instance, the overall increase in acreage under scenario five was over 2,000 acres, which is about a 17 percent increase from the base year solution.

Change in marketing costs, which is simulated under scenario three appears to have a moderate effect. A 15 percent reduction in marketing costs led to an overall increase of 539 acres, which amounted to about 5 percent increase in cultivated area. Increases in revenue and total surplus are modest under scenario three compared to scenarios six and five.

The above analysis shows that changes in the demand side are more effective in influencing other variables in the sector model. Also, the supply side of the sector model responds fairly well to changes in the demand side. Based on these results, one can say that more emphasis should be placed upon the demand side of the fresh fruit and vegetable industry in Oklahoma.

TABLE XXXIII

EXPANSION POTENTIAL FOR SELECTED HORTICULTURAL CROPS IN OKLAHOMA (ACRES)

Crop	Observed Area (1989)	Base Solution	Potential Expansion Under Various Scenarios (1)	(2)	(3)	(4)	(5)	(6)
Tomatoes	700	735	777	768	756	778	846	983
Green Peppers	467	433	505	469	461	461	539	594
Cucumbers	510	500	575	528	514	514	591	681
Cabbage	510	459	528	491	475	571	544	713
Muskmelons	2,240	2,021	2,212	2,548	2,202	2,157	2,643	4,616
Sweet Corn	6,120	5,995	6,337	6,558	6,235	6,095	6,895	9,772
Squash	1,360	1,242	1,356	1,305	1,281	1,255	1,443	1,903
Total	11,907	11,385	12,290	12,667	11,924	11,731	13,501	19,697

TABLE XXXIV

PERCENTAGE CHANGES IN PRODUCER REVENUE
UNDER VARIOUS SCENARIOS

	Potential Changes From Base Year Solution Scenarios					
Crop	(1)	(2)	(3)	(4)	(5)	(6)
Tomatoes	5.7	4.5	2.8	5.8	15	33.8
Green Peppers	16.6	8	6.3	6.2	24.2	37
Cucumbers	15	5.6	2.8	2.8	18.2	36.2
Cabbage	15	6.9	3.4	2.6	18.5	55.3
Muskmelons	9.4	26	9	6.7	30.8	128.4
Sweet Corn	5.7	9.4	4	1.7	15	63
Squash	9.2	5	3.1	1.2	16.2	61.1
Overall Change	6.4	8.5	2.7	2.0	17.0	66.6

TABLE XXXV

PERCENTAGE CHANGE IN CONSUMER AND PRODUCER'S SURPLUS

	Potential Changes From Base Year Solution Scenarios					
Crop	(1)	(2)	(3)	(4)	(5)	(6)
Tomatoes	5.7	4.6	2.9	5.9	15.2	33.8
Green Peppers	16.4	8.1	6.2	6.3	24.2	36.9
Cucumbers	15.0	5.5	8.7	2.7	25.0	36.0
Cabbage	15.0	6.8	3.3	2.5	18.3	55.1
Muskmelons	9.4	25.7	8.6	6.4	32.1	127.0
Sweet Corn	5.7	9.2	3.9	1.5	16.1	62.0
Squash	9.2	4.9	3.0	1.0	16.0	53.0
Overall Change	7.7	7.8	2.8	2.5	17.2	65.0

CHAPTER VI

SUMMARY AND CONCLUSIONS

Summary of Analysis

The purpose of this study was to investigate the economic potential of expanding the production of selected fresh vegetables in Oklahoma. To achieve this objective and provide a suitable quantitative framework for this study, a sector programming model for Oklahoma was developed.

The Oklahoma sector model developed in this study follows closely the procedure of Hazell and Norton (1986). However, the structure of the Oklahoma sector model and the data used reflect the production and demand pattern in Oklahoma.

The basic structure of the Oklahoma sector model includes an objective function, production activities, commodity balances, and demand activities. The demand side of the model includes two submodels to reflect the difference between local and out-of-state demand. To incorporate demand in the model, extensive use is made of the demand segmentation procedure. Moreover, the production side of the model includes seven sections representing the selected crop to be studied.

The model was subjected to a detailed validation procedure. The validation results supported the model use for impact analysis. The model provides a framework for tracing the direct and indirect effects of various simulated changes. The validation process resulted in a model which reflects the performance of a segment of the fresh vegetable industry in Oklahoma in 1989. As shown in Table XXV, the results of the base model solution replicate the base year data closely.

To examine the economic potential of expanding the production of selected fresh vegetables in Oklahoma, simulated changes in yield, cost, and demand were analyzed. These changes are assumed to occur as a result of improvement in various business institutions used by Oklahoma producers. These improvements in the vegetable industry could be achieved through cooperative associations or other changes in the vegetable marketing channel.

To examine the impact of changes in the vegetable marketing channel on the fresh vegetable industry in Oklahoma, six different scenarios reflecting changes in economic variables were simulated. The following scenarios were conducted:

Scenario 1: The impact of a fifteen percent increase in yield.

Scenario 2: The impact of a fifteen percent decrease in total costs.

