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IN MICHIGAN WITH PROJECTIONS TO 1990.

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SUPPLY AND DEMAND ANALYSIS FOR TART CHERRIES IN MICHIGAN WITH PROJECTIONS TO 1990

By

Ming-Wu Wu

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ABSTRACT

SUPPLY AND DEMAND ANALYSIS FOR TART CHERRIES
IN MICHIGAN WITH PROJECTIONS TO 1990

By

Ming-Wu Wu

This dissertation develops econometric models of the tart cherry industry in Michigan. The main objectives are: (1) to investigate present and past trends of the Michigan tart cherry industry with particular emphasis on the institutional framework used to counteract the unstable market conditions, (2) to theoretically formulate and statistically estimate the supply response model of tart cherries to profit and non-profit incentives, (3) to construct a demand model for tart cherries at the grower level, and (4) to predict future trends in tart cherry supply and demand.

The process involves the construction of acreage response models, demand models and projection of the exogenous variables contained in the models. The empirical results were evaluated and comparison made between selected models, and relationships analyzed between market variables in the industry, with specific emphasis upon identifying

the separable effects of the independent variables. Projections of future supply and demand for tart cherries in Michigan were made to 1990.

The analytical procedures and tools applied to develop the econometric models have been carefully chosen and stem from economic theory and characteristics of the industry. The selected models for empirical analysis included the geometric distributed lag models and the polynomial lag models. The models were estimated by using the Ordinary Least Squares method. The Cochrane-Orcutt iterative technique was used in instances where serial correlation errors were present.

The variables used to estimate the supply response model were adjusted by applying six-year moving averages to eliminate the drastic cyclical fluctuations due to the weather. This will also reflect the impact of the time span required for the growers to make decision covering planting and removal since tart cherry production involves a long term investment. In view of the six year span needed for the trees to bear fruit, the independent variables in the model were then lagged six years.

In constructing supply and demand models for tart cherries, a series of regression equations were formulated. Statistical tests and evaluations of each estimated equation are conducted to measure the performance of the model, especially in coping with the statistical problems induced by the application of a distributed lag formulation.

The constructed demand model was incorporated into the supply model together with two identity equations to facilitate future predictions. Before making the prediction, equations which resemble the future trends of each of the exogenous variables were estimated.

Four alternative projections for future tart cherry acreages and price levels were made depending upon selected combinations of conditions. The predicted market outlook for Michigan tart cherries indicates that a gradual expansion in tart cherry bearing acreage up to a total of around 44,600 acres can be anticipated by 1990. This increase, of nearly 20 percent over the current acreage level would mean an increase of 35 percent in the total production as indicated by the empirical analysis.

The acreage adjustment, in response to changes in profitability is projected to be a continuous process. Attention must be given to the required capital, processing and storage capacity and other associated resources vital to achieve this successful adjustment.

The study revealed that any policy towards an improvement in a yield higher than the projected rate of increase would require careful forethought in order to avoid a drastic upward shift in supply. Thus it would prevent a drastic drop in grower price and income, unless the industry seeks to stimulate the consumption of tart cherries and to develop overseas markets for cherries.

The theoretical and the empirical analysis contained in this dissertation may be used as an important guideline towards successful production and marketing plans concering the more distant future.

ACKNOWLEDGMENTS

I wish to express my appreciation to those persons who have contributed to my education and to this thesis. I am immeasurably indebted to the Chairman of my Guidance Committee, Dr. Warren Vincent, for his judicious advice and Counsel in this and many other facets of my graduate program.

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CHAPTER I

INTRODUCTION

The total production of tart cherries in the United States was valued at about 36.2 million dollars in 1976, and 25.4 million dollars in 1975. Michigan is by far the leading tart cherry producing state, representing over two thirds of all tart cherries grown in the United States, followed by New York with about 10 percent and Wisconsin with 4 percent. From regional distribution, the Great Lakes states (Michigan, New York, Wisconsin, Pennsylvania and Ohio) accounted for over 90 percent of the nation's production and the Western States (Colorado, Utah, Oregon, Washington, Idaho and Montana) accounted for the remaining 10 percent.[1]

Tart cherries are grown in strips of favorable climate, soil and topography. They do not tolerate excessively low temperatures or high humididty during the growing season. In Michigan, tart cherries are grown in the western counties of the lower penninsula along Lake Michigan.

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[1]USDA, "Fruit - Noncitrus: Production, Use and Value," Statistical Reporting Service (various issues).

Need of the Study

Tart cherry production in Michigan and the United States is characterized by rather large year to year variations. These variations are very drastic as compared to those of apples, peaches or other fruit crops. In the 39 year period from 1938 to 1976, there were 7 years in which the national crop was either less than one-half as large or more than twice as large as the preceding year. There were only 12 years in which the crop varied between 80 percent and 125 percent of the preceding year.[2] The greatest single factor causing variation of production is weather conditions.[3] A widely fluctuating supply of cherries causes the price to fluctuate in the opposite direction, i.e., higher production, lower prices and vice versa. Such fluctuation also severely hampers the development of a stable market as well as expansion of the long term demand for tart cherries.[4]

Little can be done in the short-run to improve the situation of the annual variability of the size of tart

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[2] USDA, op. cit. (various issues).

[3] Marshall, Roy E. Cherries and Cherry Products, Interscience Publishers, Inc., New York, 1954, p. 60.

[4] Ricks, Donald J., "Fluctuating Cherry Supplies and Some Alternative Remedial Actions," Department of Agricultural Economics, Report No. 144, Michigan State University, June 1969.

cherry crop due to the dominant impact of weather. However, reliable long term projections of supply response and demand upon uncertain market situations has assumed increasing importance in recent years in decision making. This allows growers and processors to adjust or change for planning production and marketing to meet the expected situations in years to come.

Knowledge of tart cherry supply and demand is necessary for a better understanding of the economic problems in order to formulate and implement effective marketing and production policies, A greater knowledge of supply response can also help extension specialists provide improved information to aid the farmer's decision.

Therefore, it is of great importance to growers, processors and users of tart cherries to have good information on the prospective position of the industry. This study will be focused on an analysis of factors affecting the tart cherry industry's position in respect to long term demand and supply.

Objective of the Study

The main objective of this study is to quantitatively investigate the relationships among market variables in the tart cherry industry. Specific objectives are:

(1) to describe the present and past trends of the Michigan tart cherry industry with particular emphasis on the institutional framework used to counteract the unstable market conditions,

(2) to theoretically formulate and statistically estimate the supply response model of tart cherries to profit and non-profit incentives,

(3) to construct a demand model for tart cherries at the grower level,

(4) to predict future trends in tart cherry supply and demand.

Outline of the Study

Chapter II provides a basis from which to view the overall industry situation as well as a descriptive analysis of the current institutional measures used in counteracting the unstable tart cherry market conditions. Chapter III discusses a theoretical framework consisting of the selected econometric models as a basic tool for the analysis of supply response, and the empirical results of the analysis are presented in Chapter IV. Comparisons of the results estimated from alternative models are discussed in detail along with an interpretation of the quantified economic relationships among variables in an attempt to provide a better understanding of their forces affecting future tart cherry demand and supply.

Chapter V deals with the procedures utilized in formulating the demand model for tart cherries. The empirical results are also carefully evaluated. Chapter VI is a study of the exogenous variables. The historical trend of each variable is examined, and projections are made based on the historical indications as well as future prospectives. For variables with a large extent of future flexibilities, alternative functional relationships are constructed to facilitate future predictions of tart cherry demand and supply.

Chapter VII presents projections of the tart cherry prices, acreage and production levels for 1990. Several alternative projections are made to delineate the upper and lower boundaries. An assumed higher rate of growth in tart cherry yield is also incorporated in the projection analysis so as to evaluate consequences of this possibility. Chapter VIII, the last chapter, presents the summary and conclusions.

CHAPTER II

TART CHERRY PRODUCTION IN THE UNITED STATES

INTRODUCTION

According to the Agricultural Census, cherry production in the United States started in the late 1800's. Historical data for cherry production, particularly on number of trees and acreage information are not as complete as would be desired. Prior to 1938 the census did not distinguish between tart cherries and sweet cherries.

Tart cherry growing is a very specialized business and production is concentrated in a few favorable areas determined by special climatic and topographic features. Cherries are sensitve to weather conditions. The spring temperature should remain cool to retard fruit bud development in order to minimize danger of damage due to spring freezes. During the pollination-fertilization period of bloom, temperatures should exceed 8 °C in daytime for bee activity and should not drop below -2°C to -1°C for any period of time to previent freeze damage. The desirable site would be one with fairly uniform slope and well-drained water and air flowage ways.[5]

The trends of tree population in Michigan as well as in all other states are shown in Table 2.1. The number of tart cherry trees increased rapidly in the early 1940's. Information on annual new plantings has never been estimated. The total number of trees in the United States increased from 4.9 million trees in 1940 to a record of 7.4 million trees in 1959, with a decline to 5.7 million trees in 1969.

In Michigan, the total number of trees increased from 2.3 million trees in 1940 to a peak with 4.2 million trees in 1964, then they declined to about 3.7 million trees in 1974. The ratio of bearing trees as percent of all trees increased steadily since the 1950's. The ratio was about 86 percent in 1969 and currently it is about 80 percent, reflecting a higher new plantings in recent years.

The number of tart cherry growers in the United States declined from the record high of 158 thousand growers in 1940 to 5,401 growers in 1969. In Michigan, the number of growers declined rapidly from about 29 thousand growers in 1940 to around 1,900 in 1974. However, the size of operation per farm has increased from less than one acre in

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[5]USDA, "Red Tart Cherry Site Inventory for Grand Traverse County, Michigan," Soil Conservation Service, 1971, p. 2.

Table 2.1, Number of Bearing and Non-bearing Tart Cherry Trees in the United States and Michigan, 1938-74

Census Year	United States			Michigan		
	Non-bearing	Bearing	Total	Non-bearing	Bearing	Total
			1,000 trees			
1940	a	a	4,874	290	1,977	2,267
1945	NA	NA	NA	NA	NA	NA
1950	1,690	3,977	5,667	907	2,176	3,083
1954	1,802	5,108	6,910	1,177	2,570	3,743
1959	1,428	5,951	7,379	723	3,357	4,130
1964	1,086	5,644	6,730	700	3,748	4,178
1969	857	4,812	5,669	550	3,249	3,799
1974	a	a	a	755	2,970	3,725

Sources: U.S. Census of Agriculture, U.S. Department of Commerce, Census Bureau.

a Not yet published.

1940 to an average of 20 acres in 1974 (Table 2.2).

Like in many other highly competitive businesses, small cherry growers unable to take advantage of economics of scale, and efficiently compete with larger growers, have been forced out of business or absorbed into larger units of operation.

Due to the change in the definition of commercial farms, the census data shown in Table 2.2 should be compared with care. The definition of a commercial tart cherry farm prior to 1954, was one with 80 or more trees. But for 1960, the definition was changed to a farm that had sales of products with at least $2,500 per year. Some decline in the number of tart cherry farms from 1954 to 1974 resulted from the change in census definition.

According to the 1973 Michigan Fruit Tree Survey,[6] there was a total of 2,252 growers operating 41,223 acres of tart cherry trees. Of the total acreage, about 42 percent was located in the northwest district of the State; 30 percent in the west central district and 26 percent in the southwest district. The remaining acreage of tart cherries, approximately 2 percent, was located in other districts. Unchanged from the 1969 census total, growers in 1973 reported

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[6] Wu, Ming W., "Michigan Fruit Tree Survey, 1973," Crop Reporting Service, Michigan and U.S. Department of Agriculture, August 1974.

Table 2.2, Commercial Tart Cherry Farms in Michigan and the United States, 1938 - 74

Census Year	Farms reporting tart cherry trees	Number of trees	Number of trees per farm	Bearing trees as a percent of all trees	Acres per farm (Bearing age)
		1,000		Percent	
Michigan:					
1940	28,944	2,267	78	87.2	.87
1945	NA	NA	NA	NA	NA
1950	20,091	3,083	153	70.6	1.50
1954	8,395	3,743	446	68.7	4.15
1959	6,348	4,130	651	81.3	6.66
1964	4,797	4,178	871	83.2	8.46
1969	2,397	3,799	1,585	85.5	16.69
1974	1,942	3,725	1,918	79.8	19.52
United States:					
1940	157,564	4,874	31	NA	NA
1945	NA	NA	NA	NA	NA
1950	114,259	5,667	50	70.2	NA
1954	36,299	6,910	190	73.9	NA
1959	27,880	7,379	265	80.6	NA
1964	18,607	6,730	362	83.9	NA
1969	5,401	5,669	1,050	84.9	NA
1974	a	a	a	a	a

Source: U.S. Department of Commerce, U.S. Census of Agriculture, Washington, D.C., U.S. Government Printing Office, Various issues.

a Not yet published.

about 3.7 million trees of all ages, of which, about 17 percent were not of bearing age (less than six years of age).

The density of tart cherry trees planted in Michigan averaged 92 trees per acre, with younger orchards having higher densities per acre.

Of the total 2,252 tart cherry growers, over one-fourth, or 627 growers operated less than 5 acres of tart cherries. This size group, from 1 to 4 acres, contained the largest number of growers, but accounted for only 3.4 percent of the total tart cherry acreage. There were 53 growers operating 100 acres or more. This size group contained only 2.4 percent of the growers, but accounted for over 20 percent of total acreage.

The average size of operation was 18.3 acres of tart cherries per grower. However, approximately 70 percent of the growers operated less than this amount. The survey also revealed that nearly all (99 percent) of the total trees were of the Nontmorency variety.

The harvest of cherries was historically done by hand picking which induced higher labor costs. The adoption of mechanical harvesters during the 1960's rapidly replaced hand picking, and now nearly all commercial tart cherries in Michigan are harvested by mechanical harvesters.[7]

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[7] Project 80 & 5, Michigan State University, 1973.

As cherries mature and ripen on the tree they become progressively softer. Scald damage in cherries can become severe because of greater bruising during harvest plus compaction in the container. This is most critical on hot days as hot cherries accelerate scald which results from increase in temperature through respiration. Scald damage in cherries is the major cause of losses in harvesting cherries.[8] Mechanical harvest reduces harvest costs and permits harvesting the crop in a given period of time at optimum maturity of processing.

The use of the mechanical harvester can aggravate the scald problem, but with its associated innovations in cooling, handling, sorting, and processing methods through the use of water-filled pallet tanks and hydrohandling of the cherries, the scald problem has been held to a minimum.

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[8] Bolen, J. S., and B. F. Cargill, "Mechanized Harvest Systems for Red Cherries," Extension Bulletin E-660, Farm Science Series, Cooperative Extension Service, Michigan State University, June 1970.

Production and Utilization of Tart Cherries

Tart cherry production in the United States averaged 111,589 tons per year during the ten years from 1967 to 1976, varying from a low of about 72 thousand tons in 1976 to a high of 152 thousand tons in 1969. The record high crop since 1938, the year that the tart cherry production information was first separated from sweet cherries, was in 1964. That year the crop reached 226 thousand tons, while the record low was only 40 thousand tons experienced in 1943 (Table 2.3).

Michigan's tart cherry production averaged 82,200 tons per year during the 1967-1976 period, and accounted for about 70 percent of the total U.S. crop. The production during this period varied from a low of 44 thousand tons in 1967 to a high of 107 thousand tons in 1972. The record high crop since 1938 was 150 thousand tons in 1964 and the record low was less than 11 thousand tons observed in 1943. Comparing the U.S. crop with the Michigan crop, it is easy to see that Michigan dominates the U.S. tart cherry crop (Figure 2.1).

Table 2.3 Tart Cherry Production, Michigan and United States. 1938 - 1976

Year	Michigan Production of value	Michigan Index 1960=100	United States Production of value	United States Index 1960=100
	Tons		Tons	
1938	19,000	23.8	63,000	54.4
1939	38,400	48.0	65,960	82.8
1940	45,600	57.0	103,480	89.3
1941	27,700	34.6	79,700	68.8
1942	46,500	58.1	104,040	89.8
1943	10,800	13.5	40,280	34.8
1944	50,000	62.5	112,200	96.9
1945	14,000	17.5	45,650	39.4
1946	60,500	75.6	116,010	100.1
1947	49,500	61.9	90,380	78.0
1948	69,000	86.3	131,790	113.8
1949	60,500	75.6	108,290	93.5
1950	97,000	121.3	155,240	134.0
1951	75,000	93.8	148,060	127.8
1952	59,500	74.4	109,650	94.7
1953	76,000	95.0	131,490	113.5
1954	48,000	60.0	106,320	91.8
1955	71,000	88.8	149,070	128.7
1956	55,000	68.8	99,040	85.5
1957	89,000	111.3	146,670	126.6
1958	49,500	61.9	103,410	89.3
1959	86,000	107.5	137,958	119.1
1960	80,000	100.0	115,840	100.0
1961	89,500	111.9	164,670	142.2
1962	110,700	138.4	166,655	143.9
1963	37,000	46.3	80,790	69.7
1964	150,000	187.5	225,923	195.0
1965	107,000	133.8	161,414	139.3
1966	54,500	68.1	89,496	77.3
1967	44,000	55.0	88,990	76.8
1968	100,000	125.0	137,654	118.8
1969	106,000	132.5	152,230	131.4
1970	79,000	98.8	118,990	102.7
1971	89,000	111.3	139,260	120.2
1972	107,000	133.8	134,180	115.8
1973	58,000	72.5	87,020	75.1
1974	103,000	128.6	132,300	114.2
1975	91,000	113.8	123,070	106.2
1976	45,000	56.3	72,200	62.3

Source: Fruit-Noncitrus, Production, Price and Utilization, Statistical Reporting Service, U.S. Department of Agriculture, various issues.

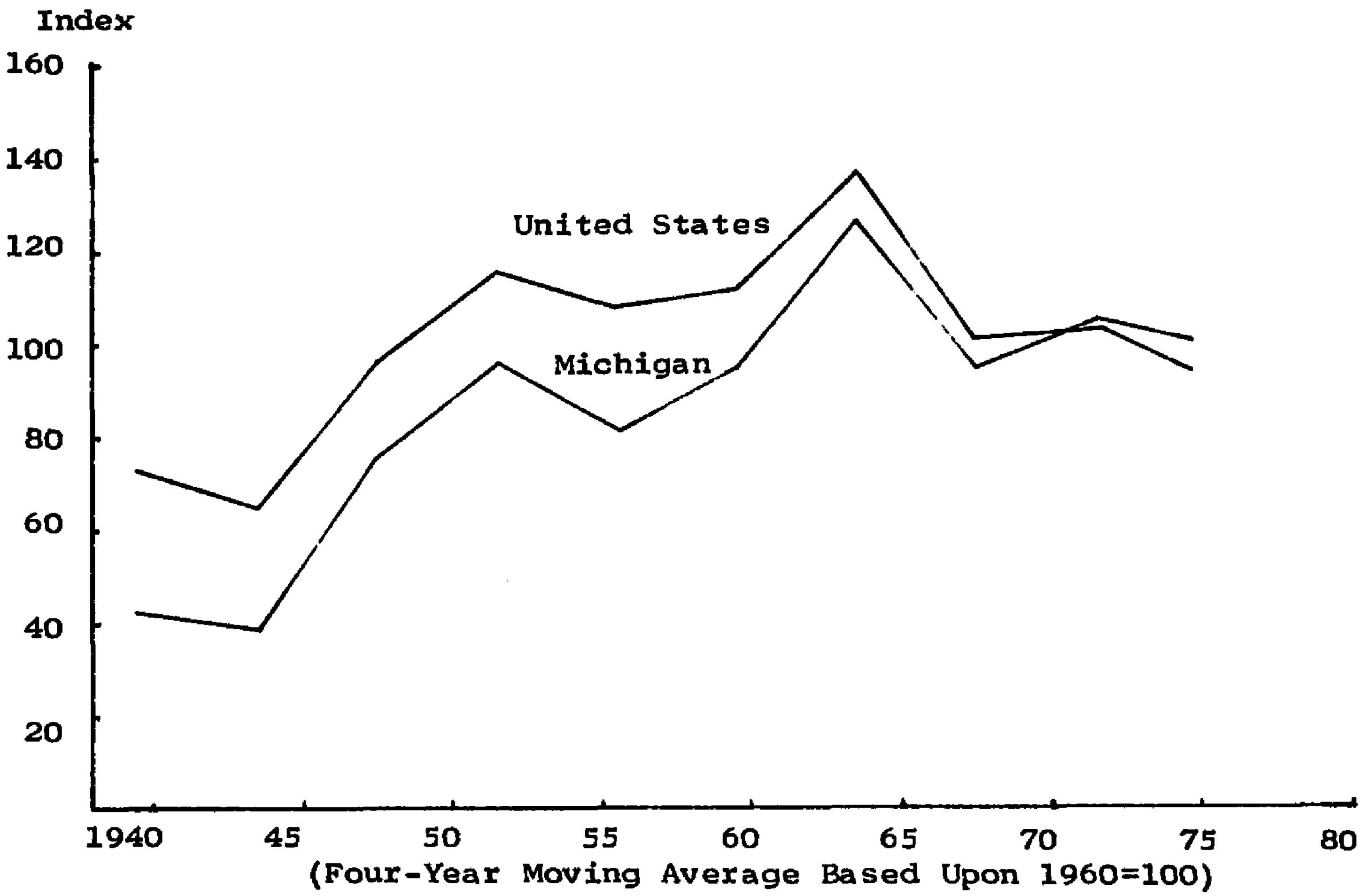

Figure 2.1 Index of Tart Cherry Production, Michigan and United States, 1938-1976.

Source: Fruits-Nonsitrus. Production, Price and Utilization. Statistical Reporting Service, U.S. Department of Agriculture, various issues.

The long-run pattern of tart cherry production and market supplies has been that of a large crop followed by a small crop in alternate years. The more recent production, however, tends to have a four-year cyclical variation of low production in two years followed by high production the next two years as shown in Figure 2.2. This cyclical nature of production is believed to be influenced by the weather conditions. With extremely favorable weather condition the production potential is great, but the hazards are usually equally as great with unfavorable weather condition.

As demonstrated in Figure 2.2, the tremendous variability in production form year to year would naturally be expected to be a contributor to year to year price instability. The relationship between these two factors would be inverse, i.e., large crops generally brought lower prices, while small crops sold for higher prices.