Scenario 3: The impact of a fifteen percent decrease in marketing cost.

Scenario 4: The impact of a fifteen percent decrease in labor use.

Scenario 5: Combined effects of increased yield, cost reduction and decreases in labor use.

Scenario 6: The impact of a fifteen percent increase in demand.

Increasing yield by 15 percent resulted in a significant change in acreage, revenue and surplus for all crops. However, green peppers, cucumber and muskmelon showed the highest relative increase in acreage, revenue and surplus. The overall increase in cultivated area was 7.9 percent. The total increase in the acreage was about 900. The sum of the consumer and producer's surplus increased by 7.7 percent. The overall increase in revenue was at a lower level and amounted to 6.4 percent. The total increase in revenue and surplus were: $1.3 and $3.0 million, respectively.

The impact of reducing cost by 15 percent was more significant than the previous one. Under Scenario 2, the overall increase in acreage was 11.3 percent, or 1,182 acres. Revenue increased by 8.5 percent ($1.7 million) and total surplus increase by 7.5 percent ($3.0 million). The most significant increases, in terms of acreage, were in muskmelon and sweet corn. These increases can be justified by the relatively higher elasticity of demand for the two crops.

The third scenario, which examines the impact of a simulated reduction in marketing margin, showed a smaller increase compared to the previous scenarios. The smaller increase ocurred because the absolute decrease in marketing cost was lower than the absolute decrease in production cost. The overall increase in cultivated area was 4.7 percent with muskmelon showing the largest relative increase in acreage. The modest increase in tomatoes and cucumber acreage, under this scenario, is due to the fact that marketing margins for these two crops are relatively small. Moreover, the production cost for tomatoes are the highest among the selected crops. Increases in revenue and surplus were not large under this scenario. For instance, the overall increase in revenue was $2.7 million and surplus was 2.8 million. The modest increase in revenue can be explained by the fact that the highest increases in acreage were among crops with low return, muskmelon and sweet corn.

Introducing new advanced method in cultivation could lead to a significant decrease in labor use. This hypothesis was examined under Scenario 4, where a 15 percent reduction in labor use was simulated. Under this scenario, the largest relative increases in cultivated area occurred in muskmelon, tomatoes and green peppers. The extensive use of labor in these three crops is one of the main reasons behind such a large increase. Therefore, the adoption of labor saving technology in planting, harvesting and packing, can result in more savings for the labor intensive crops, such as tomatoes. The overall increase in cultivated area, under this scenario, was around three percent. However, revenue increases by two percent and surplus by 2.4 percent.

Combining Scenario 1, 2 and 4 resulted in a significant increase in all crops. The overall increase in cultivated area was about 18.6 percent with muskmelon and green peppers showing the largest relative increase. Sweet corn showed the biggest absolute change where the cultivated area increased by 900 acres, compared to the base solution. Revenue increased by an average of 17 percent, compared to the based solution, which is less than the increase in acreage. This smaller relative increase is due to the decrease in equilibrium price as the supply curves shift to the right. Consumer and producer's surplus went up relatively higher than revenue. This relationship also can be explained by the lower prices as a result of shift in supply curve to the right.

The largest increase in acreage, revenue and surplus occurred under Scenario 6, where a 15 percent increase in demand is simulated. All selected crops show a very significant increase in cultivated area, revenue, and surplus. The total increase in the cultivated area was over 8,000 acres. The overall increase in cultivated area was around 75 percent. Muskmelon and sweet corn showed the largest relative increases in acreage. Compared to other crops, muskmelon and sweet corn have the highest elasticity of demand, which may explain the large increase in their acreage.

Increase in revenue was very significant for all crops, and the overall increase in revenue was about 66 percent. Increase in the consumer and producer's surplus was about 65 percent, which is relatively lower than the increase in acreage. This relationship is mainly due to the increase in price as demand shifts to the right resulting in a lower surplus and a higher revenue. The total increase in consumer and producer's surplus is estimated to be about $25.2 million.

Conclusions

Oklahoma fresh fruit and vegetable growers do face a challenge. The challenge is to find better ways to compete in the fresh fruit and vegetable market and expand their production. To examine Oklahoma potential, several scenarios were considered. Results obtained from these scenarios clearly indicate a strong potential for expansion in certain fresh vegetables.

Among the six scenarios examined in this study, change in demand appears to have the most significant impact upon cultivated area, revenue and welfare. For instance, a fifteen percent increase in demand facing Oklahoma producers led to a total increase of over 8,000 acres in cultivated area. Moreover, revenue and welfare show a significant increase under Scenario 6, where revenue increase by $13.6 million and welfare increased by $25.2 million.

Changes in various cost items appear to have a modest effect when compared to a change in demand. For instance, a fifteen percent decrease in marketing cost resulted in an overall increase of 539 acres, which amounted to about five percent increase compared to base year solution. Therefore, large changes in cost parameters are necessary to have a significant increase in the fresh fruits and vegetables area cultivated in Oklahoma.