As shown in Table 2.4 and Figure 2.3 there has been a substantial change in the proportions of the tart cherry utilization. Canned cherries accounted for about 55 percent in late 1930's but declined rapidly to the present level of 32 percent with some interruptions during the war years. Tart cherries for fresh consumption also declined steadily from 22 percent to only 3 percent during the same period. However, frozen cherries have increased their share very rapidly, from 20 percent in late 1930's to the current level of about 64 percent. Cherries for other uses such as juices or wines, have declined from 3 to 1 percent during the same

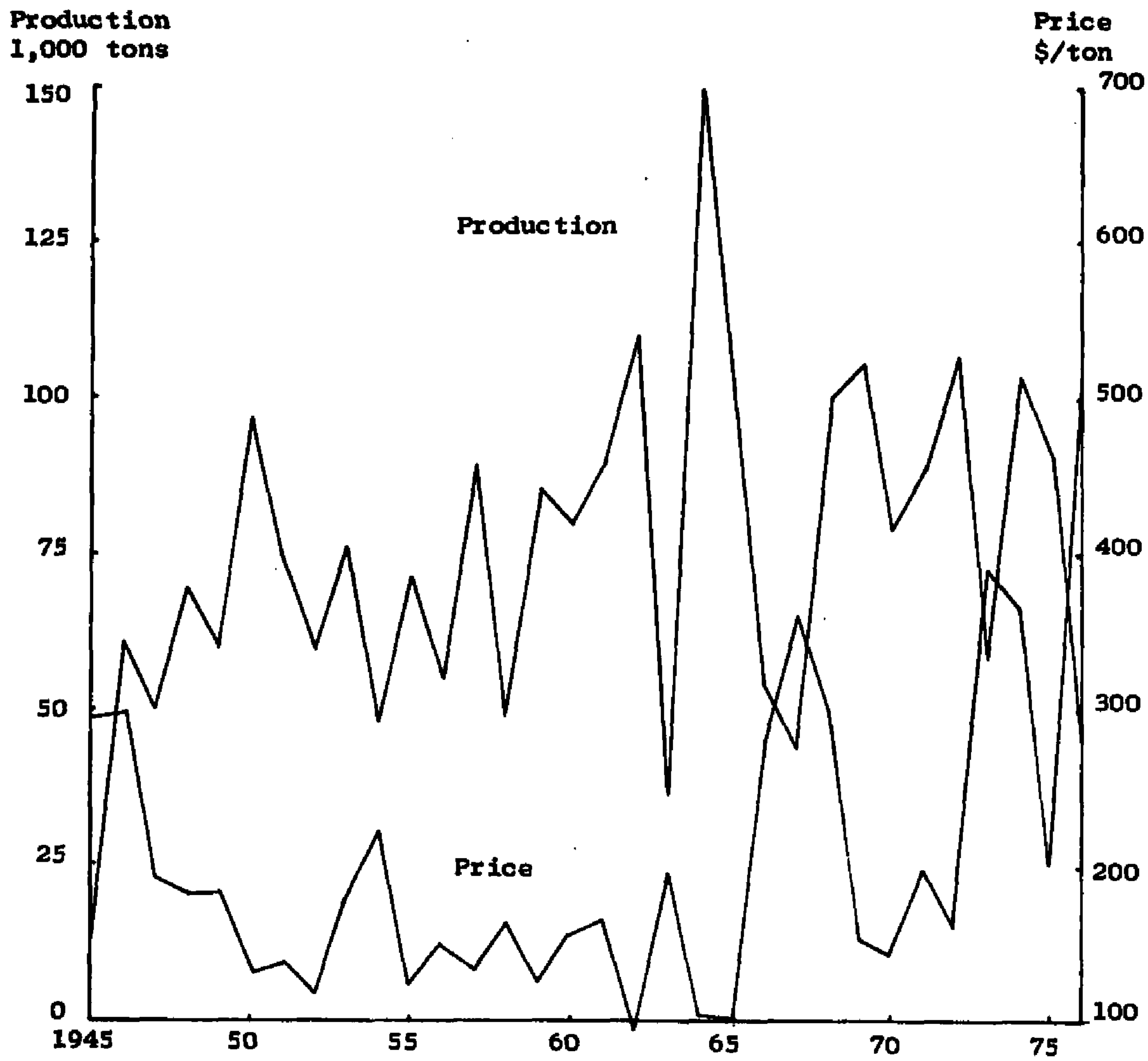

Figure 2.2 Relationship between Tart Cherry Production and Price, Michigan, 1945-76

Table 2.4 Percent Distribution of U.S. Disposition of Tart Cherries, 1938-76

Year	Fresh	Canned	Frozen	Other
1938	28.6	53.4	14.5	3.5
1939	21.8	57.4	17.7	3.1
1940	18.9	57.3	19.5	4.3
1941	20.9	47.5	28.0	3.6
1942	19.1	58.0	20.8	2.1
1943	34.8	31.4	32.6	1.2
1944	17.3	48.6	31.5	2.6
1945	23.0	55.5	19.8	1.7
1946	12.6	48.2	38.1	1.1
1947	14.2	44.8	39.3	1.7
1948	10.6	51.4	35.3	2.7
1949	11.7	54.1	32.9	1.3
1950	8.5	56.6	34.1	0.8
1951	8.5	56.9	33.8	0.8
1952	9.3	61.3	28.9	0.5
1953	7.9	46.6	44.9	0.6
1954	9.2	49.3	40.7	0.8
1955	6.3	53.2	39.4	1.1
1956	8.0	45.9	44.7	1.4
1957	5.9	45.1	48.4	0.6
1958	7.7	46.5	45.1	0.7
1959	5.4	51.6	42.3	0.7
1960	5.5	38.2	55.4	0.9
1961	4.7	38.0	57.0	0.3
1962	4.2	50.6	44.2	1.0
1963	6.0	38.2	54.9	0.9
1964	3.7	44.7	51.6	-
1965	4.0	43.3	52.7	-
1966	7.4	41.0	51.6	-
1967	5.2	34.1	60.7	-
1968	4.2	35.2	60.6	-
1969	3.7	41.6	54.6	-
1970	5.1	36.4	58.5	-
1971	4.0	29.6	66.3	-
1972	2.3	35.8	61.9	-
1973	3.0	30.9	66.1	-
1974	1.7	36.9	61.4	-
1975	2.9	33.1	60.6	3.3
1976	4.2	25.7	68.0	2.2

Dashes indicate insignificant quantity
Sources: USDA, op. cit. (various issues)

period. These changes have partially resulted from the continuous advancements and innovations in the technologies of processing and handling cherries. Other reasons for the change include changes in taste and preference of the consumers. Factors such as the increase in the consumption of pies and convenience foods, have contributed to the decline of fresh and canned uses and increase in the frozen forms.

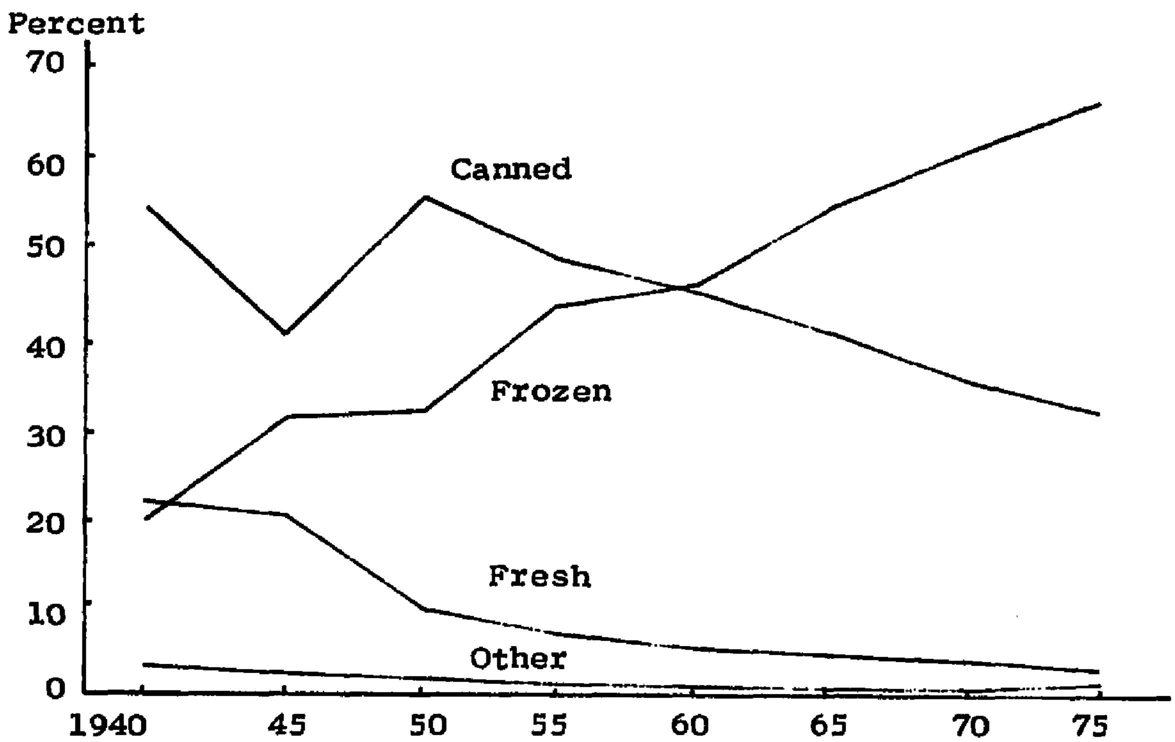

Figure 2.3 Disposition of Tart Cherry Crop in the United States, 1938-1976

Tart Cherry Supply Control Through the Marketing Order

The Tart Cherry Marketing Order was established and is based on the Agricultural Adjustment Act of 1933. This Act was amended by the Agricultural Marketing Agreement Act of 1937. The segment of the Agricultural Act of 1933 that is concerned with the Marketing Order are the laws covering the regulation of marketing through voluntary agreement from processors, associations of producers and other handlers of agricultural commodities or products, and the surplus disposal programs, The regulations that were enacted through the Agricultural Marketing Agreement Act of 1937 with respect to products have to do with the control of their quantity and quality. Also they deal with their rate of shipment to market in order to maintain the price of the products and hence the income of the growers at a reasonable level.

The Tart Cherry Marketing Order was voted and passed by both the growers and processors of tart cherries in January, 1971. This Marketing Order allows the growers and processors of tart cherries in Michigan, New York, Wisconsin, Pennsylvania, Ohio, Virginia, West Virginia and Maryland to withhold part of the cherries from the market at any time, have it processed in acceptable saleable forms, and to store and release it back to the market at expedient times.[9]

The growers in the western states, sharing about 10 percent of the nation's total of cherries, are not included in the order as of this time, because the cost of administrating the order in that area may not be justified. Also, tart cherries sold by growers direct to retail customers or for fresh consumption are not included.

The tart cherry marketing order is run by a twelve member Board, called the Cherry Administrative Board. Six member of the Board are growers and six are processors. In addition to these twelve members, there is a non-voting chairman. The grower members are voted upon by the growers in their district, and the processor members are elected in the same manner. Since this is a federal order, the persons voted upon are presented to the Secretary of Agriculture, who then appoints them to be the members of the Administrative Board. Each member serves for a three year term, but is not eligible for more than two consecutive three year terms. The Chairman is recommended by the Board and appointed by the Secretary of Agriculture to serve for an indefinite period of time.

The primary objective of the marketing order is to

[9] Owen, Frank, "Red Tart Cherry Marketing Order," Fruit Grower News, November 1971.

regulate the supply of cherries through the use of set aside[10] provisions decided upon by the Marketing Board. The amount of cherries under the set aside program in a particular year can be handled in two distinct ways.[11] One is to divert the cherries, to leave the cherries unharvested on the tree, and the other is to harvest the cherries and to store them in the reserve pool for sale at later time.

The main control mechanism, use of a storage reserve pool, is designed to play an important role in stabilizing long-run supplies and thus prices of tart cherries. A fundamental idea is to remove some cherries from the market in years of excessively large crops to the storage reserve pool and release these pooled cherries when cherries are scarce, price are higher, and more cherries are needed to maintain supplies in the market place. As a result, it is intended that growers will get a higher return in the large crop years than without the Order and they will have more cherries to sell in short-supply, high-price periods.

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[10] Set aside means to withhold cherries from the market for a certain period of time, or to leave a certain volume of cherries unharvested in order to strengthen price to the grower.

[11] Ricks, Donald J., "Economic of Storage and Partial Non-harvest Programs for the Tart Cherry Industry," Agricultural Economic Report No. 150, Michigan State University, November 1970.

Through the application of this provision, supplies and prices will be stabilized from year to year. This greater stability is desirable from the view point of consumers, institutional buyers and food manufacturing firms who use cherries in their final consumer products.[12]

A minor control mechanism which is included is to dispose of the excess cherries by means of the non-harvest option. This is the same as destroying the amount of cherries that are over-produced and is useful when the crop exceeds the processing capacity, or perhaps when the carryover stocks plus a previous reserve pool are very large.

The decision to participate in the reserve pool is up to each individual grower. Some growers may not be able to afford to pay for the processing and storage cost. Some may envision the possibility of the future supply being large enough for the market so they may not see any advantage to putting the cherries in the pool.

The cost of carrying out the order is spread between growers and processors but not equally. The processors pay for the general administration of the Order in proportion to the volume of cherries each has handled. The growers pay for the reserve pool and all costs involved in diversion.

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[12] Ricks, Donald J., "An Evaluation of the Tart Cherry Marketing Order," Dept. of Agricultural Economics, Michigan State University, 1974.

All costs are determined by the Board and are charged relative to the amount of participation. The benefits resulting from the administration of the Order have to date surpassed the cost.

The tart cherry Marketing Order alone cannot solve all the problems of the industry. Many decisions which are made outside the scope of the Marketing Order may have a great impact on the marketing order and the industry. One of these is the forecasting of the anticipated size of crop. The official tart cherry forecasting programs have been carried out by the Crop Reporting Service of the USDA for many decades. The next section is designated for the presentation of the general procedures used by the United States Department of Agriculture in arriving at the forecasts.

Tart Cherry Crop Forecasting

The Statistical Reporting Service (SRS) of the U.S. Department of Agriculture has the responsibility of collecting and distributing the annual and current agricultural statistics. The two distinct functions of SRS are (1) forecasting of crop production from current crop conditions during the growing season, and (2) annual estimates of actual crop production. The term "forecast" refers to expectations of what is likely to be accomplished at some time in the future, while the term "estimate" indicates a measure of accomplished fact, e.g., crop yields, and production after the crop is harvested.

It should be clearly understood that a forecast is made on the basis of known facts on a given date, assuming weather and other conditions during the remainder of the growing season to be similar to those experienced in past seasons.

For tart cherries, the SRS issues a forcast of the size of a crop several months before harvest time. One of the most important price-determining factors is the estimates for mid-June, generally released on June 23rd. This forecast is based on actual fruit conditions, while the mid-May forecast is based on bloom conditions.

In the past, the SRS based its tart cherry forecasts on reports from individual growers who evaluated their crops according to their normal and previous year's output. Frequently, the producers and others have differed significantly with the official forecasts.

The Marketing Order Administrative Board and many others make major marketing decisions based on the official forecasts. Thus, the mid-June forecast becomes a matter of dollars and cents as far as the tart cherry industry is concerned.

An objective yield survey, designed to improve forecasting accuracy and thereby ease some of the grower's apprehensions, has been adopted for the forecasting of Michigan's tart cherry crop since 1972. Both the tart cherry industry and the Statistical Reporting Service had long sought the improved forecasting techniques which the objective yield survey provides.

The objective yield survey involves a more direct and scientific approach then the conventional grower reporting method.[13] The survey is patterned after a special pilot study on tart cherry objective yield project conducted by

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[13] From the author's experience in participating in the crop forecasting programs with the SRS from 1972 to 1975.

the Statistical Reporting Service over a five-year period from 1958 to 1962.

The first step of the objective yield survey is the selection of sample blocks and trees. More than 3.2 million tart cherry trees hug the long stretch of Lake Michigan shoreline from Benton Harbor to Grand Traverse Bay. However, only 300 blocks and three trees per block or a total of 900 trees are needed for the survey. In fact, only a small fraction of each of the 900 sample trees is used for survey purposes.

Blocks of trees are sampled with probabilities proportional to the number of trees, which results in a self-weighted sample. According to the distribution of tart cherry trees in Michigan; about 41 percent of the sample blocks should be from the northwest district; 32 percent from the west central district; 25 percent from the southwest district, and 2 percent from other districts.[14] Under this method it is conceivable that growers with large orchards could be selected more than once.

Enumerators were trained to make field observations during mid-April. Individual growers were contacted during late April and the enumerators again made observations in

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[14]Wu, Ming W., op. cit.

early May.

The first of four surveys takes place in mid-May before the peak of bloom. Bloom counts and careful observations on the stages of fruit bud development are made on a small section of 100 preselected trees. The primary purpose of the bloom survey is to obtain as precisely as possible the data during full bloom, as most of cherry droppage[15] occurs during the first 20 days after full bloom.

The second phase of the survey occurs about mid-June and is the most important one. A fruit count is made on all 900 trees in the sample. Field enumerators are divided into teams of two and are allocated only a single week to complete the counts.

Limbs used in the bloom survey will be re-examined and counts made on the green cherries. These counts will help to provide data on fruit droppage. In addition, cherries on a small section of the preseleceted 100 trees will be stripped, counted and sent to special field laboratories for weighing and other testing. The number of cherries plus expansion factors and projected weight per cherry will determine yield per tree. Such things as droppage and

[15]Natual droppage of unmatured small cherries.

harvesting losses are included in the calculation of the expansion factor. An indication of the prediction for the production of the State can be established by extrapolation by the number of bearing trees. It is at this time that SRS issues its official tart cherry forecast, based on the mid-June phases of the objective yield survey.

The third phase of the survey takes place shortly before harvest. A return visit will be made to 100 of the sample blocks and fruit counts will once again be taken. A few cherries will be picked for laboratory purposes. This phase of the survey is primarily to evaluate the forecasting performance, but is also to measure any further cherry drop.

The fourth phase of the survey is completed not more than 5 days after harvest. Sixty blocks are used for counts of fruits left on the tree and also on a measured area of ground under the tree.

The objective yield survey approach has improved significantly the accuracy of prediction in terms of short term crop forecast. The forecast for tart cherries is generally released approximately one week prior to the beginning of harvest, or some time around June 23rd each year. This improved forecasting method provides the industry with very important information for price determination and the basis for that year's Marketing Order.

CHAPTER III

SUPPLY RESPONSE MODELS FOR TART CHERRIES

With a perennial crop such as tart cherries, supplies available in a current period are influenced in part by production decisions made six years ago.

The study of supply response here is to start from identifying the variables or factors expected to influence the number of bearing acres of trees and the size of the crop. These variables then are to be incorporated into the empirical models. The list may not exhaust the totality of the variables, but the important variables expected to play a part in an explanatory role will be carefully examined.

Tart cherry production does not start immediately after the trees are planted since the trees usually take at least six years to reach bearing age. Accordingly, the grower's production response to prices of tart cherries is delayed by the lag in production. This lag is indicated by the time span between the decision to produce and actual production. The trees will need another ten years or so to attain their full production potential and the life expectation of the trees may last as much as 30 years depending on the cultural practices applied. The expected returns from tart cherries are spread over a long time span; hence, the relationship of supply response in tart cherries differs from that of annual crops such as corn, wheat or other field crops

To construct supply and demand models for tart cherries, a series of regression equations were formulated. The empirical results were evaluated and compared among selected models.

In this study, "supply" is defined as grower's intended output of tart cherries rather than the actual quantity marketed. Hence the tart cherry supply is indicated by the product of the total number of acres that are of bearing age (six years or older) and the average yield per acre. The functional relationship can be expressed in three equations. The first equation is:

$$Q_t = A_t \times Y_t \tag{3.1}$$

where, Q_t represents output of tart cherries, at time t;

A_t is total number of bearing acres at time t;

Y_t is yield of tart cherries per acre at time t.

This equation is a non-linear identity defining the annual tart cherry output.

The second equation is:

$$Y^t = f(T) \tag{3.2}$$

This function indicates that the yield of tart cherries (Y^t) is a function of a trend variable (T).

The third equation is a behavioral equation explaining the determination of the total number of bearing acres. Due to the gap between farmers' response in tree plantings and the actual production, various distributed lag models are specified in the attempt to explain the bearing acreage response. The equation can be shown as:

$$A_t = f\left(\frac{1}{6}\sum_{i=6}^{11} GM^t_{t-i},\ \frac{1}{6}\sum_{i=6}^{11} GM^c_{t-i},\ A_{t-1},\ T,\ \text{other variables},\ \ldots\ldots\ e_t\right) \tag{3.3}$$

where, A_t = Bearing acreage of tart cherries at time t;

$\frac{1}{6}\sum_{i=6}^{11} GM^t_{t-1}$ = Six-year moving average of gross margins per acre for tart cherries lagged six years from time (t-6) to (t-11);

$\frac{1}{6}\sum_{i=6}^{11} GM^c_{t-i}$ = Six-year moving average of gross margins per acre for alternative competitive fruit crop, i.e., apples, lagged six years from time (t-6) to (t-11);

A_{t-1} = Bearing acreage of tart cherries at time (t-1); a lagged dependent variable;

T = Trend variable;

e_t = Error terms.

Gross margins in this study are defined as total receipts less total costs excluding the payment to the manager on his money capital and for his managerial talents. If such payment to the manager is not realized the owner's resources and his managerial talents may be withdrawn and reallocated to some alternative line of production or enterprise. Total costs in this study are itemed in Appendix Table B. 5.

Export of tart cherries as a proxy for market potential was not included in the models because the quantity of cherries exported averaged only about 3 percent of the total production each year and in most years were zero. Stock of tart cherries was also excluded because it seemed to be unimportant in affecting grower's tree planting decisions.

The major competitive fruits for the acreage or site of orchards in the major tart cherry production states are sweet cherries, apples, plums, pears, peaches, asparagus, etc. The competition has been the profitability of growing tart cherries relative to other fruit crops, which is mainly determined by gross margins of each of the fruits per acre.

The price variables were not directly used because tart cherry production is characterized by long periods of gestation such that production does not directly respond to price changes. The typical response to rising prices is to plant more but when prices are falling, the supply falls as acreage is reduced, but only by small amounts as the growers expect the price to rise again in the future. For a perennial crop like tart cherries it is necessary to take into account the cost of production.

The annual drastic change in tart cherry price is directly associated with the size of crops. Higher price do not necessarily mean higher gross margins to farmers as the increased return per unit resulting from higher prices is usually more than offset by the loss of smaller production per acre. Their gross margins depend on the price the growers receive, size of crop and cost of production. In this study gross margins are selected rather than prices as independent variables under the assumption that growers' decisions on tree plantings are made based on the gross margins.

Another important reason to use the gross margins in the analysis is that cost is an integral part of the theory of production and hence supply theory, particularly in studying the long-run relationships. Emphasis is therefore placed on the gross margins which include cost considerations.

It has generally been observed that for perennial crops, growers' planting and removal decisions are based on observations covering a time span longer than one year. Therefore, six-year moving averages of gross margins are applied in an attempt to cover the decision period as well as to reduce cyclical variation.

It should be noted here that using the bearing acreage as the dependent variable in the supply equation gives alternatives for testing various levels of yield for the production because supply or production is composed of acreage and yield factors as shown in Equation (3.1). Further discussion on this will be presented in the projection chapter.

Analytical Models

Alternative formulations of regression models selected for tart cherry supply response are as follows:

Geometric Lag Models

Geometric lag distribution is the most popular form of distributed lag Models. Of the geometric lag models there are many submodels, namely: (a) adaptive expectation model, (b) partial adjustment model, (c) compound geometric model, and (d) two expected variable model, etc. In this study, the first two models are chosen because of their simplicity of estimation since only one lagged dependent variable is involved, and both the long-run and short-run relationships can be estimated. Another reason for choosing these two models is that the results obtained from both models are essentially the same; they differ only in the assumption of the error terms.

(1) Adaptive expection model:

This model is characterized as:

$$A_t = a + bP_t^* + e_t \tag{3.4}$$

where, A_t is the bearing acreage at time t and P_t^* represents the expected price at the same period, and e_t is an error term. The following relationship is postulated by Nerlove:[16]

$$P_t^* - P_{t-1}^* = (1 - \lambda)(P_{t-1} - P_{t-1}^*) \tag{3.5}$$

Neither planned output nor expected price can be observed. Planned output is represented by the proxy variable of planted acreage which is of bearing age. Expected price is eliminated from the estimating equation. The expected price is represented by the previous year's price and the expected price in the same year. This indicates

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[16] Nerlove, M., "The Dynamics of Supply Estimation of Famer's Response to Price," The John Hopkins Press, Baltimore, 1958, pp. 236-242.

that the change in the expected price or gross margin is determined by some fraction of the forecasting error of the previous year's prices or gross margins.

From equations (3.4) and (3.5), the following functional relationship is derived:[17]

$$A_t = K_0 + K_1 P_{t-1} + \lambda A_{t-1} + E_t \qquad (3.6)$$

where, $K_0 = a(1 - \lambda)$

$K_1 = b(1 - \lambda)$

$E_t = e_t - \lambda e_{t-1}$, and

$(1 - \lambda)$ = the coefficient of expectation adjustment.

The condition $0 < (1 - \lambda) < 1$, holds when growers make "incomplete" adjustments for their mistakes, due mainly to their having incurred fixed costs. Koyck uses a different assumption for the expected price. His assumption is based on the concept that current expectations are derived by modifying previous observations or experience

$$P_t^* = (1 - \lambda)(P_{t-1} + \lambda P_{t-2} + \lambda^2 P_{t-3} + ---) \qquad (3.7)$$

Manipulating equations (3.4) and (3.7), the following equation is derived:

$$A_t = a(1 - \lambda) + b(1 - \lambda)P_{t-1} + \lambda A_{t-1} + e_t - \lambda e_{t-1}$$

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[17]See computation in Appendix A.1.

Substituting K_0 for $a(1 - \lambda)$, K_1 for $b(1 - \lambda)$, and $E_t = (e_t - \lambda e_{t-1})$

$$A_t = K_0 + K_1 P_{t-1} + \lambda A_{t-1} + E_t$$

This result is essentially the same as Nerlove's expectation model.[18]

The coefficients a and b of Equation (3.4), and the long-run elasticities can be derived from the relationships among K_0, K_1 and λ.

(2) Partial adjustment model:

Partial adjustment or habit persistence model assumes that it is only partially feasible to bring the actual level of acreage A_t to the desired level of acreage A_t^* during any one period. This "partial adjustment" results from technological constraints, institutional rigidities and growers' persistence of habits. This model can be denoted as:

$$A_t^* = a + bP_{t-1} + e_t \tag{3.8}$$

$$A_t - A_{t-1} = r(A_t^* - A_{t-1}) \tag{3.9}$$

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[18] See the demonstration by Kmenta, J. in his Elements of Econometrics, the Macmillan Company, New York, 1971, pp. 474-476.

where, A_t^* is desired level of acreage at time t

P_{t-1} represents previous year's price

A_t is actual level of acreage at time t

A_{t-1} is previous year's actual level of acreage

r is the supply adjustment coefficient, and 0 r 1.

The value or r lies between 0 and 1 and means that the adjustment of A_t to A_t^* is incomplete in any one period. If r equals 1, the adjustment is completed in one period, whereas if r equals 0, there is no adjustment toward the desired level.

From equations (3.8) and (3.9) we obtain a new equation as:[19]

$$A_t = ra + rbP_{t-1} + re_t$$

substituting $K_0 = ar$

$K_1 = br$

$K_2 = (1 - r)$

$E_t = re_t$

Thus $$A_t = K_0 + K_1P_{t-1} + K_2A_{t-1} + E_t \qquad (3.10)$$

Comparing the price or gross margin expectation model and the partial adjustment model we may notice that in determining the expected levels of the explanatory vari-

[19]The manipulation is presented in appendix A.2.

able the former model incorporates the past experience, while the latter takes into account the technological and institutional constraints and farmer's persistence of habit.

Polynomial Lag Model

The polynomial lag or so-called Almon lag technique is used to estimate the nature of the distributed lag structure that follows a polynomial of a given degree. The general functional relationship can be expressed as:

$$A_t = a + b(w_1P_{t-1} + w_2P_{t-2} + \text{---} \; w_nP_{t-n}) + \text{other variables} + E_t \qquad (3.11)$$

where, w_i's are the weights of the lagged variables and constrained by

$$w_0 = 0; \; w_{n+1} = 0$$

Assume the parameters of w_i are r_0, r_1, ---- r_k such that

$$w_i = r_0 + r_1i + r_2i^2 + r_3i^3 + \text{----} + r_ki^k$$

where, $i = 0, 1,$ --- n; $K \leq n$, and K is the degree of the polynomial. By transforming Equation (3.11) and using gross margin notations

$$A_t = a + b \; [(r_0 + r_1 + r_2 + \text{---} + r_k)GM_{t-1}$$

$$+ (r_0 + 2r_1 + 2^2 r_2 + ---- + 2^k r_k)GM_{t-2} + ---$$

$$+ (r_0 + nr_1 + n^2 r_2 + ---- + n^k r_k)GM_{t-n}]$$

$$+ \text{other variables} + E_t.$$

The hypothesized model for the polynomial lag can be simplified as:

$$A_t = K + b(\sum_{i=6}^{T} w_i GM_{t-i}) + \text{other varialbes} + E_t \quad (3.12)$$

where, A_t = bearing acreage of tart cherries

K = constant

$\sum_{i=6}^{T} w_i GM_{t-i}$ = lagged variables (prices) from time (t-6) to (t-T), where T is the length of lag structure.

E_t = error terms

In this analysis the variable, gross margins per acre, is used to replace the price variables in the equation. The first lag variable start from (t-6) because six years are required for the trees to reach the bearing age.

To formulate the model, there must be a prior specification of the degree of the polynomial. In addition, the lag structure can be vestricted to either start and/or end at zero.

To select the degree of polynomial, one should try several degrees of polynomial and then compare the distribution of the estimated coefficients. The distribution of the estimated coefficients should be compatible with the behavior of the forces which the study seeks to measure. If the shapes of the coefficient distribution among different degrees of polynomial appear to be similar, the lower degree polynomial should be considered because the higher degree of the polynomial gives fewer degree of freedom, In general, selection among second, third, and fourth-degree polynomial seems to be quite appropriate.

Four alternative restrictions can be imposed on the estimated lag structure, namely; (1) both the beginning and the last periods constrained to zero; (2) only the last period constrained to zero; (3) only the first period constrained to zero, and (4) unconstrained. Selection of this limit depends on the behavior to be measured.

To determine the length of the polynomial lag(i.e.,n) it is advisable to try a range of different lengths and then consider the most appropriate lag length depending upon *a priori* expectations, the values of R^2, t statistics, and Durbin Watson tests. In this study the functional relationship represented by Equation (3.12) will be estimated.

Simple Model

A simple lagged model is different from the distributed lag models in such a way that no restrictions are placed on the coefficients of the explanatory variables. Generally, a time variable is used in place of the lagged dependent variable such as

$$A_t = b_0 + b_1P^t_{t-1} + b_2P^c_{t-1} + b_3T + \text{----} + e_t \quad (3.13)$$

One advantage of this type of model over the distributed lag model is its simplicity in estimation and interpretation.

Estimating procedures of the above discussed models will include: (1) the ordinary least squares methods, and (2) Cochrane-Orcutt iterative techniques. Cochrane-Orcutt techniques are useful in the estimation of the first order serial coefficient of the disturbances. These techniques can be used to correct for serially correlated residuals when the polynomial distributed lag model is estimated.

Testing of the Supply Response Model

The purpose of testing the model is to find out how accurately the model can explain observed behavior. By feeding the past values of the exogenous variables in the system and comparing the output of the model with those actually observed, an indication of model performance can be provided.

Each equation will be evaluated by the coefficient of multiple determination, consistency of signs, significance of coefficients, presence of autocorrelation, and Theil's inequality coefficient.

One important step in estimating these regression models is to examine the feature of the regression disturbances, known as autocorrelation or as some econometricians refer to it, the serial correlation.[20] It implies that the correlation of the disturbance occurring at one point of observation is related to any other disturbance. This problem should be examined carefully in the case of equations estimated from time series data. The problem becomes more critical when dealing with the shorter interval of observations because the carryover effects of the disturbances become more severe. For instance, the effect of an irrigation to a crop at a point of time may last for several weeks until it finally dries out. But the shorter the time between each irrigation, the greater is the possibility of having carryover effects from one irrigation to the next.

A problem in estimating the model is the presence of serial correlation. Serial correlation may arise because of an improper specification of the model or may be induced by the distributed lag formulation. If the error term

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[20]Kmenta, op. cit., p. 269.

follows the standard assumptions, Ordinary Least Squares procedures may have consistent and asymptotically efficient coefficients.

The Durbin-Watson statistics is generally considered to be an invalid indication of serial correlation when the lagged dependent variable is included as an independent variables.[21] The problem with the application of the adaptive expectation model is the new disturbance, E_t, may be correlated with the lagged dependent variable. In this case, the ordinary least squares estimates of the regression parameters will be biased, because the assumption that E_t is not correlated with any of the independent variables is being violated.

Since the Durbin Watson test is not appropriate, other alternative estimating methods to correct the possible serial corelation should be explored. They include the Cochrane-Orcutt iterative (CORC) techniques, Hildreth-Lu (HILU) technique, First Difference Regression, or Maximum Likelihood method, etc. In this study the Cochrane-Orcutt iterative technique is chosen.

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[21]Durbin, J., "Testing for Serial Correlation in Least Squares Regression when Some of the Regressions Are Lagged Dependent Variables," Econometrica, Vol. 38, No. 3, May 1970, pp. 410-421.

Theil's inequality coefficients[22] are also used to evaluate the forecasting ability of the estimated models. Theil's inequality coefficient, U, shows the relationship between the individual predictions (P_i) and the actual values (A_i)

$$U = \frac{\sqrt{\frac{1}{N} \sum_{i=1}^{N} (P_i - A_i)^2}}{\sqrt{\frac{1}{N} \sum_{i=1}^{N} (P_i)^2 + \frac{1}{N} \sum_{i=1}^{N} (A_i)^2}} \qquad (3.14)$$

where, N represents number of observations.

The coefficient U varies between 0 and 1. In general a lower value of U indicates a more preferable than a higher value. When U = 0, the model forecasts perfectly, or $P_i = A_i$, and when U = 1.0, the worst possible forecast is obtained.

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[22] Theil, H., Economic Forecasts and policy, North-Holland Publishing Company, Amsterdam, Holland, 1965.

CHAPTER IV

EMPIRICAL RESULTS OF SUPPLY RESPONSE MODEL

The model was constructed using annual data from 1938, the earlist available data relating tart cherries, to 1976; a total of 39 observations. The data series used in this study are listed in Appendix B.

In the attempt to formulate the tart cherry supply response model, various functional relationships and estimation techniques have been applied. One of the major tasks in constructing the desired model is to cope with the statistical problems induced by the application of a distributed lag estimation. Statistical tests and evaluations of each estimated equation are then conducted. The results of the statistical test and evaluation suggest that the agreement of economic rationality and simplest is best.

To measure the impact of growers' response to changing profit levels on tart cherry production, gross margin variables were used instead of the prices of tart cherries and other competing fruits in the supply equation. A response to a change in gross margins essentially will not take place once and for all within a single year but is usually distributed over several years due to growers' habit persistence, adjustment lags, uncertainty, resource constraints and or other factors. One means to take into account such response was to apply a moving average of the relevant independent variables. Another means to measure such effects was to use the lagged dependent variable as an independent variable, and , of course, the third method would be to apply both approaches simultaneously.

The data on the cost of production were from the Annual Cost Account Reports of New York, published by the Department of Agricultural Economics, Cornell University. This is the only available data with respect to the cost of production since 1938. However, the report was used only as an indication because it is not applicable to average farms and has only a few cherry growers participating in the project each year. The New York cost account farmers have a large capital investment, grow more crops, hire more labor and are more progressive than the average farmer. The averages, therefore, probably reflect the relative costs of moderately sized good farms only.[23] This indicated the

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[23]Carroll, Thomas F., "Background Information and Statistics for Fruit Marketing-Cherries", Department of Agricultural Economics, Cornell University A.E. 662, Ithaca, New York, March 1948, p.43.

cost for average farms to be lower than that of the cost account farms.

Cost of growing tart cherries in the New York Cost Account Reports were divided into three groups: (1) growing costs, (2) harvesting costs, and (3) storing and selling costs. The items included in each of these groups are shown in Appendix B Table B.5.

Wright and Johnston[24] made a study relating to cherry production costs for 69 orchards in Michigan in 1943. The study revealed that the average cost was $146.00 per acre as compared to $193.00 per acre for the New York cost account farms in the particular year. This indicated that the cost of tart cherry production in Michigan was about 76 percent of the cost of New York cost account farmers. The ratio might change over time; however, for the purpose of this study it was assumed that the cost for average Michigan farms is about 80 percent of the New York cost account farms. Nonetheless in this study the "trend" of a factor was assumed to be more important than its absolute values. The average gross margins per acre were then computed based on this cost information.

[24]Wright, K. T., and Stanley Johnston, "Peach and Cherry Costs in Michigan," Department of Agricultural Economics, Agricultural Experiment Station, Circular Bulletin No. 201, June 1946.

The gross margins per acre for tart cherries and for the competing crops used as independent variables were thus expressed as six-year moving averages in an attempt to capture the above impacts and to reduce the fluctuations in prices resulting from annual variations in production. If the annual cyclical effect due to the impact of weather is not removed, the variation in yields tends to obscure the nature of the supply response.

Application of six-year moving average reduces observations by five. In addition, the use of independent variables which are lagged by six years further reduces the observations by six. As a result, the total number of observation is reduced from 39 to 28 for this study. However, for a time series analysis using the annual data, this is considered to be sufficient with respect to the number of observations.

It would be desirable to estimate one function that respresents tree removals and another function that specifies tree plantings. Unfortunately, both the removal and planting data are not available at any level. However, in this analysis only the annual total bearing acreage is concerned. In other words, if the new plantings made six years ago (t-6) were greater than the removals made in the current year (t), then there will be an increase in the bearing acreage in the current year (t), and vice versa for a decrease in the bearing acreage. Another factor that is also extremely complex to take into account is the age distribution among trees. Yield varies with age of trees as well as locality, cultural practices and weather conditions, etc. To disentangle these effects is extremely difficult. Nonetheless, it may be logical to assume that these yield factors remain a linear trend throughout the entire period.

The first two sections of this chapter are to present the selected geometric models. The distinction between the adaptive expectation model and the partial adjustment model must be made clear. The adaptive expectation model is to reflect the importance of past experience in determining the expected values of the price or gross margin variable. The partial adjustment model reflects technological and institutional constraints which allows only a fraction of the intended acreage response or production response to be realized during a period.

In the study both the Ordinary Least Squares and the Cochrane-Orcutt iterative methods have been used for estimation purposes. Following are the discussion and examination of the results of the alternative schemes.

Geometric Distributed Lag Model

According to Nerlove's model, planned output (represented by planted acreage) is a function of the price which growers expect to receive for their crop. In this study, the expected price is replaced by the gross margin of tart cherries per acre because the gross margin is used as a measure of profitability of tart cherry production. The growers' incentive in planting tart cherries is assumed to be motivated by the gross margins rather than by the prices the growers receive as discussed earlier.

The production decision is made on the basis of a past price or profit performance. In other words, the growers' planting response can be expressed in the previous year's gross margins and the previous year's acreage. Accordingly, those trees that reach bearing age the current year (t) were the result of the planting response made six years ago (t-6). These behavioral relations make it possible to estimate the relationship.

The estimated results from the partial adjustment model, Equation (3.10), are as shown in Table 4.1. The results of Equations (4.1) and (4.2) are estimated by using the Ordinary Least Squares and the Cochrane-Orcutt iterative techniques, respectively. All signs of the regression

Table 4.1 Geometric Lag Models for Michigan Tart Cherry Acreage Response from 1938 to 1976[1]

Equation No.	Estimation technique	C	A(t-1)	$\frac{1}{6}\sum_{i=6}^{11}(GM^{t}_{t-1})$	$\frac{1}{6}\sum_{i=6}^{11}(GM^{a}_{t-i})$	$\frac{1}{6}\sum_{i=6}^{11}(GM^{sw}_{t-i})$	R^2	R^2	d.w.	U	h
(4.)	OLS	2.9886	.92953[a]	.00362[a]	-.00201[b]	-.00358[b]	.993	.9922	1.43	.00773	1.59
			(.0236)	(.0008)	(.0012)	(.0021)					
(4.)	CORC	3.70482	.90954[a]	.00306[a]	-.00259[b]	-.00304[b]	.993	.9921	1.96	.00895	-
			(.0316)	(.0011)	(.0016)	(.0022)					

[1]The dependent variable is tart cherry bearing acreage at time t (A_t) in 1,000 acres. Figures in parenthesis are standard errors.

Where, C = Constant terms;

$\frac{1}{6}\sum_{i=6}^{11} GM^{j}_{t-i}$ = Six year moving average of the gross margins of jth fruit per acre lagged six years from time t in dollars. expressed in real terms (where, j=t, a, and sw for tart cherries, apples, and sweet cherries, respectively);

A^{t}_{t-1} = Previous year's tart cherry bearing acreage;

R^2 = Correlation of multiple determination;
$\bar{R}^2$ = Corrected coefficient of determination;

d.w. = Durbin Watson statistics (not for precise indicator of autocorrelation as the lagged variable is on the right hand side of the equation);
U = Theil's inequality coefficient;
h = Statistic testing for the presence of serial correlation, evaluated as a t statistic;

a = Statistically significant at the one percent probability level;
b = Statistically significant at the 20 percent probability level.

coefficients are in agreement with economic rational.

The coefficient of tart cherry gross margins and the previous years' acreage in each of the equations are significant at one percent probability level, while the gross margins for the competing fruits, apples and sweet cherries, are significant at the 20 percent probability level.

Equations (4.1) and (4.2) have similar $\bar{R}^2$ values at .992 and the Theil's inequality coefficients from .008 to .009. But the h statistic of Equation (4.1) indicates the presence of serial correlation at the 20 percent probability level. Equation (4.2) with serial correlation absent is preferred to Equation (4.1) to represent the partial adjustment model for tart cherry acreage response in Michigan.

Equation (4.2) indicates a one dollar per acre of tart cherry gross margin increase expressed in real terms resulting in a 3.1 acre increase in the tart cherry bearing acreage, ceteris paribus. Applying the current average yield of cherries per acre, at 4,700 pounds, a one dollar per acre increase in tart cherry gross margins will result in an increase of 14,570 pounds of cherries in the total tart cherry supplies. A one dollar per acre change in apple gross margins will generate an inverse change in the tart cherry acreage by 2.6 acres or 12,220 pounds of cherries per acre. A one dollar increase in the gross margins of sweet cherries results in a 3.0 acre decrease in tart cherry acreage. The function also indicates that a one acre change in the previous year's tart cherry acreage change current acreage positively by .90 acres. The correlation of multiple determination .99 means that this function explains about 99 percent of the variation in tart cherry acreage.

Coefficient of Adjustment

The geometric model postulates that actual acreage (A_t) adjusts over time to the desired level (A_t^*), and that such an attempt is only partially successful during any one year period. The possible explanation of this includes technological constraints, biological constraints, institutional rigidities, uncertainty of long run profits and persistence of habits, etc.

It is interesting to see how many years are required for the growers to adjust their acreage to the long run equilibrium level and what is the shape or locus of the adjustment time path. According to Nerlove and Addision's adjustment formula[25]

$$(1 - r)^t \leq .1$$

[25]Nerlove, M., and W. Addision, "Statistical Estimation of Long Run Elasticities of Supply and Demand," Journal of Farm Economics, Vol. 40, No. 1-4, 1958, pp. 861-880.

where, r is the coefficient of adjustment and t is the number of periods required for adjustment and .1 indicates the adjustment made within ten percent of the desired level.

The estimated coefficient of adjustment (r) from the selected partial adjustment model equals .09041 indicating that the growers require about 24 years to adjust to within ten percent of the long run equilibrium acreage.[26] The adjustment time path is shown in Figure 4.1. The vertical axis shows the acreage difference between time t and (t-1) while the horizontal axis represents the time period.

Elasticities

As shown in Table 4.2, all gross margin elasticities are estimated at the respective means over the sample period. The elasticity of tart cherry acreage with respect to its gross margins derived from the two models presented above ranges from .009 to .010 in the short run and from .082 to .108 in the long run.

The estimated cross elasticities of tart cherries with respect to the apple gross margins ranges from -.003

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[26] Computation of t: $(1 - .09041)^t \leq .1$

$$(.90959)^t \leq .1$$
$$t \leq \log(.1) / \log(.90959)$$
$$t \leq 24.30$$

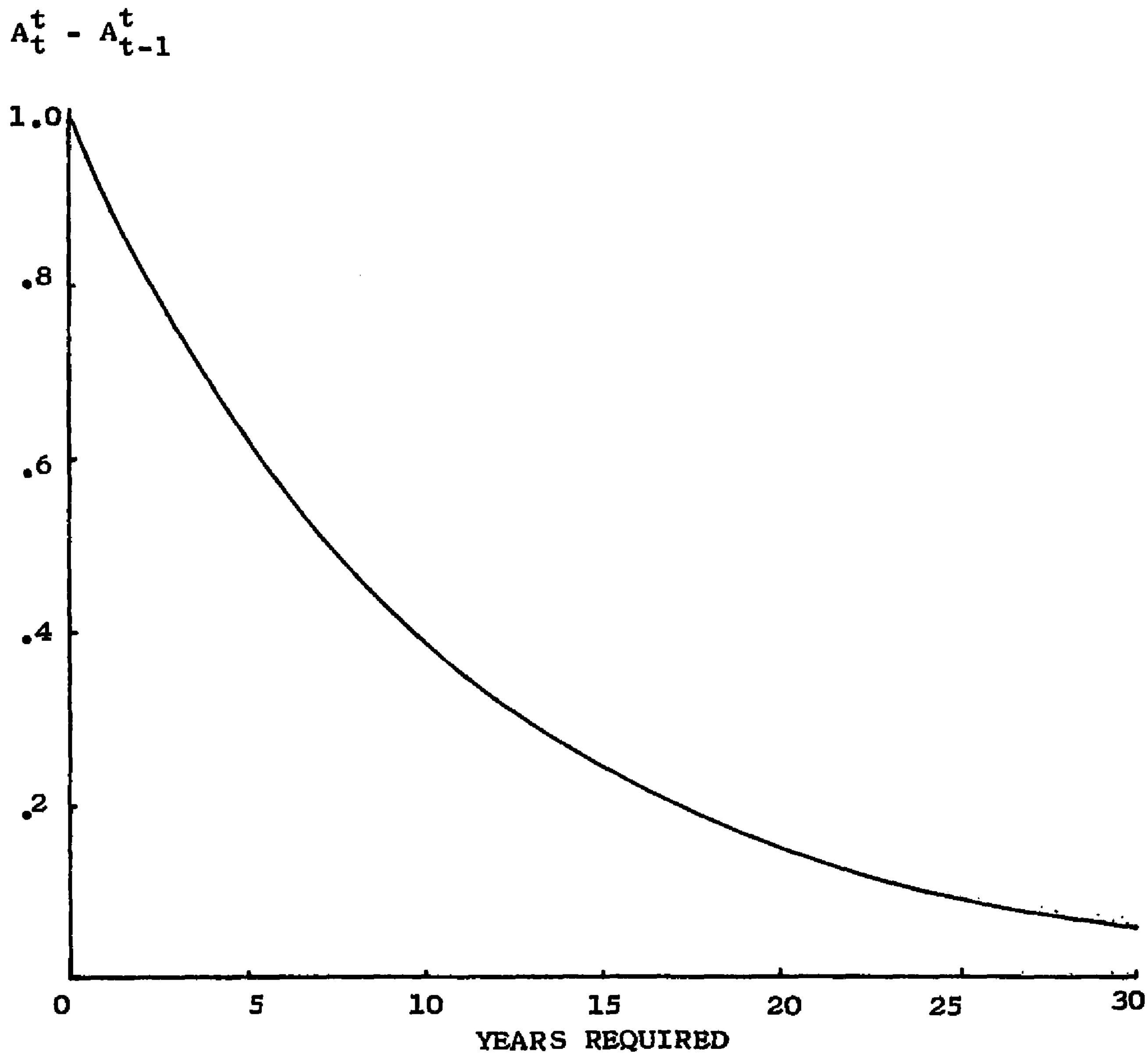

Figure 4.1, Adjustment Time Path for Tart Cherry Acreage in Michigan

Table 4.2, Estimate of Short and Long-run Elasticities of Tart Cherry Acreage Response[1]

Equation Number	Estimation Technique	Elasticities with respect to $GM^{t}_{(t-6)}$ Short-run	$GM^{t}_{(t-6)}$ Long-run	$GM^{a}_{(t-6)}$ Short-run	$GM^{a}_{(t-6)}$ Long-run	$GM^{sw}_{(t-6)}$ Short-run	$GM^{sw}_{(t-6)}$ Long-run	$A_{(t-1)}$
(4.1)	OLS	.01037	.10818	-.00306	-.03194	-.01340	-.13977	.91337
(4.2)	CORC	.00876	.08235	-.00394	-.03704	-.01137	-.10688	.90154

[1]Estimated at means for the sample period.

GM^{j}_{t-6} = Gross margins of jth fruit per acre lagged six years from time t in real dollars, (j=t, a, and sw for tart cherries, apples, and sweet cherries, respectively);

A^{t}_{t-1} = Previous year's tart cherry bearing acreage.

to -.004 in the short run and from -.032 to -.037 in the long run. The cross elasticity of sweet cherry gross margins is from -.0114 to -.0134 in the short run and from -.1069 to -.1398 in the long run. The estimated elasticity for each of the gross margins is very inelastic, This means the growers have a relatively insensitive response on tart cherry acreage with respect to the variation of gross margins. However, the long run elasticities, as is the case, appear to be slightly higher than the short run elasticities because some economic, institutional, behavioral and technical constraints which hindered the acreage adjustment in the short run are eased in the longer run.

The inelastic response in the tart cherry acreage with respect to its gross margins may also be explained by the fact that growers are very careful in making their long term production commitments. For instance, when the gross margin is low the growers will not immediately reduce their acreage, rather, they tend to keep the variable costs at a minimum, and hope the profit will rise again in the future. The reverse is true when the profit is rising; the growers tend to wait and not to take immediate actions to expand the size of operation, because they suspect the profit may drop in the future.

To visualize how accurately the selected model

(Equation 4.2), in an overall perspective, can reproduce the observed past, the observed values and the predicted values using Equation (4.2) are shown in Table 4.3 and in Figure 4.2. For the estimated acreage, each dot represents a six-year average centered on the years specified.

By feeding the past values of the variables into the system and upon comparing the output of the model with those actually observed, a judgement can be made. Although the estimated supply model does not explain much of the year to year change in acreages, it does explain most of the long run variation in average levels of acreage that are of bearing age. For the estimated model, it can be concluded safely that the tracking ability and the reliability of Equation (4.2) are highly satisfactory.

Table 4.3 Comparison of Observed and Predicted Acreage of Michigan Tart Cherries, 1949 - 1976

Year	Observed Acreage	Predicted acreage
1949	29,300	29,119
1950	30,100	30,234
1951	31,300	31,083
1952	32,200	32,568
1953	33,500	33,572
1954	34,800	34,846
1955	36,300	36,295
1956	37,700	37,870
1957	39,800	39,157
1958	41,300	40,669
1959	42,300	41,881
1960	42,100	42,566
1961	41,900	42,377
1962	41,700	41,863
1963	41,000	41,424
1964	40,600	40,874
1965	40,100	40,558
1966	40,100	40,070
1967	40.500	39,739
1968	40,100	40,036
1969	40,000	39,727
1970	39,500	39,552
1971	39,100	38,897
1972	39,100	38,587
1973	38,500	38,594
1974	37,900	38,233
1975	37,400	37,803
1976	37,500	37,324

Figure 4.2, Actual Versus Predicted Tart Cherry Bearing Acreage Using Partial Adjustment Model

Polynomial Distributed Lag Model

In applying the polynomial distributed lag model, an a priori specification of the degree of polynomial with the constraints of the weight distribution must be selected.

In order to select an appropriate degree of the polynomial, a second, third, and fourth-degree polynomial models were estimated. The results indicate that the distributions of the estimated coefficients for the third and fourth-degree are nearly identical; both have skewed distributions with near zero and small negative coefficients in the first three lagged periods. The lag coefficients for the second-degree polynomial appear to have negative and small coefficients in the first two lagged periods but are more symmetrically distributed over the entire lagged periods than other degrees of polynomial. A plot of the coefficients representative of the second, third and fourth-degree polynomial is shown in Appendix C Figure C.1.

In this study a second-degree polynomial was selected because: (1) the structure of the coefficient distribution was conceptually similar to other degrees of polynomial, (2) it has more degrees of freedom than the higher order polynomials, and (3) the distribution of the coefficients seemed to be more compatible with the pattern of the cherry growers tree planting decisions.

The selected constraint for the lag distribution is such that it forces the weights at the last period of the lag to be zero. This constraint is selected to reflect the growers' behavioral characteristics which suggests that profits in some distant past period cease to influence their planting decisions in the present.