Results of the comparative static analysis clearly indicate that changes in the demand side are more effective in influencing other variables in the

Oklahoma sector model. Furthermore, the supply side responds fairly well to changes in the demand side. Therefore, more emphasis should be placed upon the demand side of the fresh fruits and vegetable industry in Oklahoma. Improvement in various business organization used by Oklahoma growers should be part of any successful policy aimed at expanding the fresh fruit and vegetable industry in Oklahoma.

Both cooperative and non-cooperative forms of organization can be used by Oklahoma growers to attain such improvement. However, cooperative associations may have several advantages, such as the low cost per unit of service and the ability to reduce the required rate of return on equity. Therefore, the establishing of cooperatives could be an important part of any policy aimed at improving various business institutions used by Oklahoma producers.

Policy Implications

The current state of the fresh fruit and vegetable production imply certain policy implications which should be taken into consideration by policy makers. First, on the production side many Oklahoma growers have little knowledge or expertise in the production of commercial fresh fruits and vegetables. Educational institutions, especially the Agricultural Experiment Station and the Agricultural Extension Division, have an important role in studying and evaluating alternative projects which will help new producers to undertake those enterprises with the highest probability for success. This can facilitate and promote expansion in the fresh fruit and vegetable production in Oklahoma.

On the input side, most inputs used by Oklahoma producers must be obtained from organizations outside of Oklahoma. Furthermore, few current producers have the facilities and machinery which are necessary for grading, precooling and packing the produce for the commercial wholesale market. Without such facilities, opportunities for expansion are limited. The relatively higher degrees of risk associated with establishing such facilities make it difficult to obtain financing for new enterprises. Therefore, the state government should consider subsidizing new commercial facilities for grading and packing in their initial years of operations. Moreover, the establishment of producers' cooperative should be encouraged as a method of promoting expansion and also to spread the fixed costs associated with grading, precooling, and packing fresh fruits and vegetables.

Second, on the consumption side, results of the analysis clearly indicate the importance of the demand side, therefore more emphasis should be placed upon the promotion of the locally grown fresh fruits and vegetable in Oklahoma. A large number of consumers are unaware of the many varieties of fresh fruits and vegetables that are grown in Oklahoma. The establishing of more farmer's markets in various parts of the state should be promoted by local authorities. Moreover, advertising for locally grown produce should be expanded in order to inform consumers and help expand the market for Oklahoma grown fresh fruits and vegetables.

Limitations of the Study

The main limitations to this study involve simplifying assumptions and data availability. Data were gathered from different sources. Reconciliation of differences in data to arrive at a consistent estimate requires some value judgement. Enterprise budgets prepared at Oklahoma State University were the major source of data for costs, yield and return. Moreover, Dallas terminal market prices were used in the Oklahoma sector model. However, Oklahoma growers might sell at different prices than the Dallas market prices.

Assumptions in the Oklahoma sector model are numerous. Thus, results and conclusions are based upon these assumptions. The following are the main assumptions and their implications:

1. Constraints for land and other resources are assumed to be unbinding. This assumption reflects the current condition in Oklahoma where land and other resources are available as needed. However, a constrained maximization might give a more accurate solution.
2. Demand elasticity parameters for Oklahoma were assumed to be the same as the U.S. parameters. However, in reality, Oklahoma parameters may be slightly different.
3. It was assumed that the hypothetical cooperative would result in several changes in the sector model. Most of these changes affect yield, cost and demand for the Oklahoma sector model. No attempt was made to verify these assumptions and estimate the magnitude of these changes.
4. Only seven selected fresh vegetables were examined, and the cross price and income elasticities were assumed to be zero. The inclusion of more crops would probably change the results, especially with respect to the cultivated area.

Nevertheless, the Oklahoma sector model, in its present form, can be used to simulate the impact of various changes on acreage, revenue and welfare.

Improvements for Further Research

The results of the Oklahoma sector model were useful in simulating the impact of various hypothetical changes in yield, costs and demand. However, to support and strengthen the results of this study, further research is needed. The following are some of the areas which should be addressed through further research.

1. Oklahoma sector model can be modified to incorporate risk parameters. To do that, the model in its present form needs some modifications. The major difficulty for such modification would be the availability of data on Oklahoma fresh fruit and vegetable industry.
2. Another important improvement is to estimate the cost savings resulting from the cooperative association and include them in the model. This can result in a more accurate estimate of the Oklahoma potential for expansion.
3. Disaggregating the State into multiple regions should be investigated. This disaggregation can be used to determine comparative advantage of each region to produce certain crops. Thus, each region can concentrate on specific crops.
4. The Oklahoma sector model can be expanded to include other traditional crops, such as wheat and cotton. Under such an expanded model, tradeoff between various crops could be considered and resource constraints are more likely to be binding.
5. The model is a partial equilibrium model and can be transformed into a general equilibrium model for the Oklahoma economy emphasizing resource flows between various sectors. Such a model could account for linkages between the agricultural sector and other sectors, such as food processing and various services.
6. Finally, institutional constraints, such as laws and regulations, should be investigated to determine its impact upon the fresh fruit and vegetable industry in Oklahoma.

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