The third specification is the length of the distributed lag. Since the length of the lag is not known in advance, several experiments with a range of lag length have been conducted. Some important criteria used for the selection of the length of lag are: how well the lag shape fits with economic theory, the associated R^2 values, and the t-statistic of each lagged coefficient.

When ordinary least squares methods were employed, the results appeared to have serial correlation errors and the R^2 values were quite small. These results are shown in Appendex C.1. The equations were corrected for serial correlation, using a technique which combines the ordinary least squares and the Cochrane-Orcutt iterative methods.[27]

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[27] Bronuyn H. Hall, "Time Series Processor," Version 2, Harvard Institute of Economic Research, Technical Paper Series, Combridge, Massachusetts, Dec. 1976.

The results were encouraging.

From among the ten different lengths of lags estimated for Michigan tart cherry acreage response, the shorter distributions frequently have kinks with larger negative weights at the beginning period. For the longer distributions this characteristic diminishes and a smooth and more symmetric curve is formed.

As shown in Table 4.4, the R^2 value of each estimate increases with the lag lengths, contributing more explanatory power to the variables. The R^2 value reaches maximum at the lag length of 12 periods then declines as more periods are added.

Of these estimates, the ones with 11, 12, 13 and 14 lag lengths appear to be equally good. There is not much difference among their R^2 values; all exceed .99 and the structures of the lag shape conform with a priori expectations. The shape for lag lengths of 9 (from t-6 to t-14) through 14 (from t-6 to t-19) years are shown in Figure 4.3.

The Durbin-Watson statistics for all estimates indicate that the error terms may be autocorrelated except for those with lag lengths of 12 and 13 periods. The Durbin-Watson test indicates that the hypothesis of no serial correlation for these two estimates should not be rejected at the .05 percent level of significance (d_1=1.05, and d_u=1.33).

Table 4.4, Tart Cherry Gross Margin Distributed Structual Coefficients for Second Degree Polynomial

Vari-able	Length of Distributed Lag						
	9	10	11	12	13	14	15
C	39.5175	39.2804	38.9704	38.6388	38.3796	38.2022	38.0466
t-6	-.00068	-.00063	-.00067	-.00057 (1.53)	-.00046	-.00026	-.00006
-7	.00036	.00047	.00045	.00044 (1.43)	.00043	.00051	.00059
-8	.00113	.00132	.00133	.00126 (4.30)	.00116	.00116	.00115
-9	.00163	.00191	.00198	.00189 (6.10)	.00173	.00168	.00161
-10	.00185	.00224	.00240	.00233 (7.01)	.00215	.00208	.00196
-11	.00180	.00231	.00258	.00257 (7.43)	.00242	.00235	.00222
-12	.00147	.00212	.00253	.00262 (7.64)	.00254	.00249	.00237
-13	.00087	.00167	.00225	.00248 (7.74)	.00250	.00251	.00243
-14		.00096	.00173	.00215 (7.80)	.00231	.00240	.00238
-15			.00098	.00163 (7.82)	.00196	.00217	.00224
-16				.00091 (7.83)	.00146	.00182	.00199
-17	Figures in parenthesis are t statistics				.00081	.00134	.00164
-18						.00073	.00120
-19							.00065
R^2	.9818	.9864	.9901	.9918	.9909	.9907	.9893
d.w.	.6771	.9891	1.2277	1.3617	1.4070	1.1513	1.0848
$\bar{R}^2$	.9804	.9854	.9893	.9912	.9902	.9900	.9885
Average t value	2.3237	3.5742	4.8926	5.7797	5.499	5.5843	5.1665

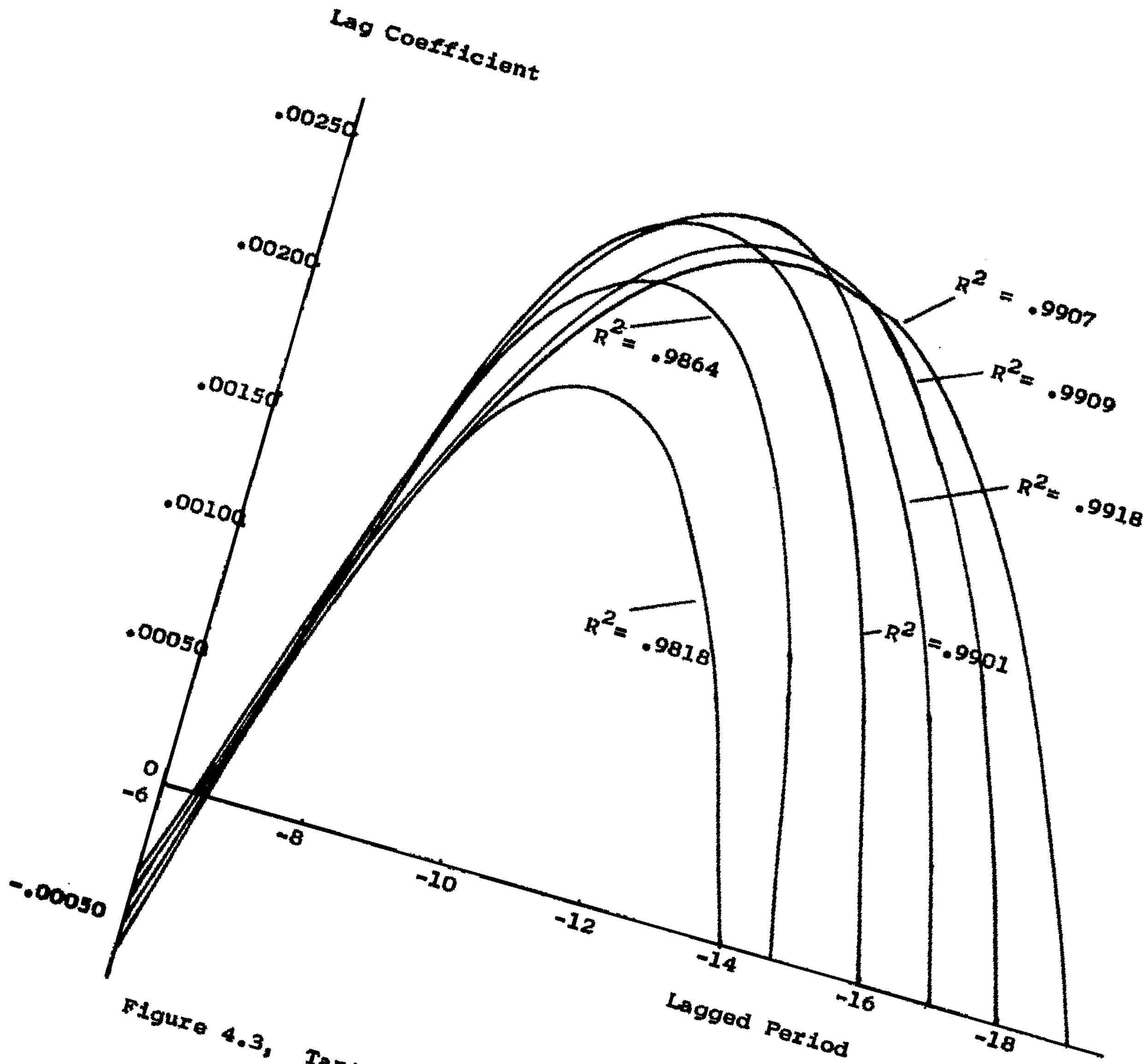

Figure 4.3, Tart Cherry Gross Margin Distributed Weights

In view of the slight difference among their R^2 values and close similarity of the lag shapes, selection among them becomes very difficult. However, the one with the lag length of 12 seems to be the best by using the R^2 criterion even though its value is only slightly larger than the other. The values of the t statistics for the lagged tart cherry gross margins range from 1.43 to 7.83 and average at 5.7797, indicating the distributed lag coefficients for this function are quite significant, and the average t statistics indicate they are significantly different from zero at the one percent probability level.

The lag coefficients of the selected 12 period (from t-6 to t-17) distribution is roughtly symmetric centered around the 12th lagged period, or six years prior to planting.

The maximum degree of growers' response occurs within 10 to 13 lagged years. In all cases the grower's response started with negative, increasing steadily to a maximum and declining toward zero response at the end of the period.

A plausible interpretation for the negative coefficient in the beginning period might be that growers tend to respond in a cautious manner. High gross margins stimulated plantings but high gross margins in the current period may serve to warn growers of possible impending increases in production when the new trees reach the bearing age and result in low prices.

The empirical evidence indicates that the growers tend to emphasize the gross margins 3 years to 6 years prior to planting seasons. They may be conservative in making planting decisions immediately after the change of gross margins. However, a discussion with the knowledgeable industry leaders in Michigan indicates that this might not seem to agree with the real situation. They feel that the weight distribution should start with some positive value for the most recent year. The hypothesis is that growers tend to place heavier weight on responding immediately to the gross margins during the first 4 to 6 years and then decline rapidly toward the end of the period around 10 to 12 years. This would conform more to the geometric lag model than the estimated polynomial lag model.

The estimated regression coefficients for the selected polynomial distributed lag model are represented by the following equation:

$$A_t = 38.6388 - \underset{(1.531)}{.00057}GM^t_{t-6} + \underset{(1.433)}{.00044}GM^t_{t-7} + \underset{(4.298)}{.00126}GM^t_{t-8}$$

$$+ \underset{(6.104)}{.00189}GM^t_{t-9} + \underset{(7.005)}{.00233}GM^t_{t-10} + \underset{(7.432)}{.00257}GM^t_{t-11}$$

$$+ \underset{(7.640)}{.00262}GM^t_{t-12} + \underset{(7.744)}{.00248}GM^t_{t-13} + \underset{(7.797)}{.00215}GM^t_{t-14}$$

$$+ \underset{(7.822)}{.00163}GM^t_{t-15} + \underset{(7.833)}{.00091}GM^t_{t-16} \qquad (4.3)$$

$R^2 = .9918$

d.w. = 1.3617

u = .0578

Figures in parenthesis are t statistics of the coefficients. GM^t_{t-i} represent the gross margins of tart cherries per acre in time (t-i) in dollars per acre.

The predicted and the actual acreage are depicted in Figure 4.4. As shown in this figure, the forecasting ability of Equation (4.3) is quite poor eventhough its R^2 value exceeds .99. Essentially this is due to high auto-correlation resulting from specification errors.

Equation (4.3) was expanded to include two other variables, one is the previous years acreage (A_{t-1}) and the other is the average gross margins of the competing fruits per acre (GM^c_{t-6}). Competing fruits include apples and sweet cherries. The preliminary results of this estimate are shown in Table 4.5 and are graphically demonstrated in Figure 4.5.

Inclusion of the previous year's acreage and the average gross margins of the competing fruits reduce

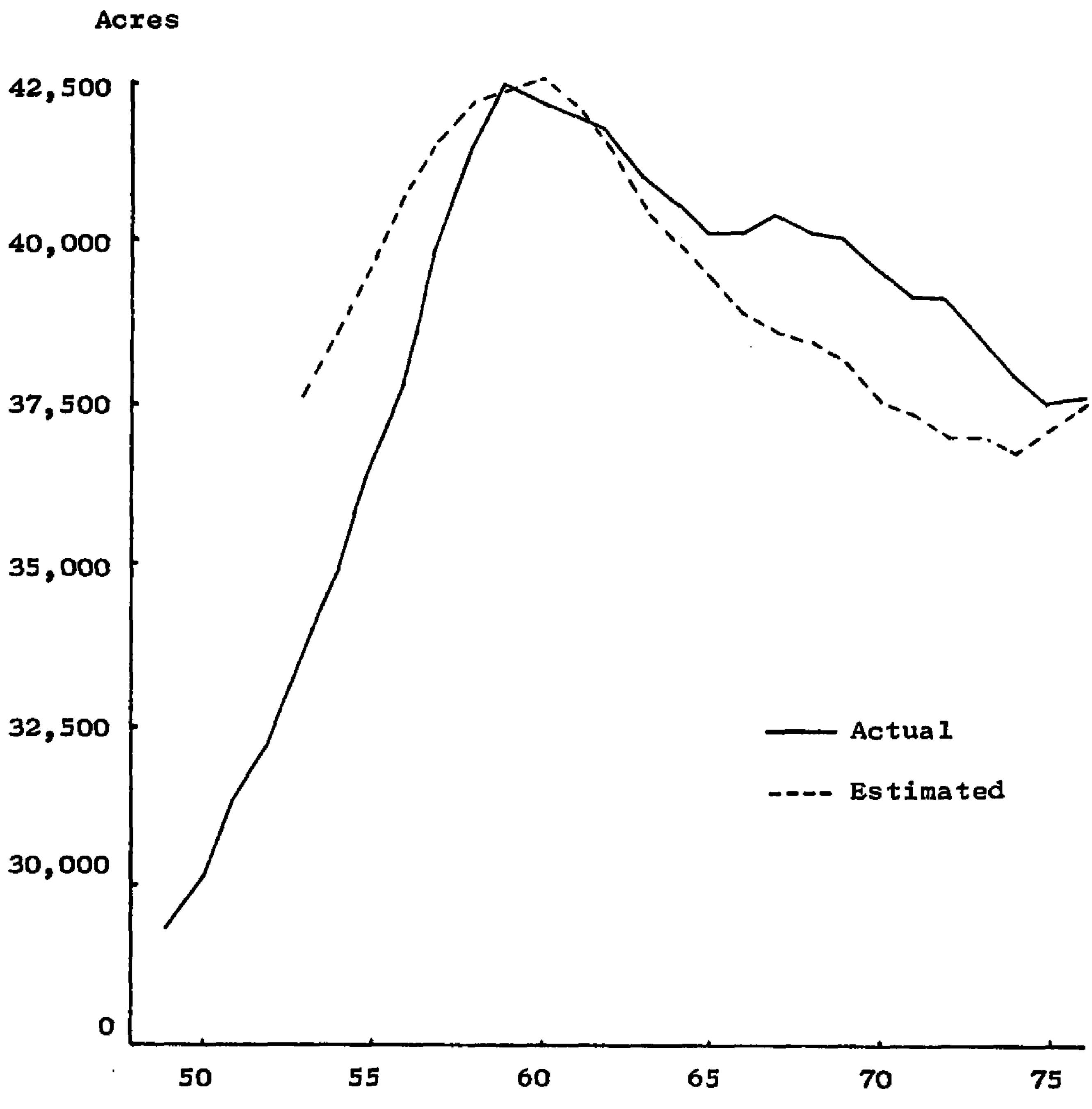

Figure 4.4, Actual Versus Predicted Tart Cherry Bearing Acreage Using Tart Cherry Gross Margins Estimated From a Polinomial Lag Model

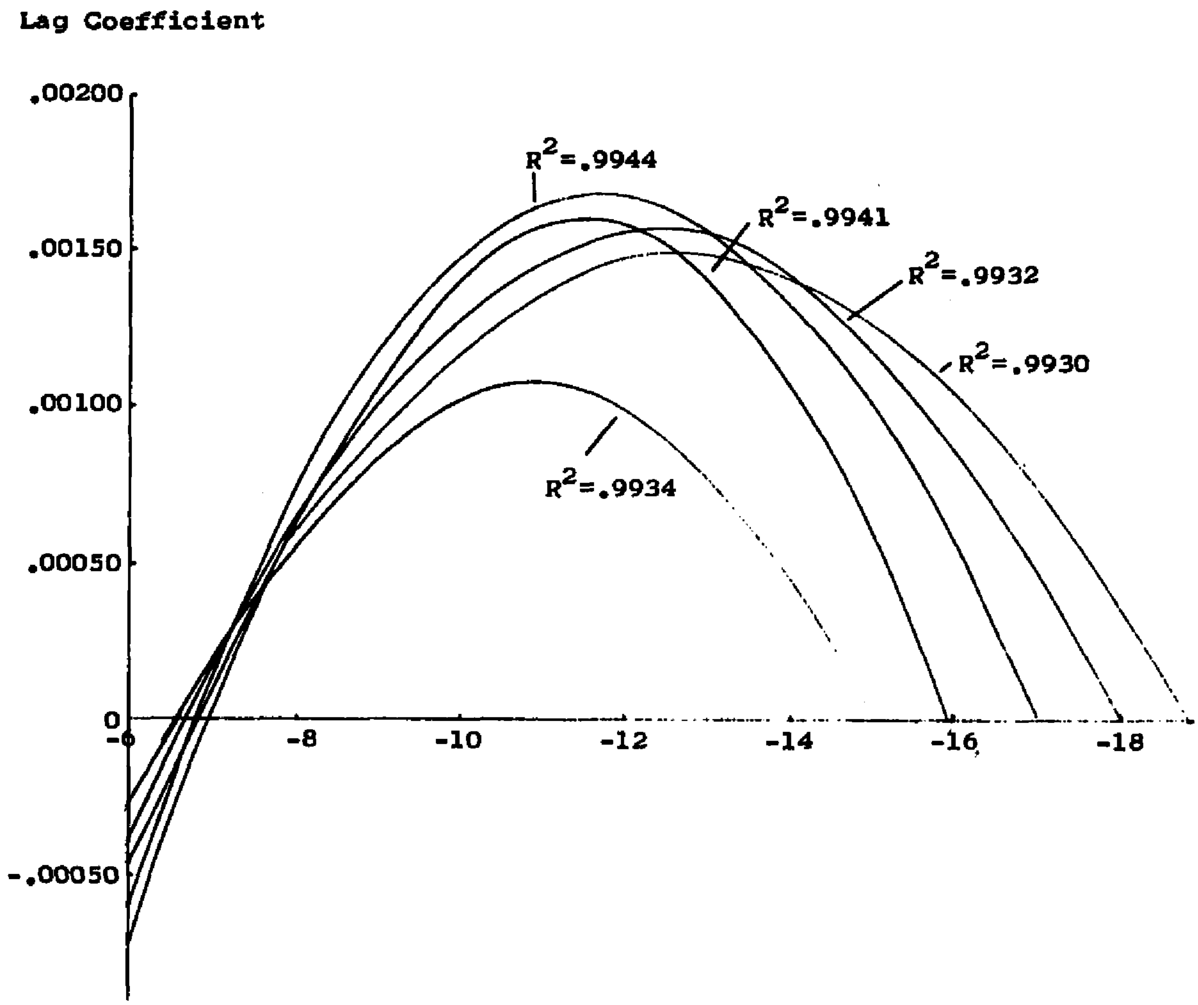

Figure 4.5, Tart Cherry Gross Margin Distributed Weights in Association with other Selected Variables

Table 4.5, Tart Cherry Gross Margin Distributed Coefficients in Association with other Selected Variables

Vari-able	Length of Distributed Lag				
	10	11	12	13	14
C	7.60927	19.5715	22.2498	22.1718	21.4160
A_{t-1}	.79333	.48569	.41447 (3.38)	.41472	.43208
GM^c_{t-6}	-.00006	-.00020	-.00017 (.67)	-.00018	-.00010
GM^t_{t-6}	-.00043	-.00072	-.00063 (1.77)	-.00051	-.00031
t- 7	.00011	.00005	.00007 (.27)	.00008	.00017
- 8	.00053	.00066	.00065 (2.44)	.00057	.00057
- 9	.00082	.00112	.00109 (3.55)	.00095	.00090
-10	.00100	.00142	.00141 (3.97)	.00125	.00116
-11	.00105	.00157	.00160 (4.14)	.00144	.00133
-12	.00097	.00156	.00166 (4.22)	.00153	.00143
-13	.00077	.00140	.00158 (4.25)	.00152	.00146
-14	.00045	.00109	.00138 (4.27)	.00142	.00140
-15		.00062	.00105 (4.28)	.00121	.00128
-16			.00059 (4.28)	.00091	.00107
-17	Figures in parenthesis are t statistics			.00050	.00079
-18					.00043
R^2	.9934	.9941	.9944	.9932	.9930
d.w.	2.45	2.63	2.37	2.20	1.91
$\bar{R}^2$	.9926	.9934	.9938	.9924	.9922
Average t value	3.39	3.08	3.08	2.47	2.43

possible autocorrelation errors as compared to Equation (4.3). The selected equation is

$$\begin{aligned} A_t = 22.2498 &+ \underset{(3.380)}{.41447A_{t-1}} - \underset{(.669)}{.00017GM^c_{t-6}} - \underset{(1.771)}{.00063GM^t_{t-6}} \\ &+ \underset{(.2708)}{.00007GM^t_{t-7}} + \underset{(2.440)}{.00065GM^t_{t-8}} + \underset{(3.545)}{.00109GM^t_{t-9}} \\ &+ \underset{(3.970)}{.00141GM^t_{t-10}} + \underset{(4.140)}{.00160GM^t_{t-11}} + \underset{(4.215)}{.00166GM^t_{t-12}} \\ &+ \underset{(4.250)}{.00158GM^t_{t-13}} + \underset{(4.267)}{.00138GM^t_{t-14}} + \underset{(4.276)}{.00105GM^t_{t-15}} \\ &+ \underset{(4.279)}{.00059GM^t_{t-16}} \qquad (4.4) \end{aligned}$$

$R^2 = .9944$

d.w. = 2.3717

U = .0279

Figures in parenthesis are t statistics of the regression coefficients.

where, A_{t-1} = previous years bearing acreage of tart cherries.

GM^c_{t-6} = average gross margins of competing fruits (apples and sweet cherries) in time (t-6) in dollars per acre.

GM^t_{t-i} = gross margins of tart cherries in time (t-i) on dollars per acre.

The value of the t statistics for the gross margins of tart cherries averages at 3.4, indicating the distributed lag weights for Equation (4.4) are significantly different from zero at the 5 percent probability level.

The forecasting ability of Equation (4.4), as graphically shown in Figure 4.6, also shows an improvement over Equation (4.3) and is more satisfactory.

It is interesting to explore the growers' response to the gross margins of competing fruit along with the gross margins of tart cherries over the distributed lag periods, 12 years. Again, this equation is estimated by means of the Cochrane-Orcutt iterative techiniques to avoid possible serial correlation errors induced by the lagged dependent variable.

The results are shown in Table 4.6. The distributed coefficients associated with the competing fruits are all negative, except for the one for thefirst period. The coefficient for the first period, as indicated by its t-statistic, is not significantly different from zero.

The largest coefficient for tart cherry gross margins appears in the 12th lagged period which is the same period in which the competing fruit coefficient is at the low point. The distributions are also roughly symmetic over the entire distributed lag periods, higher coefficients for tart cherry gross margins are associated with lower coefficients for competing fruits as seen in Figure 4.7.

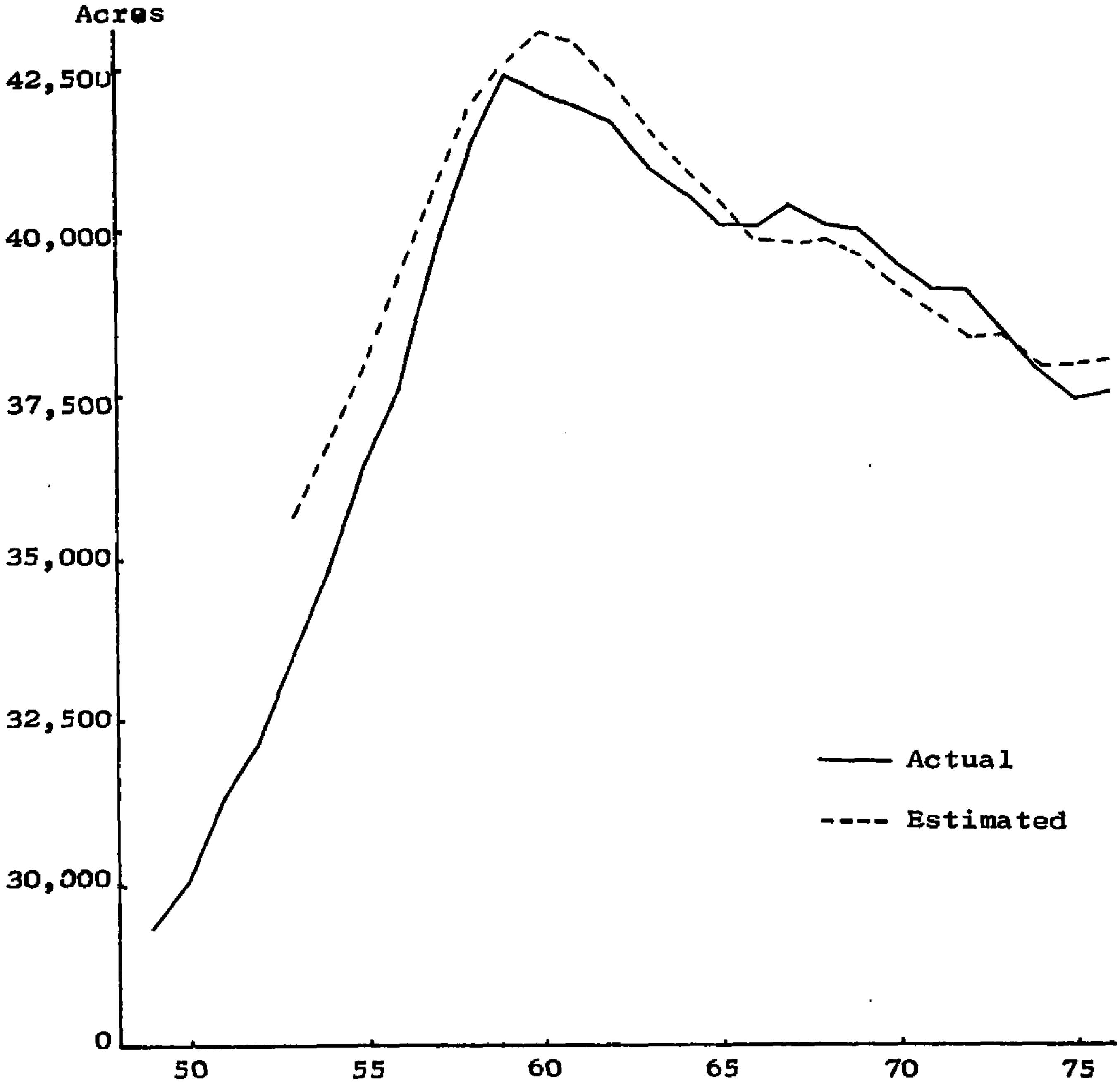

Figure 4.6, Actual Versus Predicted Tart Cherry Bearin
Acreage Using Tart Cherry Gross Margin and
Other Selected Variables Estimated from a
Polynomial Lag Model

Table 4.6, Polynomial Distributed Lag Model for Tart Cherry Acreage using Tart Cherry and Competing Fruit Gross Margins (Equation 4.5)

Time Period	Regression Coefficients and t-values for:			
	(GM^t_{t-i}) Tart cherry gross margins		(GM^c_{t-i}) Competing fruit gross margins[1]	
t- 6	-.00045	(-1.300)	.00004	(.1161)
- 7	.00035	(1.248)	-.00061	(-1.560)
- 8	.00099	(3.496)	-.00113	(-2.279)
- 9	.00148	(4.559)	-.00152	(-2.588)
-10	.00182	(4.965)	-.00178	(-2.743)
-11	.00201	(5.124)	-.00191	(-2.833)
-12	.00206	(5.188)	-.00192	(-2.890)
-13	.00195	(5.214)	-.00179	(-2.929)
-14	.00169	(5.223)	-.00154	(-2.957)
-15	.00127	(5.224)	-.00115	(-2.978)
-16	.00071	(5.221)	-.00064	(-2.994)
Average	-	(4.011)	-	(2.416)

Constant = 41.4116

R^2 = .9942

$\bar{R}^2$ = .9935

d.w. = 1.8332

U = .0761

[1] Including apples and sweet cherries.

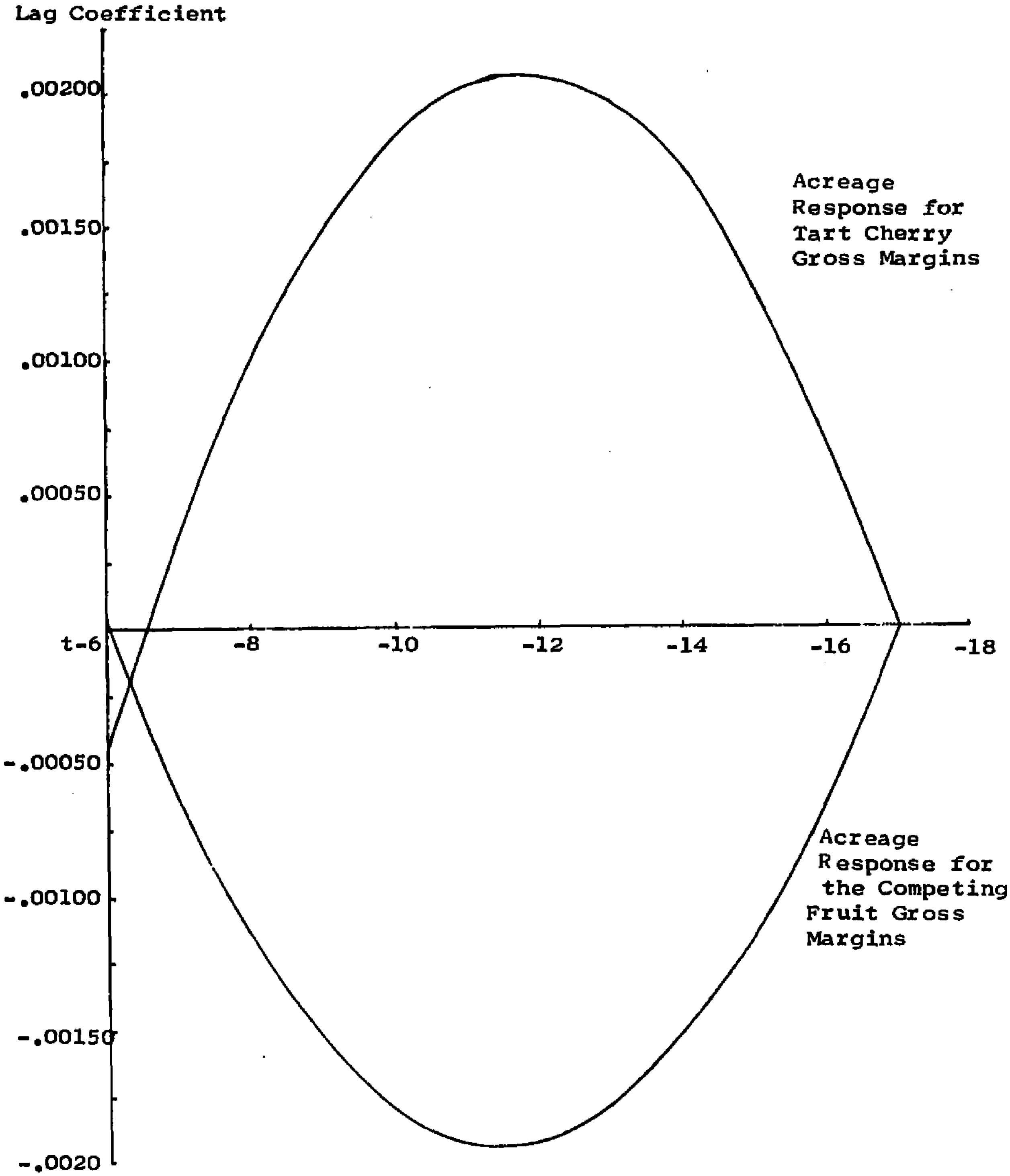

Figure 4.7, Distributed Cefficients for Tart Cherry Gross Margins and the Competing Fruit Gross Margins

This implies a fairly even pace for completion of adjustments to changes of tart cherry gross margins as to changes of competing fruit gross margins. These empirical results appear to capture the growers' response pattern in making planting decisions among competing enterprises.

These distributions yield a coefficient of multiple determination of .9942, indicating that nearly all changes in the tart cherry bearing acreage can be explained by changes in the gross margins of tart cherries and the competing fruits over the 12-year period prior to planting.

The values of the t statistics indicate the distributed coefficients are significantly different from zero at the one percent and five percent probability levels for tart cherries and apples, respectively.

For the purpose of comparison, the forecasting ability of this equation is demonstrated in Figure 4.8. The results were unsatisfactory particularly in the beginning period.

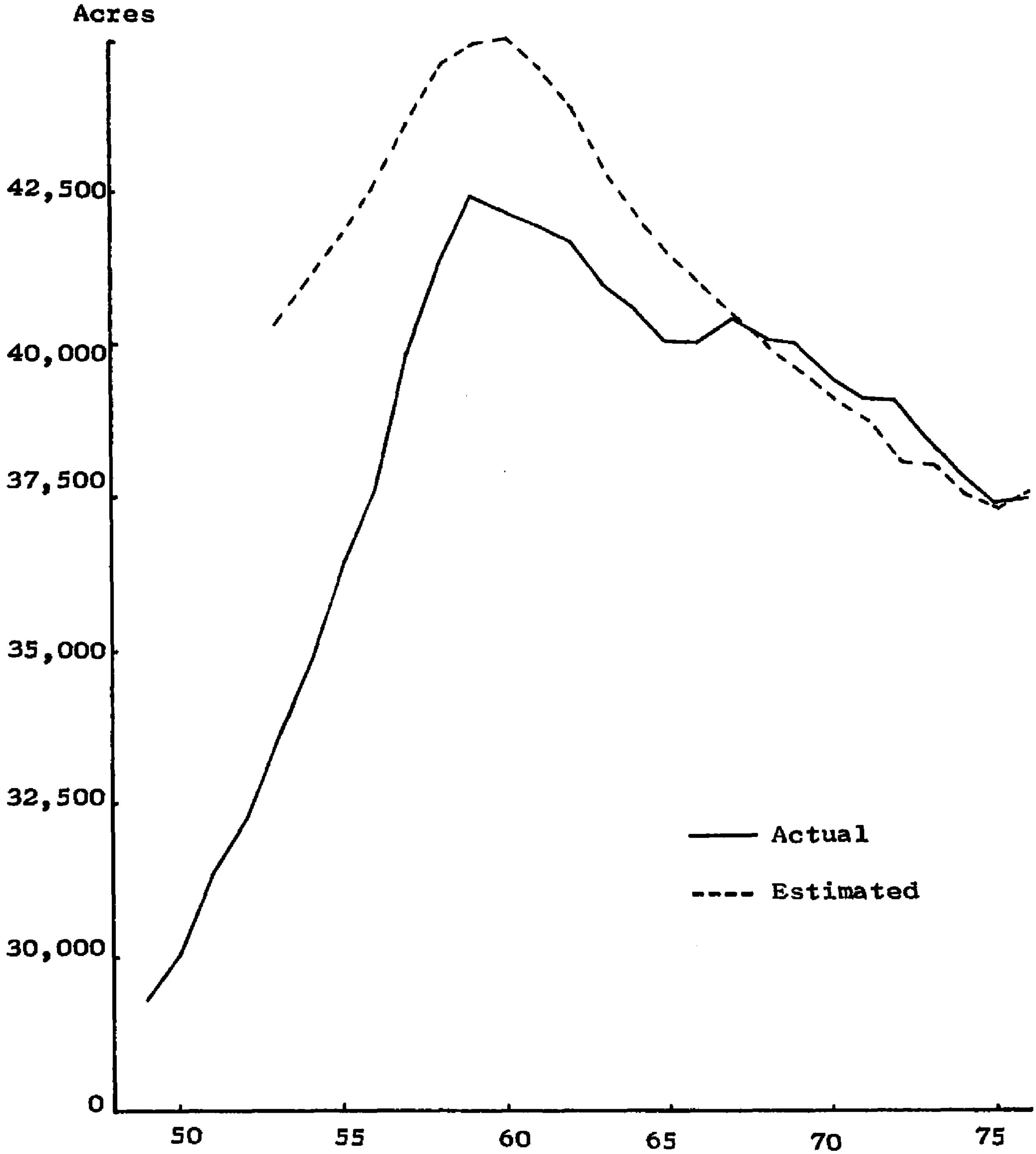

Figure 4.8, Actual Versus Predicted Tart Cherry Bearing Acreage Using Tart Cherry and Competing Fruits Gross Margins Estimated from a Polynomial Lag Model

SUMMARY

Five different models have been estimated for Michigan's tart cherry acreage response, two for geometric lag models and three for the polynomial distributed lag models.

For the geometric lag models, the new disturbance E_t is correlated with the lagged dependent variable because the lagged dependent variable is used as one of the independent variables. Applying the ordinary least squares for this formulation the estimates of the coefficients (Equation 4.1) will be biased and inconsistent. However, if the error term is a normally distributed random variable with mean zero and variance σ^2, using the ordinary least squares method can yield consistent and asymptotically efficient estimates of the coefficient[28]. If the error term does not meet the standard assumption and is serially correlated, the ordinary least squares method would yield inconsistent estimates.

In the geometric lag models, the lagged dependent

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[28]Kmenta, op. cit., p. 279.

variable (A_{t-1}) is used as an explnatory variable. This leads to a problem of testing the hypothesis of no serial correlation because the Durbin-Watson statistic is not applicable. The test statistic "h" is then used in place of the Durbin-Watson statistic, however this is for large samples only. The results of the "h" test show Equation (4.1), estimated by using the ordinary least squares, present serial correlation errors at the 20 percent level. As mentioned previously, the properties of h-statistics for small samples are not known.

The estimates for Equations (4.2) estimated by the Cochrane-Orcutt iterative techniques corrected the error term E_t. The process is that all data are transformed by ρ such as:[29]

$$(A_t - \rho A_{t-1}) = K(1 - \rho) + K_1(GM^i_{t-1} - \rho GM^i_{t-2})$$

$$+ K_2(A_{t-1} - \rho A_{t-2}) + E_t$$

and regression is estimated from the transformed data. So, the estimated coefficients will not have serial correlation errors.

As for the polynomial distributed lag models,

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[29] Ibid., p. 287.

Equations (4.3), (4.4) and (4.5), the important advantage is that it could show how the magnititude of multiple lag structures are distributed over certain lengths of lagged periods. This model permits inclusion of more than one lagged variable and each variable may have different lengths of lags. Another advantage of the polynomial lag model is that it does not induce serial correlation errors.

Polynomial distributed lag techniques like other models have some disadvatages. The high correlation between the lagged variables some times makes it difficult to estimate reliable coefficients. The polynomial degree is not known in advance. If the distributed coefficients fo not lie on the a priori specified degree of polynomial a serial correlation problem may be induced due to specification errors.

Another problem involved in the polynomial lag model is the selection of zero restrictions or constraints in weight distributions. Selection of the constraint requires a considerable knowledge regarding the industry as a whole. For example, in this study the selected restriction is to force the weight in the last period to be zero, and hope the weights for the beginning period will have certain positive coefficients if such are believed to be realistic a priori. Some close to the industry believe that gross margins in the first lagged period enter into their planting decisions. Unfortunately, the estimated coefficient in the first period appears to be negative. It is not clear which captures the true relationship.

All estimated models have their advantages and disadvantages. From a conceptual point of view none were superior to any others. For the purpose of this study, Equation (4.2), the geometric lag model estimated by the Cochrane-Orcutt iterative techniques, was chosen as most adequate due to its ability to explain facts empirically and its applicablity for future predictions.

CHAPTER V

DEMAND MODEL FOR TART CHERRIES

Specification of the Model

During the formulation process of an economic model designed to analyze long-term trends of the demand for tart cherries, certain value judgements in the selection of the relevant variables in concurrence with the economic theory underlying that model are generally involved.

Conceptually, a demand model for tart cherries can be conceived in a way similar to that of any other consumer good. The functional form of the demand for tart cherries can be expressed as follows:

$$P_t = f(Q_t^t,\ S_t,\ PDI_t,\ POP_t,\ CPI_t,\ Q_t^t,\ X_t,\ T,\ e_t)$$

For estimation purposes, price is considered here as a dependent variable. This is with the assumption that other variables affect the price of tart cherries, but they are not influenced by the tart cherry prices in return during the same period. It means that the farm price of tart cherries in a given period (P_t) is functionally related to the total production of tart cherries sold in the United States during the same period (Q_t), disposable income of consumers (PDI_t), United States population (POP_t), the consumer price index (CPI_t), consumption of the competing product - frozen apples (Q_t^c), carryover stocks of processed tart cherries from the previous year's crop (S_t^t) as surplus cherries reflect the level of stocks which are to be added to the following year's total supply, tart cherry exports (X_t), and time variable (T).

Tart cherries are mostly canned or frozen for pies and other bakery products. The amount of tart cherries for fresh use, according to the Crop Reporting Board, USDA, accounted for just over 1 percent of the total production. Therefore, in this analysis, all tart cherries are considered for processing use.

The coefficients of the demand model will be derived from annual data for the 22-year period from 1955, through 1976. The main reason for using the data covering this period is due to the fact that the utilization of tart cherries have formed more distinct patterns within this time period. As can be seen in Figure 2.3, a pattern of tart cherry disposition following a steady set of trends among all uses was formed in mid 1950's. The steady increase in the ratio of frozen cherries reflects the growing demand for convenience food such as cherry pies. If a shorter period for data is used, the estimated model due to lower degrees of freedom may not adequately embrace some forces that prevail into the future and thus make the long term projections inaccurate. While if a substantially longer period is used some factors that were important in the past but are no longer important currently, will materially alter the results obtained.

Empirical Results and Analysis of the Model

The demand function for tart cherries has been estimated with measurements in natural logarithmic forms. The Cochrane-Orcutt iterative techniques are applied to estimate the coefficients to minimize possible serial correlation errors.

The variable, United States population (POP_t), is not entered in the equation as a separate variable since all related explanatory variables are expressed in "per capita" (1,000 people) terms. The time variable (T) represents the taste and preference of consumers and the steady changes of other excluded factors over time, is being dropped because the variable of the consumer price index (CPI) carries strong trend impacts. The quantity of tart cherries exported (X_t) is also dropped from the equation because the historical data showed very insignificant quantities of tart cherry exports. The correlation matrix for the Michigan farm prices of cherries is shown in Appendix C, Table C.3.

The simple correlation between the consumer price index (CPI) and the per capita disposable income (PDI) was .98. Inclusion of these two variables as separate measurements will induce multicollinearity problems. However, multicollinearity problems in this study would not seem to produce serious damaging results because the major objective of this study is to construct a model for future projections. The simple correlations among other variables appear to be fairly low and should be of little concern to multicollinearity.

It should be noted that the main emphasis in this analysis is first in forecasting future cherry price and production levels, and secondly, in analyzing the separable effects of the independent variables. An entry or deletion of a new variable should be determined to be based on theoretical grounds as well as empirical observations. If the empirical results contradict with the economic theory, the decision will be geared by the objectives of the study.

The price, per capita disposable income, and the value of the competing fruit (frozen apples) consumed per person are in current dollars. Production figures are defined as the total U.S. of crop having value which is the quantity sold or utilized. This is estimated by subtracting the quantities not harvested for economic reasons and excess cullage of harvested fruit from the total production, and using only net production as having value per capita (1,000 people) as the production variable.

The empirical results of the estimated demand model, using Cochrane-Orcutt iterative techniques, are shown in Table 5.1. To evaluate the performance of the model, similar criteria as are used in evaluating the supply response models will be applied. These critiria are: (1) the estimated R^2, (2) the statistical significance of the coefficients of each of the variables, (3) the conformity to economic theory by the signs or the directions of influences of each explanatory variable upon the dependent variable, (4) the presence of serial correlation, and (5) Theil's inequelity coefficient.

Of the six demand equations presented in Table 5.1 the first three equations are estimated with nondeflated values, and the second three equations with deflated values in an attempt to take into account inflationary changes in the economy.

Table 5.1, Comparison of Estimated Demand Models for Michigan Tart Cherries

Equation No.	Constant	Q_t^t	S_t^t	Q_t^a	CPI_t	PDI_t	P_{t-1}^t	R^2	$\bar{R}^2$	d.w.	U
A. Nondeflated											
(5.1)	-1.91053	-1.22164[a]	-.61837[a]	-.02542[h]	-.76869[e]	.70083[c]		.963	.955	2.18	.0121
		(.1310)	(.0926)	(.2233)	(.7921)	(.4946)					
(5.2)	1.0770	-1.2066[a]	-.61548[a]	.06251[hx]	-.17527[d]	.3208		.961	.954	2.17	.0123
		(.1280)	(.0914)	(.1894)	(.1738)	-					
(5.3)	-1.1848	-1.2178[a]	-.6300[a]	.1686[fx]	-.6165[e]	.6182[c]	-.3417[hx]	.928	.904	2.02	.0125
		(.1441)	(.1346)	(.2696)	(.7644)	(.4756)	(.1431)				
B. Deflated											
(5.4)	8.534	-1.07695[a]	-.56883[a]		.29294[dx]	-.61708[bx]		.893	.874	1.91	.0159
		(.1456)	(.1120)		(.3204)	(.3673)					
(5.5)	-7.199	-1.17583[a]	-.60046[a]		-.22374[e]	1.3421		.750	.706	2.45	.0412
		(.1263)	(.0981)		(.27910)	-					
(5.6)	8.8008	-1.06025[a]	-.60514[a]	.28541[ex]		-.61375[bx]	-.0674[gx]	.891	.864	1.89	.0160
		(.1530)	(.1313)	(.3386)		(.39356)	(.13031)				

The dependent variable is the grower prices of tart cherries (P_t^t), in dollars per ton.

where P_{t-1}^t = the grower price of tart cherries in Michigan in year t-1 in dollars per ton, the lagged dependent variable.

Q_t^t = tart cherry production of value (Total production less economic abandoment) in the U.S., in year t, in tons per 1,000 people.

S_t^t = Tart cherry carryover stocks on April 1, in the U.S., in year t in tons per 1,000 people (expressed in raw product equivalent).

Q_t^t = Consumption of frozen apples in the U.S., in the year t, in pounds per 1,000 people (expressed in raw product equivalent).

CPI_t = Consumer Price index, in year t

PDI_t = U.S. per capita disposable income in year t, in dollars.
The figures in parentheses are standard errors of the regression coefficients.

Significant level of each coefficient: a = 1 percent; b = 10 percent; c = 20 percent; d = 30 percent; e= 40 percent; f = 50 percent; g = 60 percent; and h = over 80 percent.

x indicates the sign of the estimated coeffiecient is opposite to conceptual expectations.

The estimation procedure for Equations (5.2) and (5.5) must be explained here. The coefficients for the per capita personal disposable income in each of these two equations are adapted from previous studies made by Thompson and Butler,[30] and Ricks,[31] respectively.

In this study, both equations are estimated in

such a way that the pre-estimated variable with its coefficient is placed on the left hand side of the equation along with the dependent variable to compute the regression coefficients for other variables, such as:

$$P_t^t - K\ (PDI) = f(Q_t^t,\ S_t^t,\ Q_t^a,\ CPI,\ e\ )$$

where, K is the pre-estimated coefficient for the personal disposable income, After such a functional relationship has been estimated, the pre-estimated variable is then moved to the right hand side of the equation, such that

$$P_t^t = f(Q_t^t,\ S_t^t,\ Q_t^a,\ CPI) + K(PDI)$$

It is interesting to note the change of the R^2

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[30]Thompson, Stanly R. and L.J. Butler, "Price Relationships for Apples and Tart Cherries," Staff paper #77-41, Dept. of Agricultural Economics, Michigan State University, 1977.

[31]Ricks, Donald J., and David Amon, "Tart Cherry Market Information and Price Analysis," Agricultural Economics Report No. 291, Michigan State University, June 1975.

value improved from .897 to .961, but for Equation (5.5) it declined slightly from .786 to .750.

Of the six equations, Equations (5.2), (5.3), (5.4) and (5.6) are not acceptable because some variables in each equation have signs opposite to conceptual expectations resulting from multicollinearity and other specification errors. Equation (5.5) is also dropped due to a lower R^2 value and a relatively high U value. This leaves only Equation (5.1) for futher consideration. The coefficients for variables "consumption of frozen apples," (Q_t^a), and "Consumer price index," (CPO_t), in Equation (5.1) are found to be insignificant - significant at 90 percent and 40 percent levels, respectively. However, Equation (5.1) has the highest R^2 and $\bar{R}^2$ values and the lowest U value among all equations so that it is accepted as a good fit. The selected equation is functionally shown as:

$$\begin{aligned}\operatorname{Log}(P_t^t) = -1.91053 &- \underset{(.1310)}{1.22164} \log(Q_t^t) - \underset{(.0926)}{.61837} \log(S_t^t)\\ &- \underset{(.2233)}{.02542} \log(Q_t^a) - \underset{(.7921)}{.76869} \log(CPI_t)\\ &+ \underset{(.4946)}{.70083} \log(PDI_t) \qquad (5.1)\end{aligned}$$

$R^2 = .963$

$U = .0121$

d.w. = 2.18

Figures in parentheses are standard errors.

The calculated multiple correlation coefficient, R^2 is .963 which means that over 96 percent of the variation in the Michigan tart cherry grower prices is explanied by the variables included in the model. The remaining 4 percent of the variation is influenced by unknown factors. This is considered to be highly satisfactory.

The estimated regression coefficients for the production of tart cherries, and carryover stocks of tart cherries are significantly different from zero at the 1 percent level; the personal disposable income is significant at the 30 percent level and the remaining variables, consumption of frozen apples and the consumer price index are quite insignificant as discussed previously.

It should be noted that the significant test of the coefficients as a criterion for the selection of a variable should be geared to the economic theory. Certain variables may be retained in the model even though not significant but because they are belived to be relevant and carry the correct sign.

In the estimated demand model, all signs for each of the coefficients are in agreement with a priori anticipations. Ceteris paribus, a one percent increase in the total U.S. production of tart cherries (Q^t) is associated with a decrease of 1.22 percent in the grower price of tart cherries in Michigan; an increase in April 1 carryover stocks (S^t) in the U.S. of ten percent is associated with a decrease of 6.2 percent in the grower price of tart cherries in Michigan.

A ten percent increase in the per capita consumption of frozen apples in the U.S. (Q^a), will result in a decrease in the grower price of tart cherries by one-quarter of one percent in Michigan; an increase of one percent of the consumer price index (CPI), is associated with a decrease of .77 percent of grower price of tart cherries in Michigan. A change of 1 percent in the personal disposable income is associated with a change of the grower price by .7 percent in the same direction

The Durbin-Watson statistics of d.w. = 2.18 shows no serial correlation errors. The calculated Theil's inequality coefficient (U) at .0121 is highly satisfactory. As mentioned in Chapter III, the Theil's inequality coefficient should be used along with the R^2 of the estimated model to determine its performance in future projections. This is to say that a small value of U associated with a high R^2 is most desirable. The results indicate that there is a considerably high agreement between the actual observed values and the predicted values derived from the estimated model.

The tracking or forecasting ability of the model and the observed values are compared in Table 5.2 and depicted in Figure 5.1.

An important method of evaluating a model is to see how well it captures turning points in the historical trend. During the entire period over which the model is tested, the only turning point which is not very well captured by the model is in 1970 where the model predicts the price rise one period early. However, the error does not appear to be significant and thus should be of little concern in view of the models overall performance. It can be concluded that the ability of the model to make accurate market forecasts is quite high.

Michigan is the leading state in tart cherry production and is the price leader of all tart cherry producing states in the United States and Canada.[32] In recent years Canadian tart cherry prices have been determined in a manner that adds 3 cents per pound to whatever Michigan prices are. Apparently, the findings in this analysis can be applied to all other tart cherry producing states and Canada with few modifications.

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[32] A conversation with Robert C. Frohling, Excutive Secratary of the National Red Tart Cherry Institute.

Table 5.2, Comparison of Observed and Predicted Tart Cherry Grower Prices in Michigan, 1955 - 1976

Year	Observed Price	Predicted Price
	Dollars per ton	
1955	121	112.62
1956	149	161.59
1957	132	138.60
1958	163	174.48
1959	125	133.83
1960	154	163.48
1961	166	145.24
1962	95	87.40
1963	195	197.57
1964	101	109.45
1965	99	85.86
1966	280	220.00
1967	360	406.30
1968	300	256.43
1969	152	150.64
1970	143	203.31
1971	198	198.14
1972	161	178.28
1973	390	368.24
1974	367	326.50
1975	203	229.02
1976	507	457.34

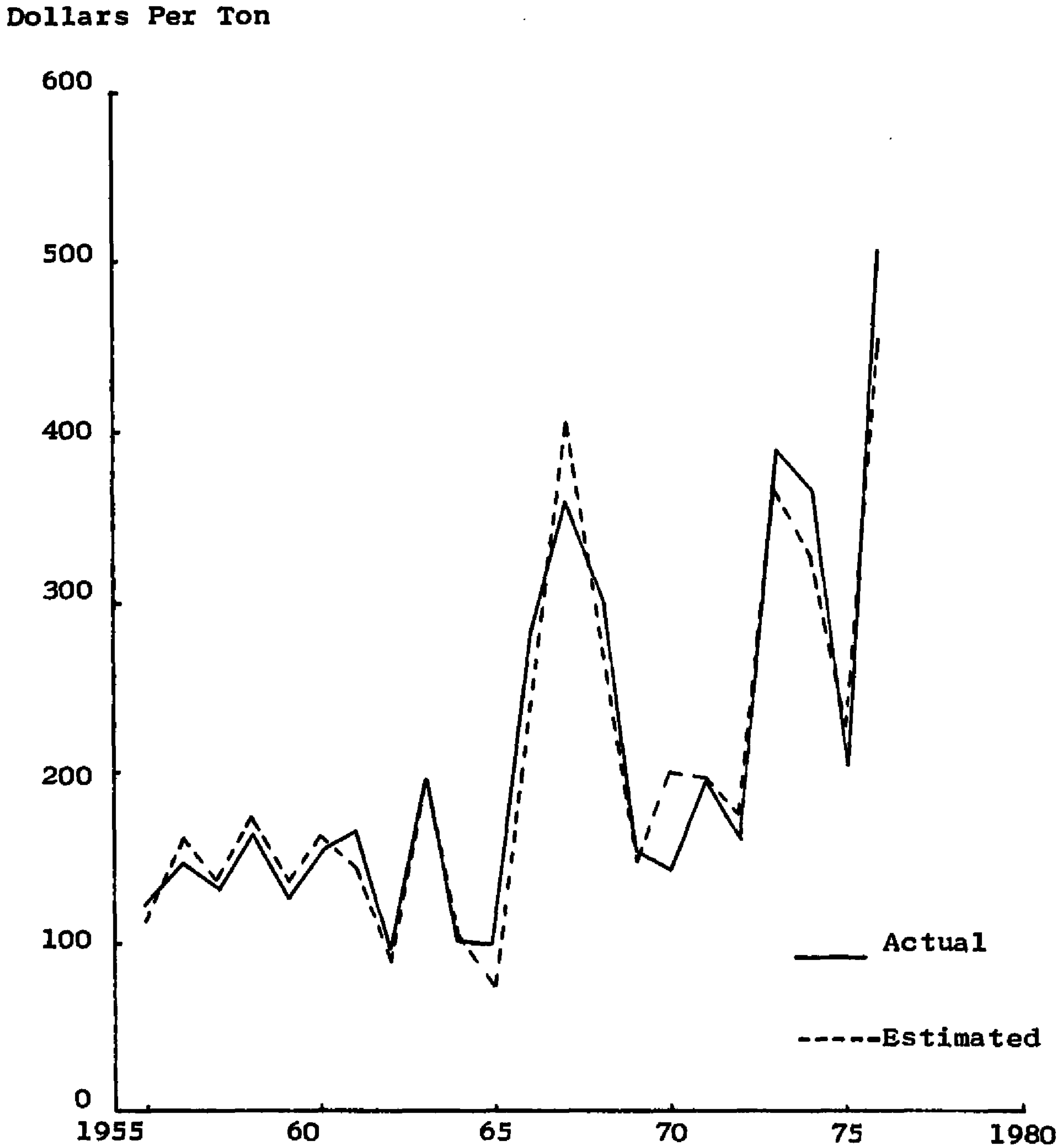

Figure 5.1, Actual and Predicted Tart Cherry Grower Price in Michigan, 1955 - 1976

Summary

An analysis of the demand model at the grower level as presented in this chapter provides useful information on how and what factors influence the tart cherry prices they received. Prices recieved by tart cherry growers in Michigan have been influenced by changes in production, carryover stocks, the consumption of competing fruit (frozen apples), per capita disposable income and the consumer price index (1976 = 100).

Some of the problems confronting the tart cherry industry in the U.S. hinge on price uncertainty and its direct effect upon growers' income. With the separate forces identified in this analysis together with their respective magnitude of influences upon the growers' prices, our understanding of the market situations is greatly improved.

The performance of the model, as evaluated according to the criteria, is highly accurate in making future predictions. It is important to provide indicators of the future in order to introduce public policies or provide policy makers with a means which will reduce tart cherry market uncertainties.

CHAPTER VI

PROJECTION OF THE EXOGENOUS VARIABLES

The structual models for the supply response and demand for tart cherries include exogenous variables such as gross margins of tart cherries, apples, and sweet cherries, as well as consumption of tart cherries, carryover stocks of tart cherries, consumption of frozen apples, consumer price index, disposable income and population. Each of these variables along with the composing factors for some variables need to be projected separately up to 1990.

To project long-term trends in supply and demand for tart cherries, it has been assumed that certain variables or basic factors will either remain unchanged, or that they will continue at the same trend as experienced in the past, or will only change in certain defined ways. Following are detailed discussions on the historical trends and future predictions for each of the variables.

Gross Margins of Growing Tart Cherries

Gross margins in this study are defined as the gross income less total costs, which can be denoted as

$$GM^i_t = (P^i_t \cdot Y^i_t - C^i_t) \;/\; CPI_t$$

where:

GM^i_t = the real gross margin of i-th crop in time t (per acre);

P^i_t = price of i-th crop in time t;

Y^i_t = yield per acre of i-th crop in time t;

C^i_t = variable cost per acre in growing i-th crop;

CPI^i_t = the consumer price index in time t.

Gross margins of tart cherries are one of the explanatory variables in the supply model, while one of the components of the gross margins, the grower price of tart cherries, is the dependent variable of the demand model. In order to predict the gross margins it is necessary to project other components of the gross margins separately. Those components are, (1) yield of tart cherries, (2) cost of production, and (3) the consumer price index. projections of these components are presented below.

(1) Comsumer Price Index

First attempts to project the consumer price index were made with 1960 - 1976 as the base period and fit to a curve which resembles the historical trend of increasing at an increasing rate. The estimates resulted in very steeply increasing trend and improbably high projection values due mainly to the extremely high growth rates experienced in recent years.

The current indication of the situation is that inflation is coming down and there are signs of general upturn in the economy. So, in view of the data comparability problems, the procedure adopted for the prediction is chosen to be more subjective, fitted by the method of selected functions with the assumption that the inflection point on the trend curve would be somewhere between 1976 and 1977.

The estimated process can be divided into two stages. First, the consumer price index in 1990 is projected using a linear trend line under the assumption that the average rate of increase will maintain at the same rate as observed during the 1960 - 1976 period. Second, a functional relationship using a time variable in a logarithms form is fitted to the data and forcing it to pass through the point as predicted in step one for 1990. In other words, the first projection is used as a guide to project to 1990 and the second projection gives the prospective time path. The estiated function is:

$$CPI_t = 1.5261 + .3779 \log(t) \qquad (6.1)$$

t represents time and t = 0 in 1976.

Equation 6.1 which shows a moderate rate of tapering off during the foreseeable future is considered to be quite appropriate. The observed and predicted values of the

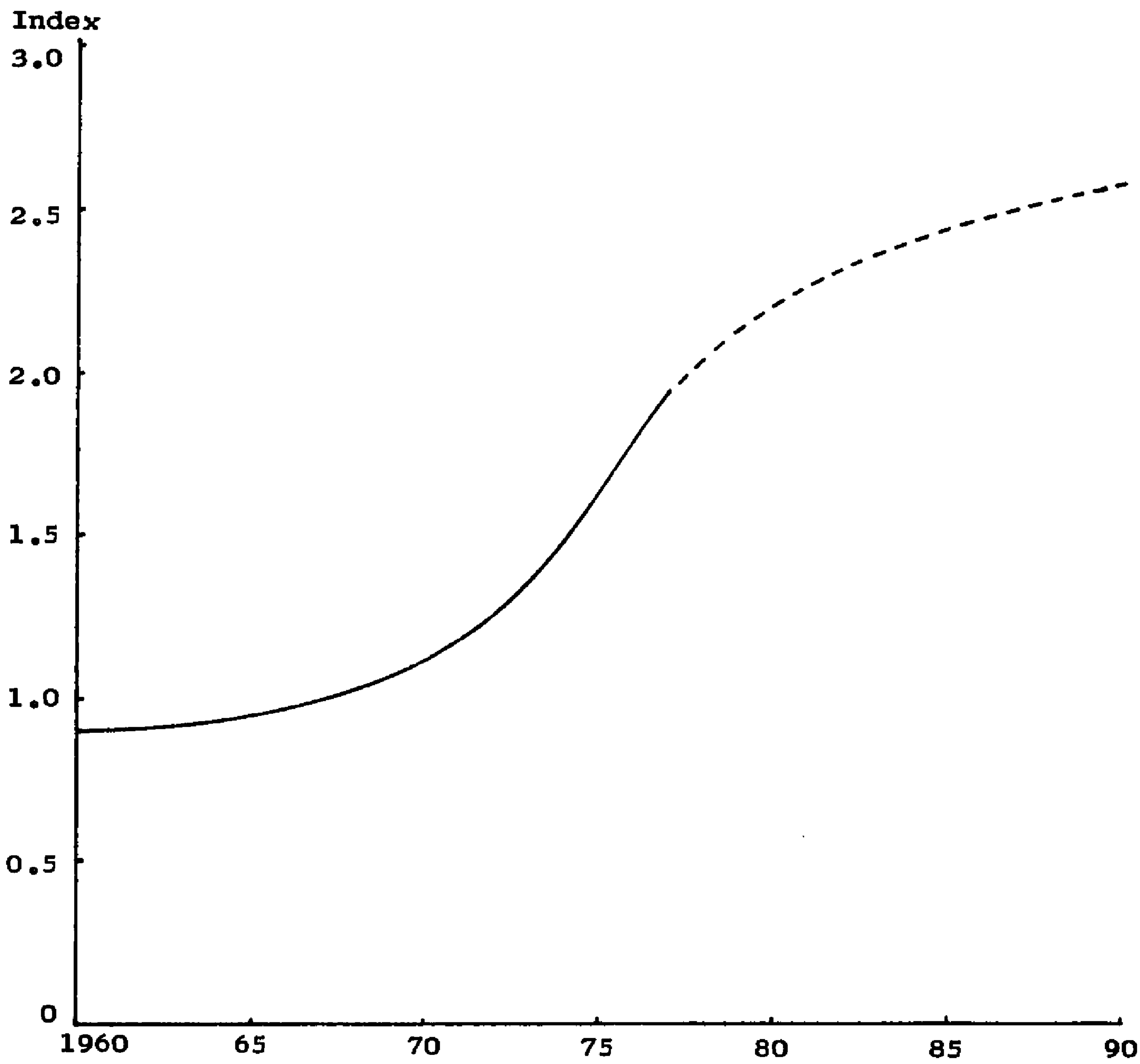

Figure 6.1 Consumer Price Index projected to 1990, United States

consumer price index are as shown in Figure 6.1.

(2) Yield of Tart Cherries

Yield of tart cherries in Michigan has increased from about 1.5 tons per acre in the early 1940's to about 2.4 tons per acre in recent years. Figure 6.2 presents a historical perspective of the yield of tart cherries. One can not help noticing the great yearly fluctuations mainly resulting from weather conditions, while the upward trend remains quite clear. The increase in yield of tart cherries could be accounted for by improvements in production technology, and the average age of trees.

From the historical yield trend, a relatively lower yield level was observed around mid 1950's. According to the industry sources, a large number of trees were planted during late 1940's and early 1950's, which resulted in a lower average yield per acre around mid 1950's because of the higher ratio of young bearing trees. From 1963 to 1973, the average age of bearing trees remained around 21-22 years of age - 21.4 years old in 1963,[33] 22.4 years

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[33]Derived from "Michigan Cherry Tree Survey, 1963-64," Michigan and U.S. Department of Agriculture and Michigan Cooperative Extension Service, Michigan State University.

old in 1968, and 22.2 years old in 1973.[34]

The yield data excluding some extremely high or low years were fitted to a linear trend and the results can be expressed as:

$$Y^t = 1.80237 + .01737(t) \qquad (6.2)$$

$$t = 0 \text{ in } 1938$$

where, Y^t is yield of tart cherries in tons per acre. This equation indicates that the yield of tart cherries has been increasing at an average rate of .01737 tons or about 35 pounds per acre annually.

The rate of increase could be adjusted either upward or downward depending upon assumptions about the future. Factors to be considered for the yield adjustment are the historical developments as well as future changes in factors affecting yield such as the improvements in disease and pest control methods, the application of mechanical harvesters,tree pruning, tree spacing, site selection, tree age and to a much lesser degree the installation of frost protection devices in the orchards, etc.

In light of the interests and efforts of the cherry industry, the steady and continuing increase at .01737 tons

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[34] Derived from "Michigan Fruit Tree Suevey," 1968 and 1973 issues, Crop Reporting Service, Michigan and U.S. Department of Agriculture.

per year is considered to be quite appropriate and hence no adjustment in the growth rate is necessary. However, as it will be presented in the projection chapter, a higher rate of increase in tart cherry yield will be tested in order to see its impacts on tart cherry prices.

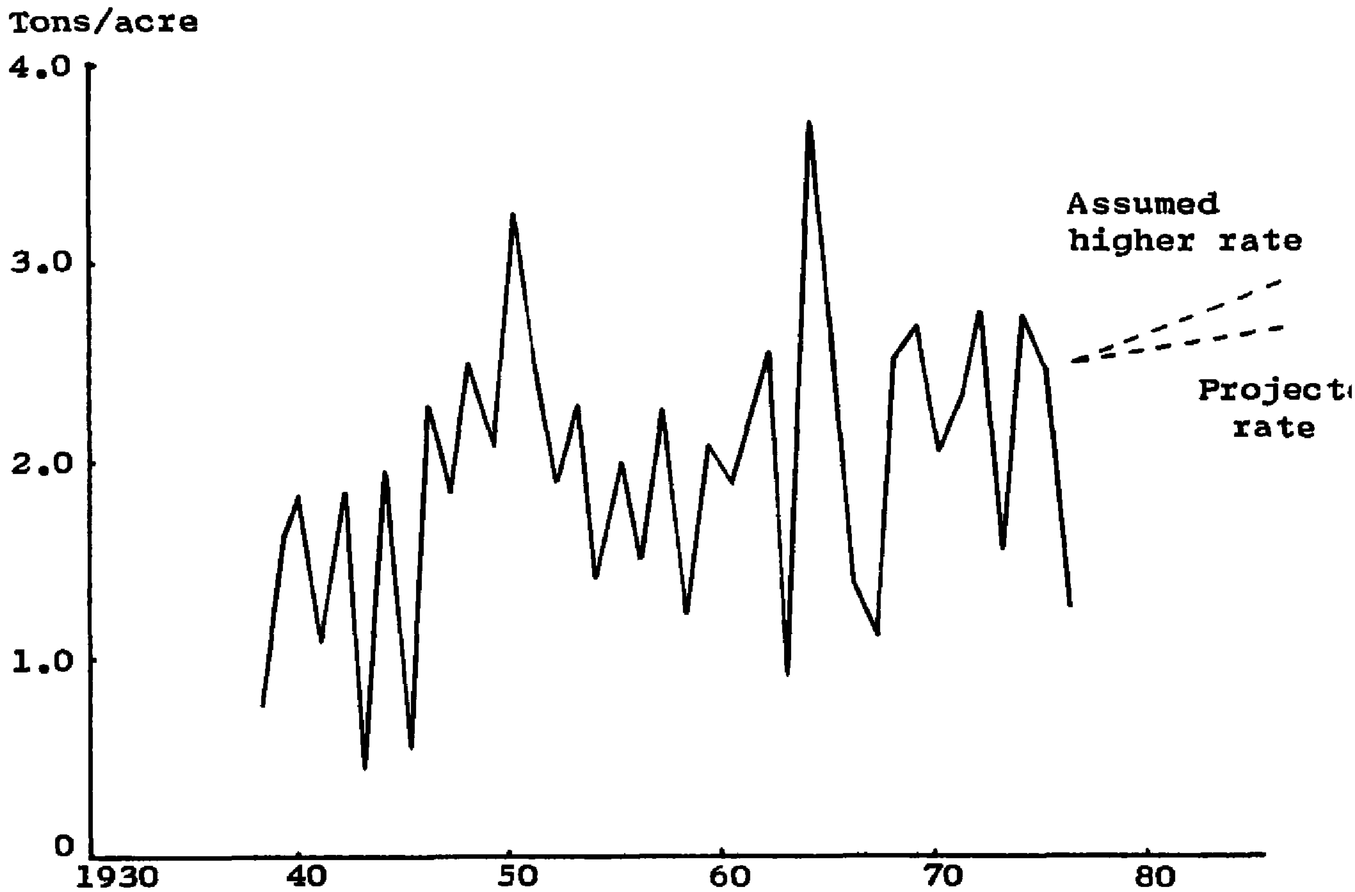

Figure 6.2 Yield of tart cherries in Michigan projected to 1985

The higher rate of increase is assumed to be at the rate such that by the year 1990 the yield will reach 3.0 tons per acre in contrast to the earlier projected level at 2.7 tons per acre (Figure 6.2). This would give an annual growth rate of .0384 tons per acre and the yield equation can be represented by

$$Y^t = 2.4624 + .0384(t) \tag{6.3}$$

$$t = 0 \text{ in } 1976.$$

(3) Cost of Growing Tart Cherries

Figure 6.3 shows costs per acre of growing tart cherries in Michigan from 1960 to 1976, computed as described in Chapter IV. They fluctuate greatly with an upward trend. A logarithmic equation is fitted to represent the trend which is given by the equation as follows:

$$\text{Log}(C^t) = 2.8299 + .91395 \log(t) \tag{6.4}$$

$$t = 0 \text{ in } 1938$$

where, C^t is the costs of growing tart cherries in dollars per acre. This curve, which eventually increases at a very small decreasing rate, seems acceptable both in terms of describing the historical trend and the expected future growth rates.

Tart cherry gross margins can not be estimated without knowing the prices which are to be projected in

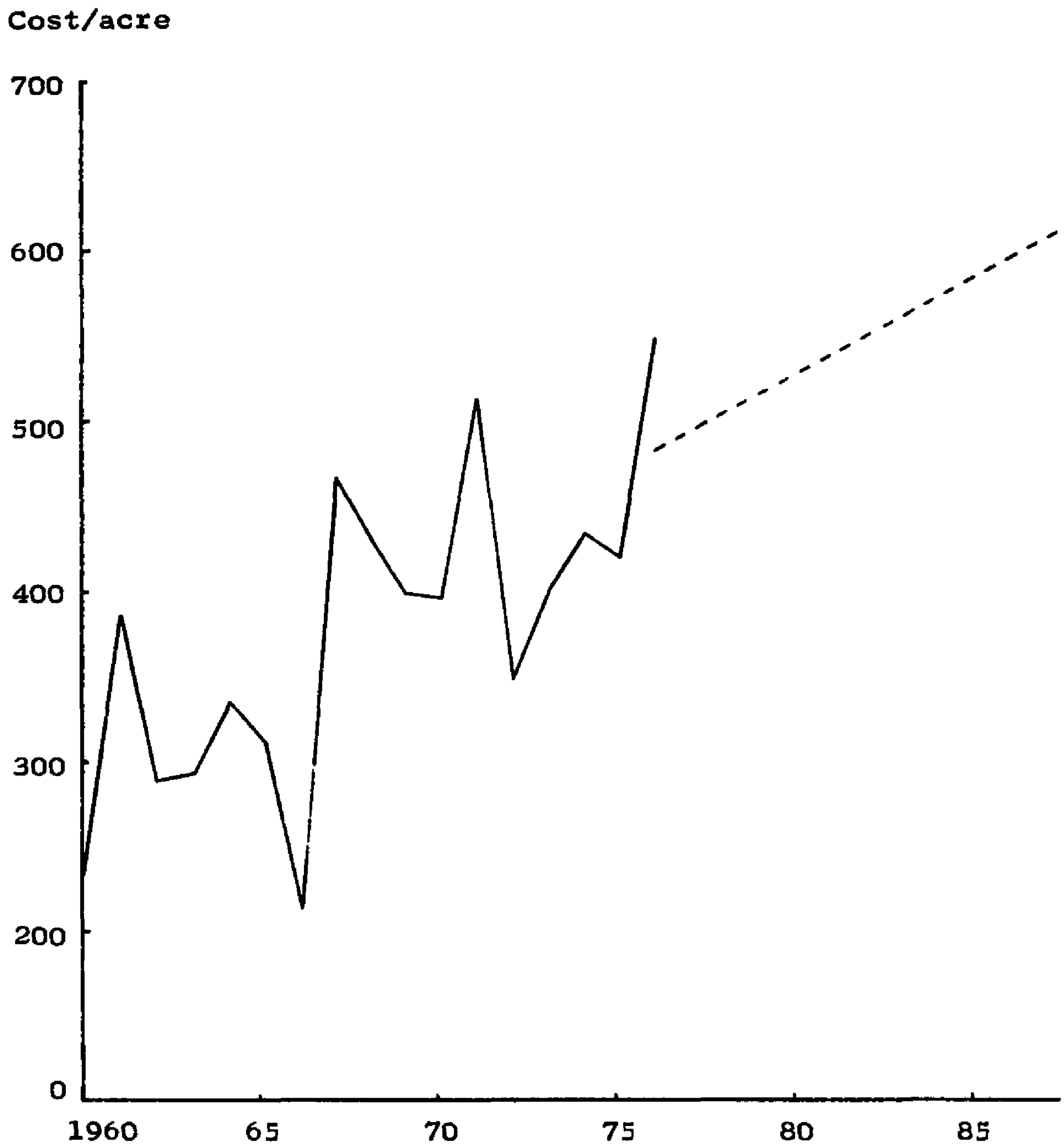

Figure 6.3 Cost per acre of tart cherries in Michigan projected to 1985

Source: Derived from "Farm Cost Account Reports," Department Agricultural Economics, Cornell University, Ithaca, New York, (various issues).

the next chapter. Therefore, estimation of tart cherry gross margins will be presented in Chapter VII.

Gross Margins of Growing Apples

Figure 6.4 shows the grower gross margins of apples in Michigan from 1950 to 1976 in real dollars (1967 = 100). Observing the historical data on the gross margins, one could raise a logical question as how growers continue to produce apples with those negative gross margins. Some explanations should be made here. First, fruit growers have a long time planning horizon by nature of fruit production, when they plant trees they expect the trees to bear fruit for 30 years or more. Due to resource fixity, growers will begin to adjust their investment only if those losses continue over a number of years. Secondly, the growers tend to delay long term investment to minimize costs in lean years. Thirdly, very few apple growers only grow apples. According to the 1973 Michigan Fruit Tree Survey, Michigan's fruit growers had a combination of fruit averaged three kinds in their operations. For the 2,380 apple growers in the state, 53 percent had tart cherries; 44 percent had pears; 43 percent had peaches; 40 percent had prune-plums, and 33 percent had sweet cherries.[35] In view of such

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[35]Wu, Ming W., op. cit., p. 16.

diversified combinations of fruit, it appears possible that a loss from growing one kind of fruit could be offset by profits received from other fruits.

In view of the wide variation in the values of gross margins observed it is quite difficult to formulate a simple equation using a time variable to represent the historical trend. Based on this situation, projection of the gross margins for apples are made by projecting each component of the grower gross margins.

The grower gross margins of apples are composed of (1) yield of apples, (2) price of apples of all sales, (3) cost of growing apples, and (4) the consumer price index. Except for the consumer price index, projection of each of the components are as follows:

(1) Yield of Apples per Acre

There has been a continued trend toward increasing yields of apples since apples have been grown commercially in Michigan. The average yield in early 1940 was about 3,600 pounds per acre and reached over 12,000 pounds per acre in recent years. The increase in yield of apples could be accounted for by improvements in varieties, cultural practices, technologies and age of trees.

Since the yield has been increasing steadily, a linear equation was used to establish the trend for

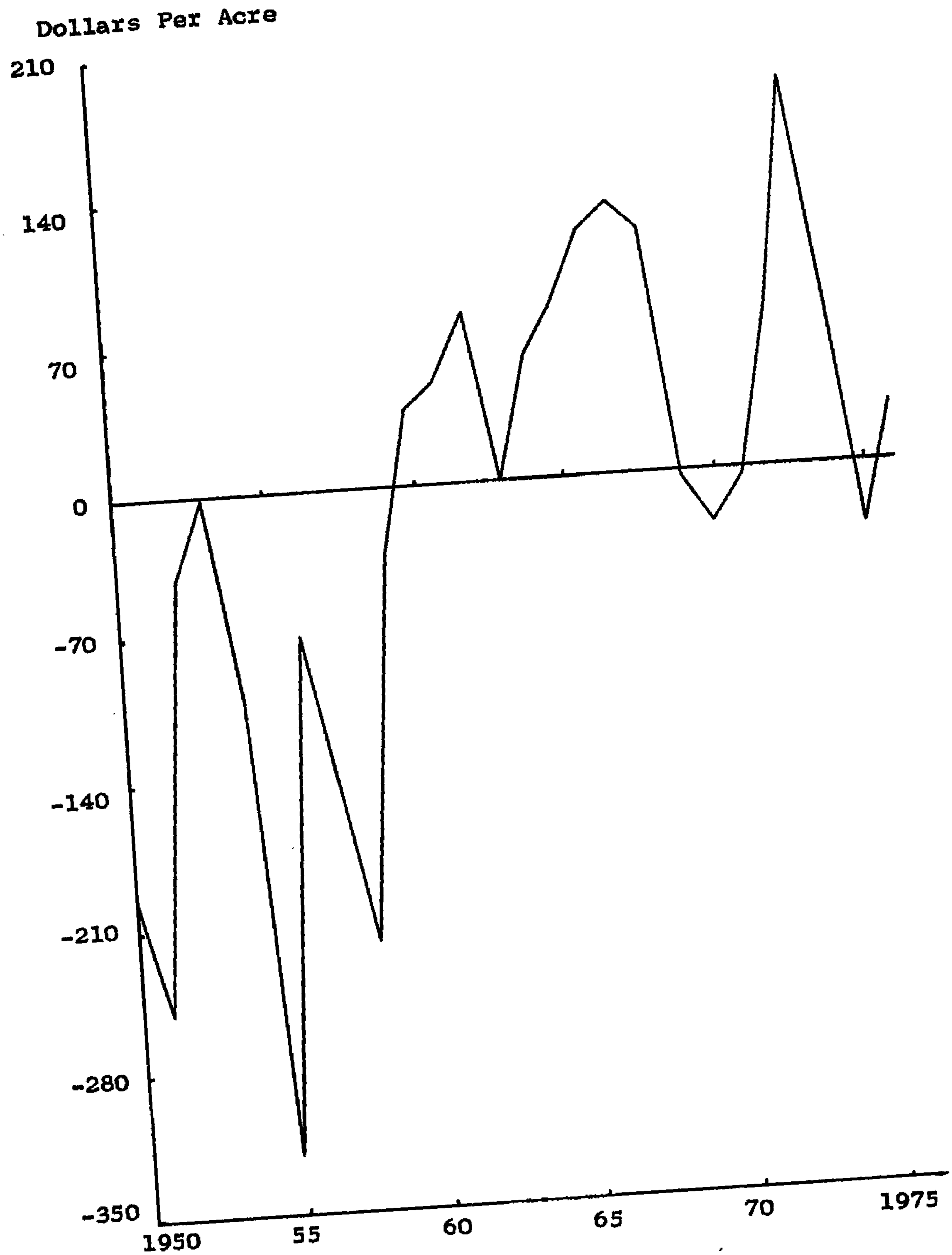

Figure 6.4, Gross Margins of Growing Apples, Michigan, 1950-1976

technology and hence for expected yield. The estimated result is:

$$Y^a = 5667.63 + 314.37(t) \qquad (6.5)$$

$$t = 0 \text{ in } 1950$$

where Y^a represents the yield of apples in pounds per acre. The equation indicates that the yield of apples has been increasing at an average rate of 314.37 pounds per acre annually during the period from 1950 to 1976.

The annual increase of 314.37 pounds per acre may seem to be on the high side. In fact the average yield in most recent years has tapered of as shown in Figure 6.5 and this process is likely to continue for several years due mainly to the average age of trees. Since early 1970's, many older apple trees have been removed and at the same time new trees have been planted. Nonetheless, Equation 6.5 can be used as a guide but a somewhat less rapid increase in apple yield for the future would be more appropriate, as the new trees gradually reach the full bearing stage.

In view of the above situation, the expected annual increase in yield of apples is assumed to be about 40 percent of the average growth rate experienced during 1950 and 1976. Based on this assumption, we would expect the yield of apples to rise from the present 12,700 pounds

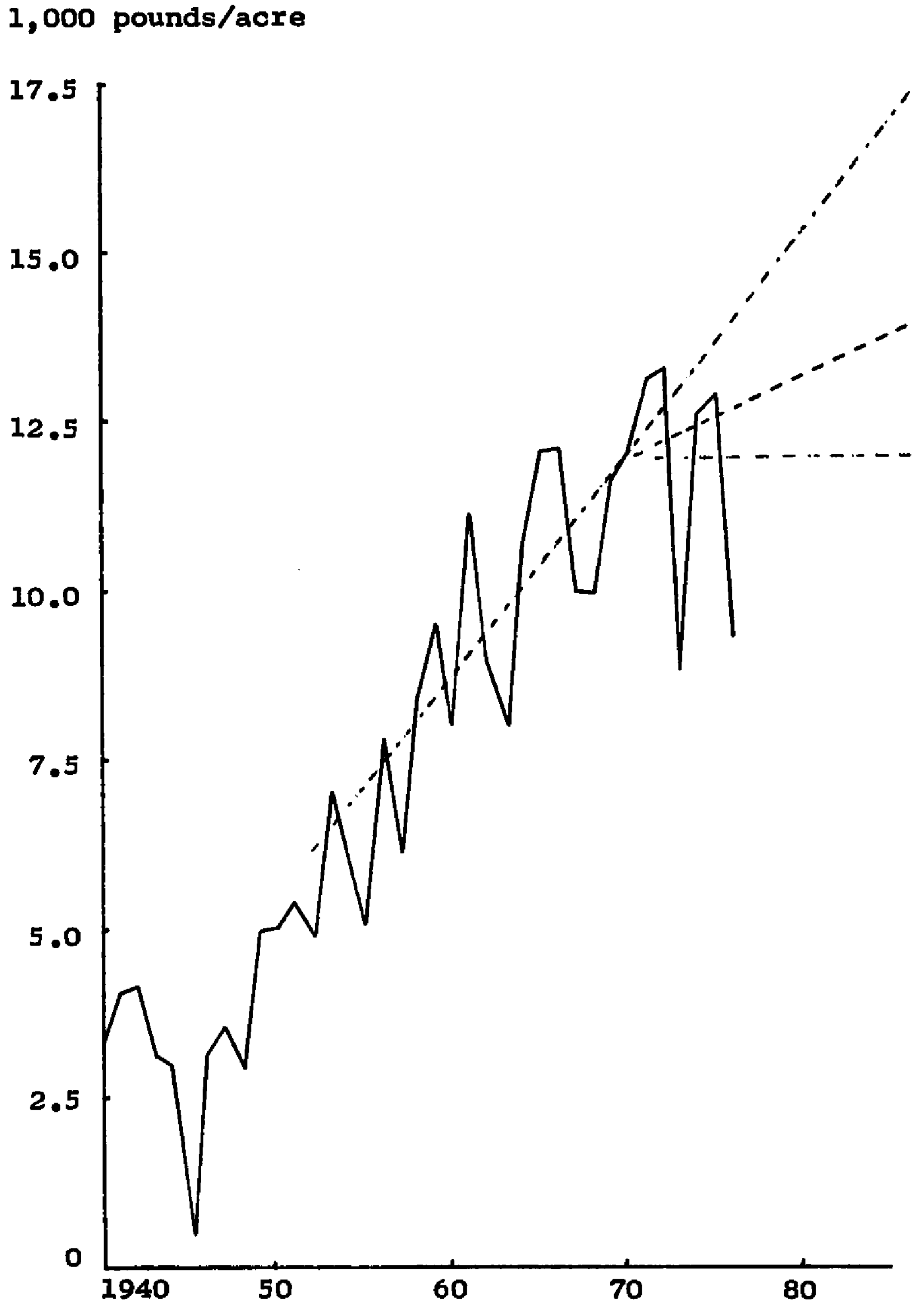

Figure 6.5 Yield of apples per acre in Michigan and projected to 1985

Source: Crop Reporting Service "Michigan Agricultural Statistics," Michigan Department of Agriculture, (various issues).

per acre to about 14,500 pounds per acre by 1990, which would be an average annual increase of 125.75 pounds per acre. This relationship can be represented by the following equation:

$$Y^a = 11{,}955.03 + 125.75(t) \qquad (6.6)$$

$$t = 0 \text{ in } 1970$$

where Y^a is yields of apples in pounds per acre. Figure 6.5 shows the yield trend and yield variations for apples in Michigan.

(2) <u>Price of Apples Received by Growers</u>

The price of apples (non deflated) received by growers, averaging about 6.1 cents per pound over the last 6 years, may be expected to decline slowly as evidenced during the period from 1950 to 1972. The prices in 1973 and 1976 with 9.3 cents per pound and 8.1 cents per pound, respectively, were considered to be due to unusually short supply years; thus they were excluded from the data used for projecting the future rate of growth.

The estimated function is

$$P^a = 5.579 - .0184(t) \qquad (6.7)$$

$$t = 0 \text{ in } 1950$$

where, P^a is the price of apples received by growers from all sales in cents per pound. The prospective grower price of apples in 1990 is projected to be near 4.9 cents per pound with the annual rate of decline averaged at .0184 cents per pound.

An alternative projection of apple prices is to assume that the real price will remain constant. This means that the apple price will increase at the same rate as the consumer price index. The historical price and projected price trends are as shown in Figure 6.6.

(3) Cost of growing apples

Examination of historical data on the cost of growing apples indicated that the cost increased rapidly at about \$20.00 per year from \$250.00 per acre in the mid 1940's to \$450.00 per acre in the mid 1950's. The cost dropped significantly in the late 1950's and stayed at about \$350.00 per acre for about a decade and rose again beginning in the late 1960's to 1976 with \$700.00 per acre, averaged at about \$40.00 per acre. This was nearly twice as fast as was experienced during the 1940's and the mid 1950's.

Following discussions with the industry leaders, it is conceivable that the rate of increase in the cost of growing apples will be substantially lower than the current rate due to the adoption of mechanical harvesters. The projection is then made based on the historical data from 1938 to 1976, which averages out the three different rates

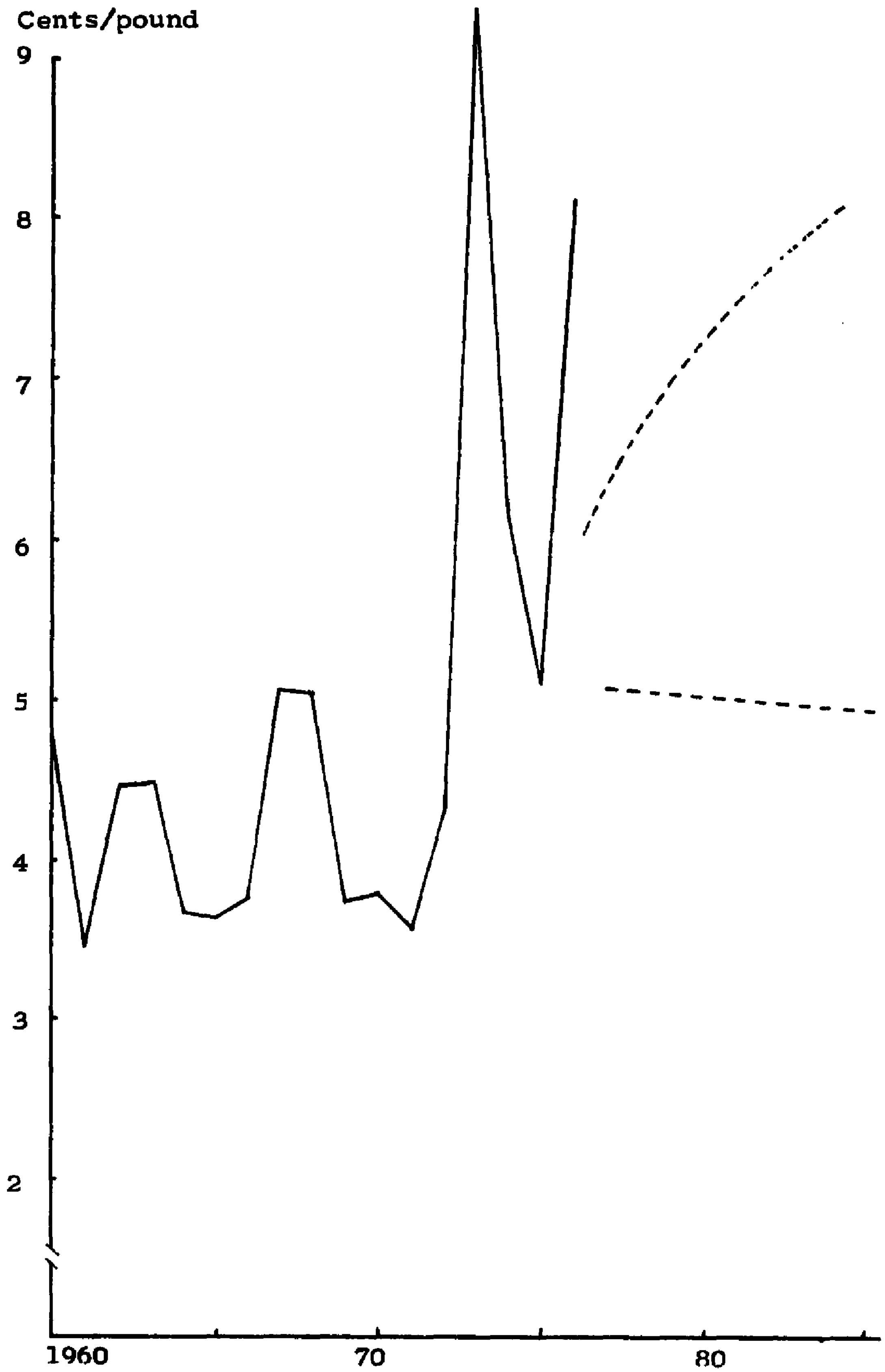

Figure 6.6 Price of apples received by growers from all sales in Michigan projected to 1985
Source: See Figure 6.5.

of changes observed in the sub-sets of time periods. The estimated equation is:

$$C^a = 124.7314 + 12.6998\,(t) \qquad (4.8)$$

$$t = 0 \text{ in } 1938$$

where C^a represents the cost of growing apples in dollars per acre. The rate of increase is at about $12.70 per acre per year.

An alternative projection of the cost of growing apples is to assume the real cost will remain at the current average level. In other words , the current cost will increase corresponding to the increase in the consumer price index (Figure 6.7).

The price, yield, and cost of production of apples discussed in the preceding sections are used to construct grower gross margins. In general, a higher level of gross margins is a reflection of a higher product price or a higher efficiency of production. In a pessimistic view, the slowly improving yield accompanied by declining prices may not be able to offset the rapidly increasing costs. For this reason, the future real gross margins for apple growers may be anticipated to continue its downward trend.

The gross margins of growing apples can be derived from the projected equations representing each of the composing variables. The calculations for projection of

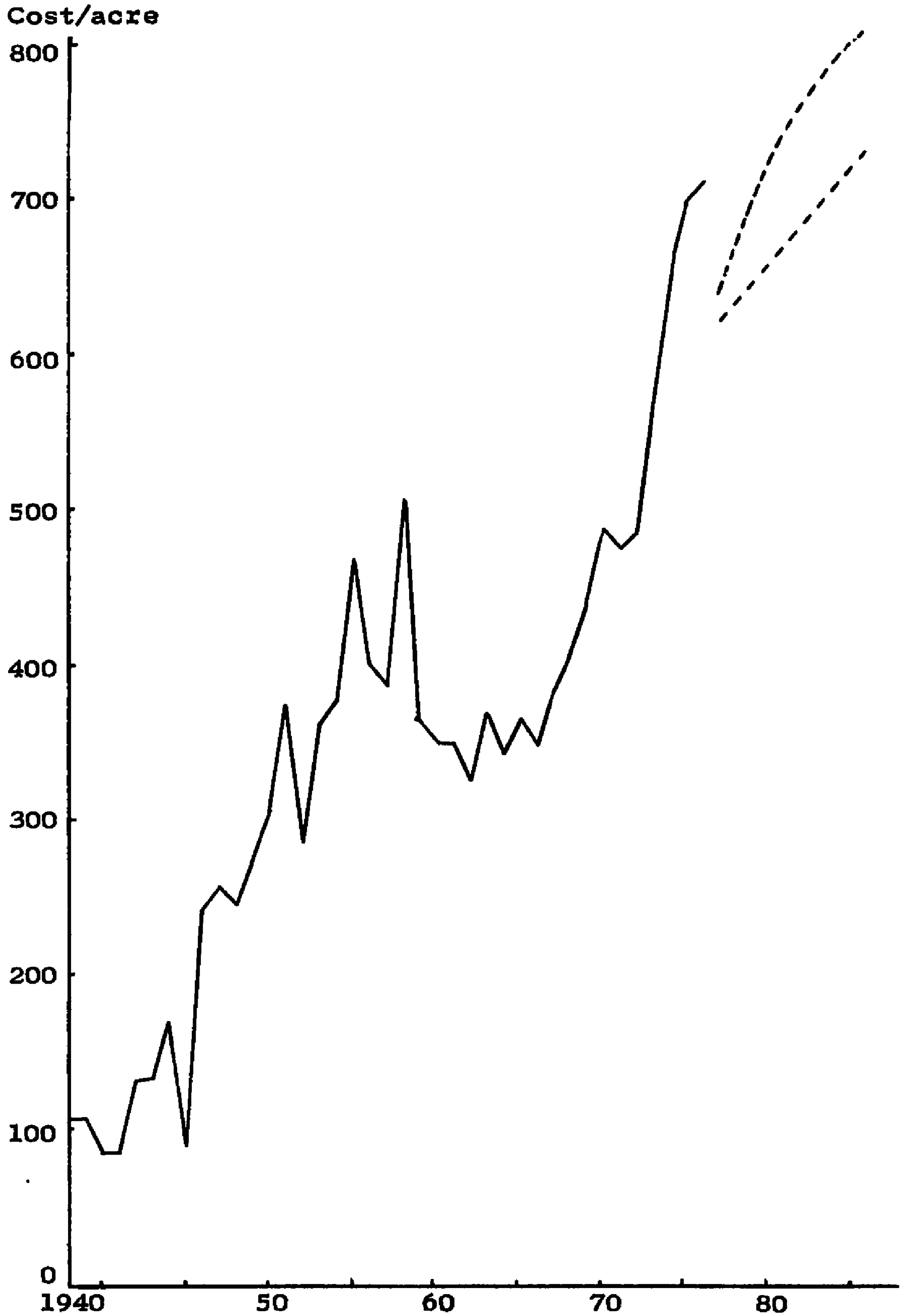

Figure 6.7 Cost of growing apples in Michigan projected to 1985

Source: See Figure 6.3

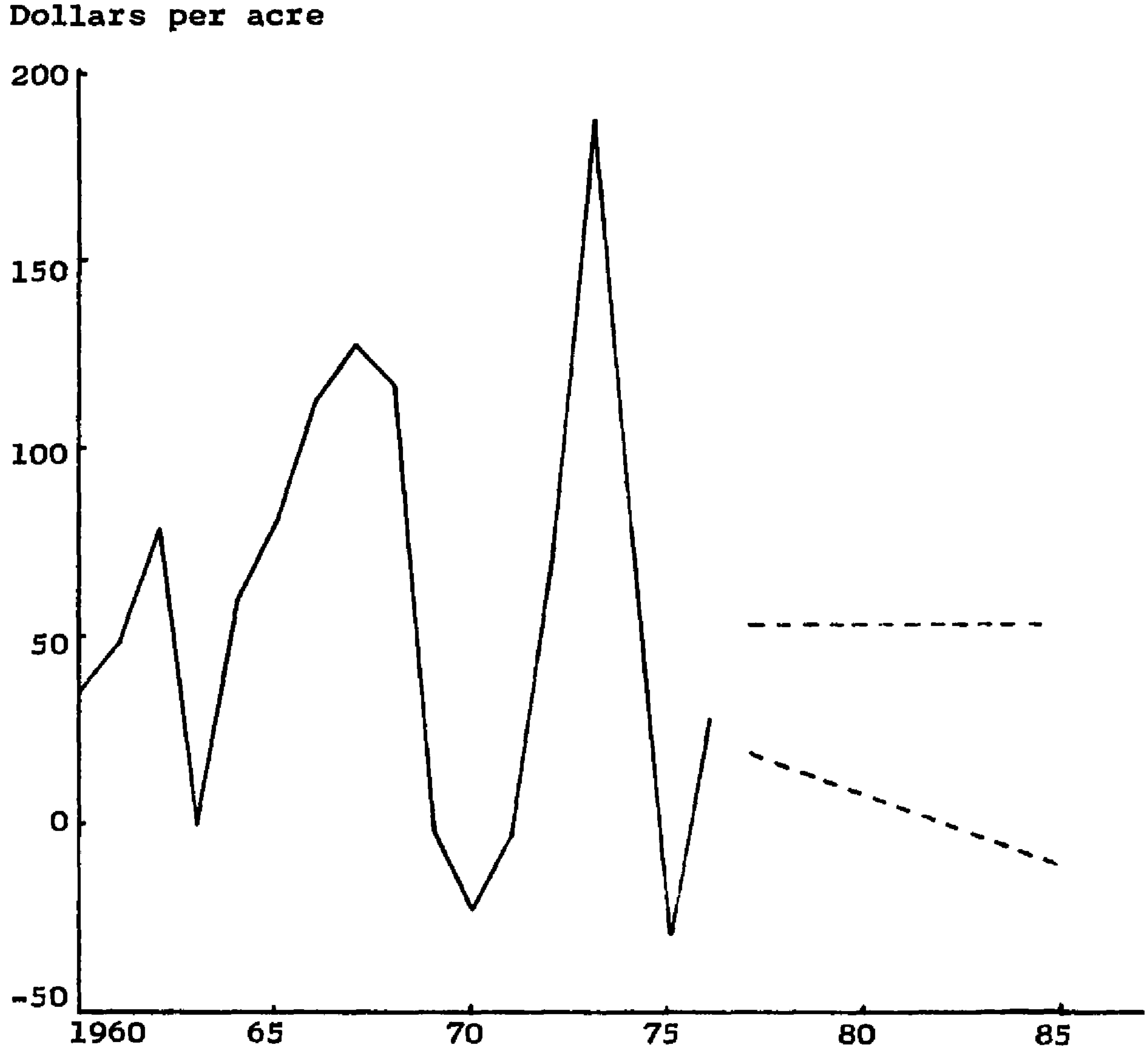

Figure 6.8 Gross margins of growing apples in Michigan projected to 1985

can be applied here. In other words, the gross margins for growing apples per acre can be calculated from the esimated equations representing each of the composing variables, namely, (1) yield of sweet cherries, (2) grower price of the gross margins are displayed in Appendix D Table D.1. The deflated grower gross margins and the six-year moving average of gross margins are shown in Figure 6.8.

A possible alternative projection of the apple grower real gross margins is to assume that it would remain unchanged at the current average level, at $51.928 per acre. This is to say that the components of gross margins such as the real price of apples, real cost of production and yield of apples are assumed to remain at heir current average levels. The six-year moving average of the deflated grower gross margins and the projected trends are shown in Figure 6.8.

The lower projection of a pple gross margins appears negative values after 1980. As discussed earlier, if such losses continue to prevail for several years, growers will begin to withdraw or reallocate their resources to some alternative line of production. Thus, in the later part of the projection as growers start to remove trees or make the production adjustment, one would expect the gross margins to rise. This may be expected to occur around mid 1980's.

Gross Margins of Growing Sweet Cherries

As discussed in the preceding section the same concept in projecting the gross margins of growing apples sweet cherries, and (3) cost of growing sweet cherries.

(1) <u>Yield of sweet cherries</u>

Figure 6.9 shows the yield of sweet cherries since 1938. Sweet cherry yields also fluctuated drastically from year to year with an upward trend. There appears to be little reason to expect a substantial increase in sweet cherry yield in the future. In fact the growth rate has slackened in recent years, probably because of a decrease in the number of trees of full bearing age.

Projection of sweet cherry yield is then made based on the data observed since 1955 but excluding those with extremely high or low years. The estimated equation gives the form of

$$Y^{sw} = 2.07954 + .00642(t) \qquad (6.9)$$

$$t = 0 \text{ in } 1954$$

where Y^{sw} is the yield of sweet cherries in tons per acre. The estimated function gives an annual rate of increase at .00642 tons or 12.84 pounds per acre. This means the yield is expected to increase from the current level of about 2.22 tons per acre to 2.31 tons per acre in 1990.

(2) <u>Price of sweet cherries</u>

Figure 6.10 shows the variation of sweet cherry prices (non-deflated) and the projected price trend. The trend was estimated by fitting a linear function to the data

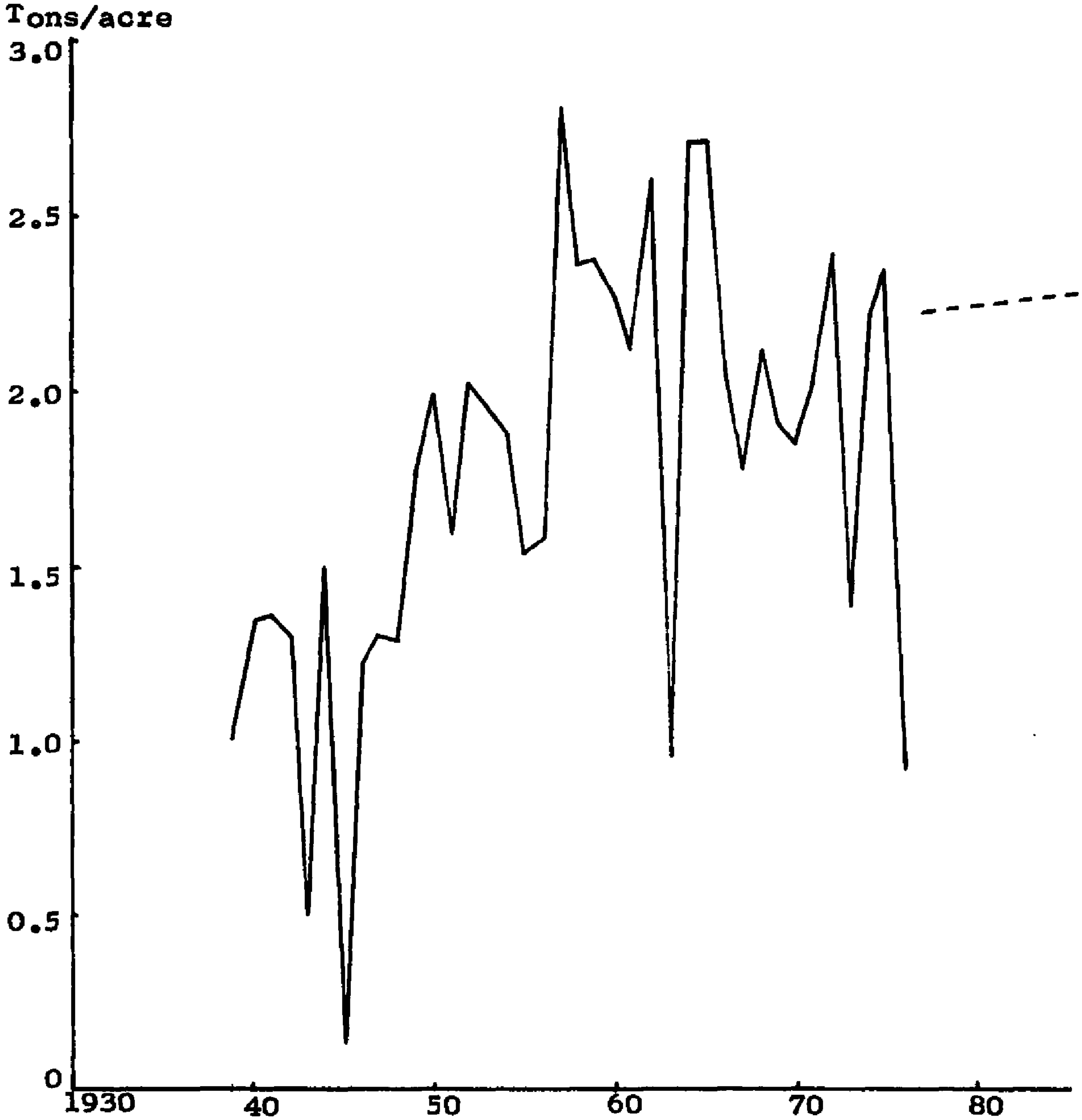

Figure 6.9 Yield of sweet cherries in Michigan and projected to 1985

Source: See Figure 6.5

excluding the extreme values. The estimated relationship is:

$$P^{sw} = 248.502 - .752(t) \tag{6.10}$$

$$t = 0 \text{ in } 1954$$

where P^{sw} is the price of sweet cherries received by growers in dollars per ton. According to the estimated function, a slight decrease in sweet cherry prices will be observed.

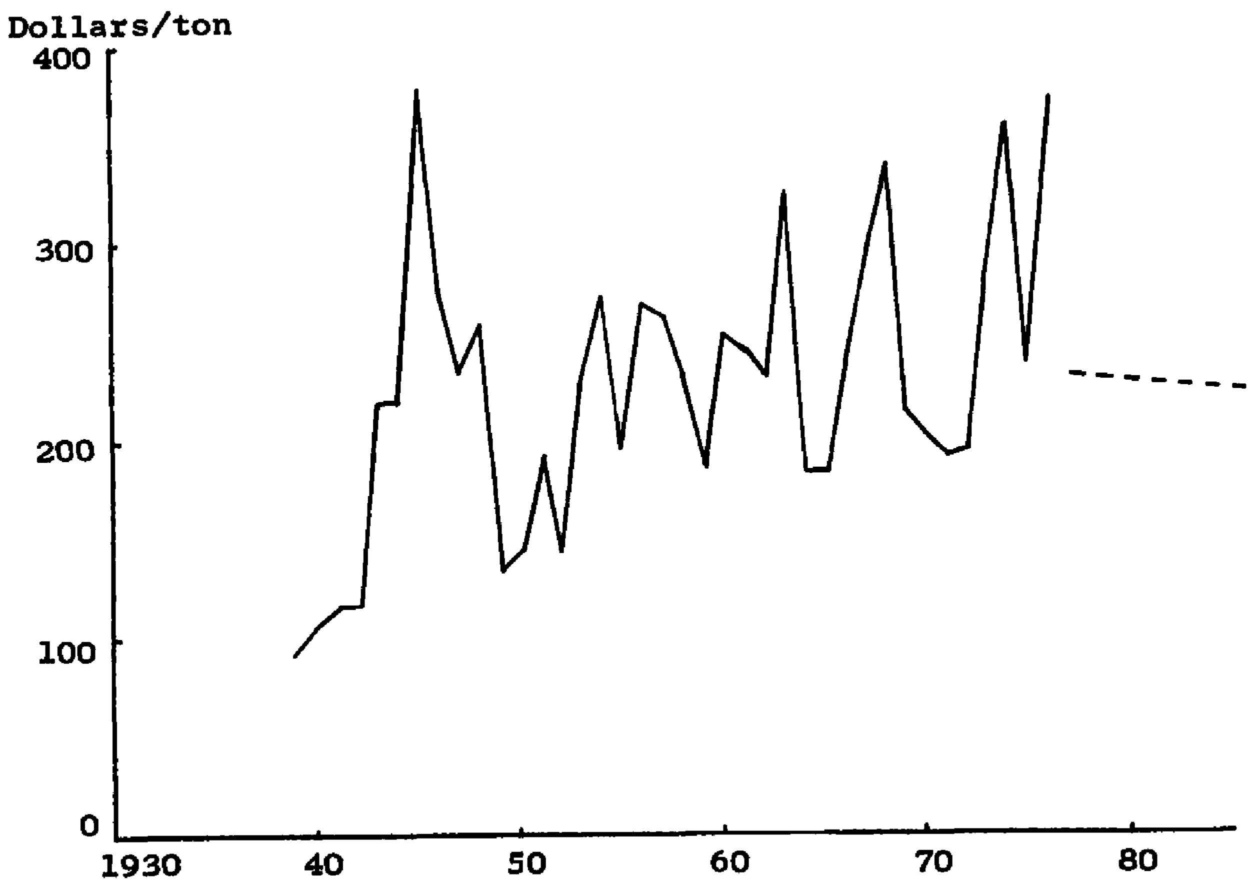

Figure 6.10 Price of sweet cherries in Michigan projected to 1985

Source: See Figure 6.5

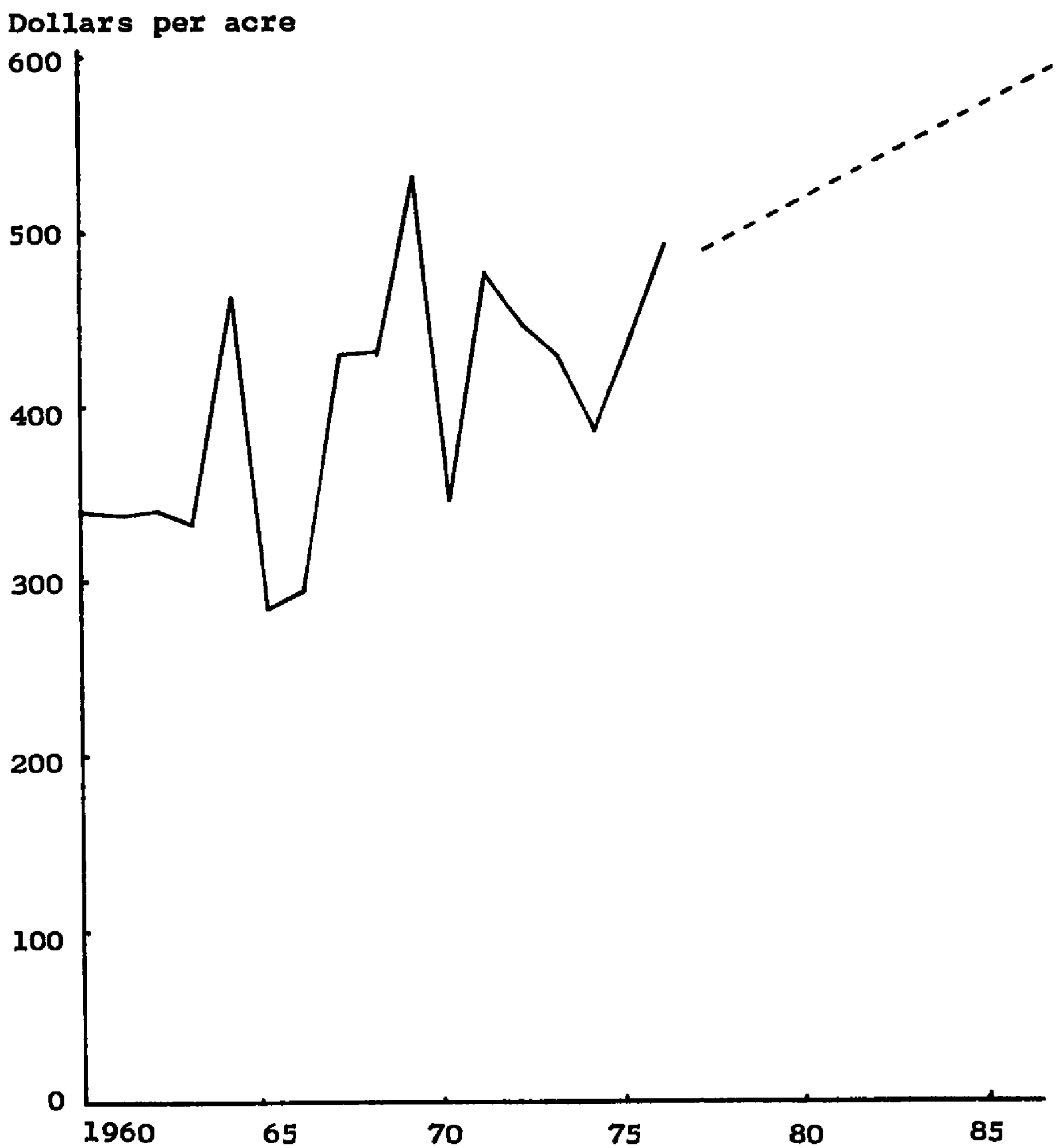

Figure 6.11 Cost of growing sweet cherries projected to 1985

Source: See Figure 6.3.

The price is expected to fall slowly at a rate of $.752 per ton per year from the recent average level of about $231.00 per ton to $220.00 per ton in 1990.

(3) Costs of Growing Sweet Cherries

As shown in Figure 6.11, the average cost in the early 1960's was about $330.00 per acre, followed by disproportional fluctuations from a low of about $280.00 per acre in 1965 to a peak of near $530.00 per acre in 1969. The average cost in 1976 was $485.00 per acre. The trend in sweet cherry costs has been very consistantly and rapidly increasing primary because of inflationary increases in costs of inputs such as spray materials and labor, and it is expected to continue at the same rate.

The anticipated cost in 1990, indicated by Equation (6.11), would be near $623.00 per acre which gives an annual increment of about $6.60 per acre.

$$C^{SW} = 348.271 + 10.577(t) \qquad (6.11)$$

$$t = 0 \text{ in } 1964$$

where C^{SW} is costs of growing sweet cherries in dollars per acre.

Since the yield, price and cost variables have been projected, the gross margins can now be calculated accordingly. The procedures are shown in Appendix D, Table D.2. The deflated gross margins for sweet cherry grower together with the six-year moving averages are plotted in Figure 6.12. Some periods of negative gross margins of sweet cherries were observed. To counteract the negative gross margins of sweet cherries, the growers can adopt the

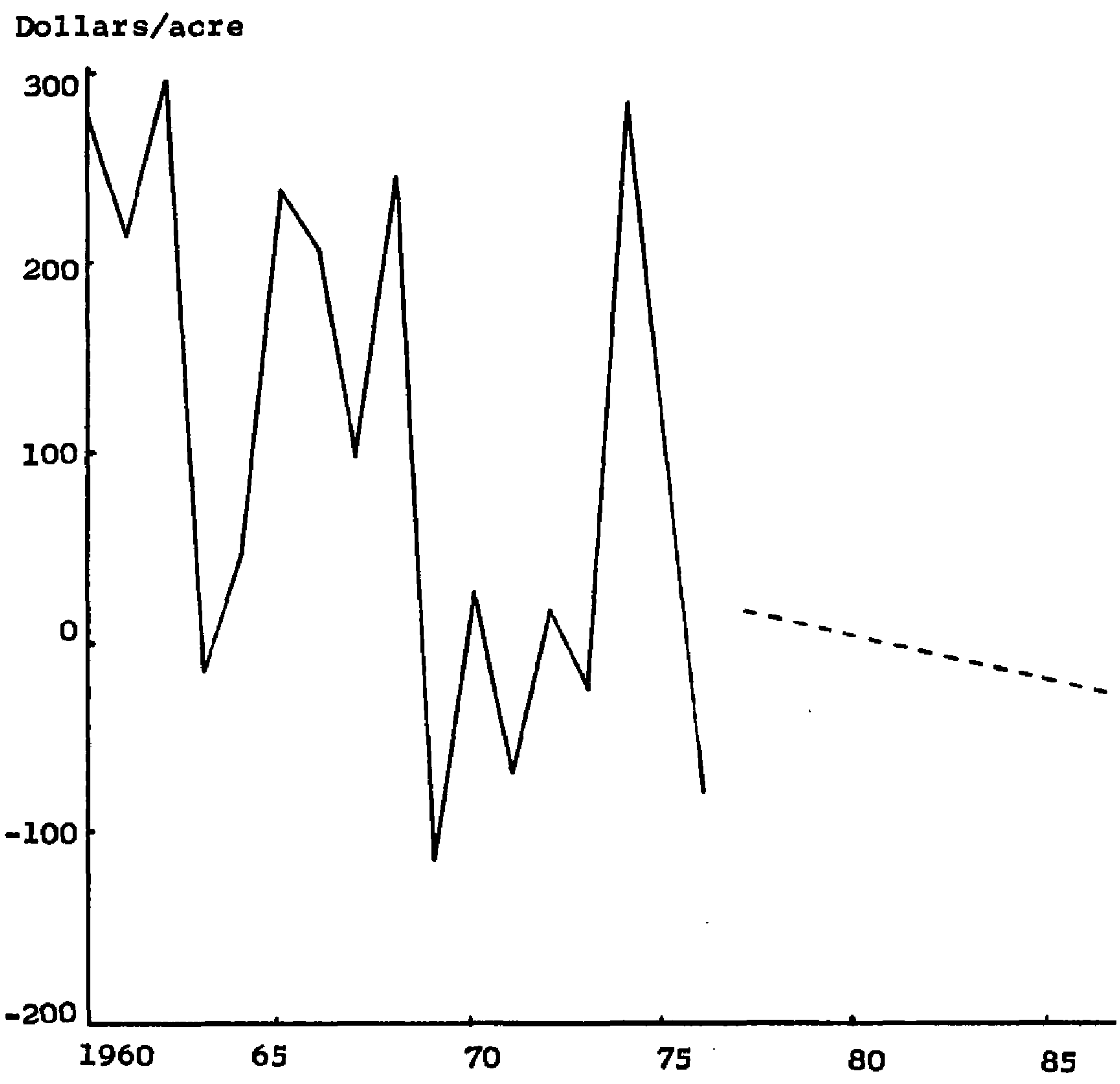

Figure 6.12 Grower gross margins of sweet cherries and six-year moving average projected to 1985

same strategies as used by apple growers. In addition, sweet cherry growers may seek parttime jobs off the farm to make up the losses since sweet cherries in most farms are a minor crop.

The cost-price squeeze, as can be seen from this figure, is expected to force the projected gross margins to drop slowly.

As discussed in the preceding section, when growers start to adjust their investment in response to continual negative gross margins, the average gross margins may gradually turn upward in the later part of the projection. However, if the Food and Drug Administration's banning of red colors is realized, the future market demand for sweet cherries and hence the gross margins may be negatively influenced,[36] because red colors are used for maraschino cherries which account for about 80 percent of Michigan's sweet cherry uses.

Population

Population is an important variable affecting the demand for tart cherries and hence the price of tart cherries. In principle, as population increases, assuming

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[36] Ricks, Donald J., "U.S. Cherry Planting and Production Trends," Staff Paper No. 77-55, Department of Agricultural Economics, Michigan State University, p. 18.

other variables remain constant, the demand for tart cherries and hence the price can be expected to increase. But in the estimated model, population is not used as a separate variable because all quantity variables are expressed in per 1,000 people terms.

Table 6.1 gives different series of population

Table 6.1 Alaternative Projections of United States Population to 1990

Year (July 1)	Series			
	B	C	D	E
		1,000		
1977	225,065	223,548	222,018	220,407
1978	228,797	226,850	224,888	222,826
1979	232,692	230,274	227,839	225,282
1980	236,725	233,798	230,855	227,765
1981	240,866	237,401	233,919	230,264
1982	245,085	241,057	237,012	232,767
1983	249,350	244,741	240,113	235,259
1984	253,632	248,427	243,204	237,725
1985	257,903	252,093	246,265	240,153
1986	262,141	255,721	249,282	242,531
1987	266,329	259,296	252,244	244,852
1988	270,461	262,812	255,144	247,108
1989	274,537	266,268	257,982	249,301
1990	278,570	269,673	260,762	251,431

Source: Current Population Reports, Population Estimates and Projections, U.S. Department of Commerce, Bureau of the Census, Series p-25, No. 470 November 1971.

projections made by the United States Bureau of Census. In this study only two different projections, Series C and D, are considered.

Carryover stock of Tart Cherries

Carryover stock of tart cherries shows varying seasonal amplitude from year to year depending upon the size of the crop in the preceding year. Various functional relationships were fitted to the data to measure the relationships between these two variables. The most staisfactory of all is in the logarithmic form as follows:

$$\operatorname{Log}(S_t^t) = -1.405 + \underset{(.1287)}{1.23654} \log(Q_{t-1}^t) \qquad (6.12)$$

$$R^2 = .82$$

where S_t^t is carryover stock of tart cherries and Q_{t-1}^t is the previous year's crop of tart cherries. Both are expressed in terms of tons per 1,000 people.

This function indicates that a one percent change in the size of crop will result in a 1.24 percent change in the carryover stock in the same direction.

Previous study by Ricks[37] also attempted to have an equation to predict carryover stocks for tart cherries.

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[37]Ricks, *op. cit.*, 1970, p. 26.

He used the same exogenous variable but the result was somewhat different because in this study a relatively longer time period was used, and all variables were expressed in logarithmic and per capita forms rather than in absolute and total forms.

Per Capita Consumption of Frozen Apples

Per capita consumption of frozen apples over the years has fluctuated but appears to be centered around one pound per person annually.

The historical data suggest that there is a strong possibility that the consumption of frozen apples may remain equal to the current level. For this situation it is assumed that for the next decade and a half the per capita comsumption of frozen apples will remain at the 1971-76 average of 1.0269 pounds per person. The historical trend is shown graphically in Figure 6.13.

Per Capita Disposable Income

To project the per capita disposable income, the Gompertz curve is selected to fit the data because the behavior of the data resembles such a curve. The Gompertz curve describes a trend in which the growth increments of

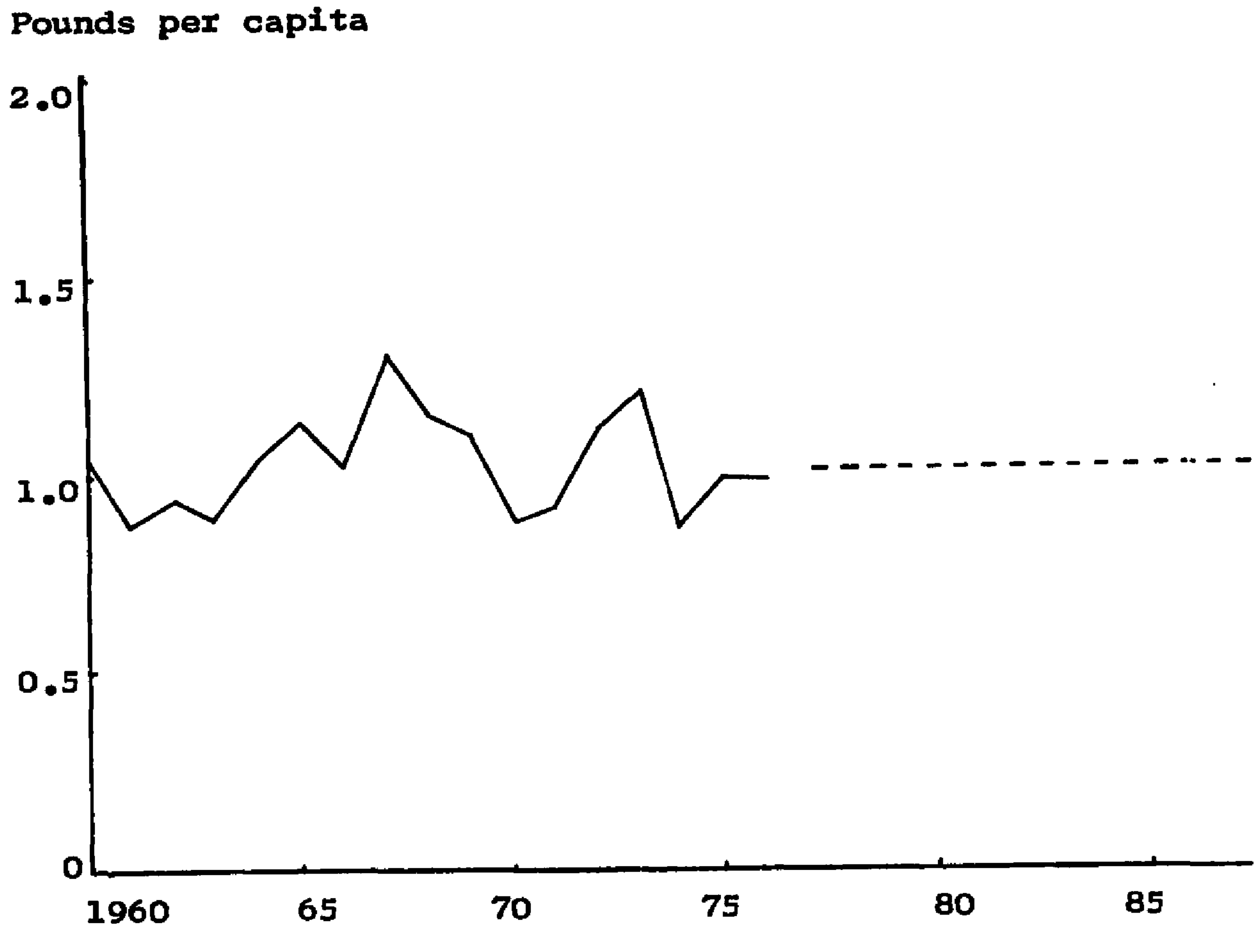

Figure 6.13 Per capita consumption of frozen apples in the United States and projected to 1985

the logarithms are declining by a constant percentage. The equation is:

$$I = Ka^{b^t}$$

or, in logarithmic form

$$\text{Log}(I) = \log(K) + b^t \log(a)$$

Figure 6.14 shows the per capita disposable income since 1960 in current dollars. The upper curve is projected

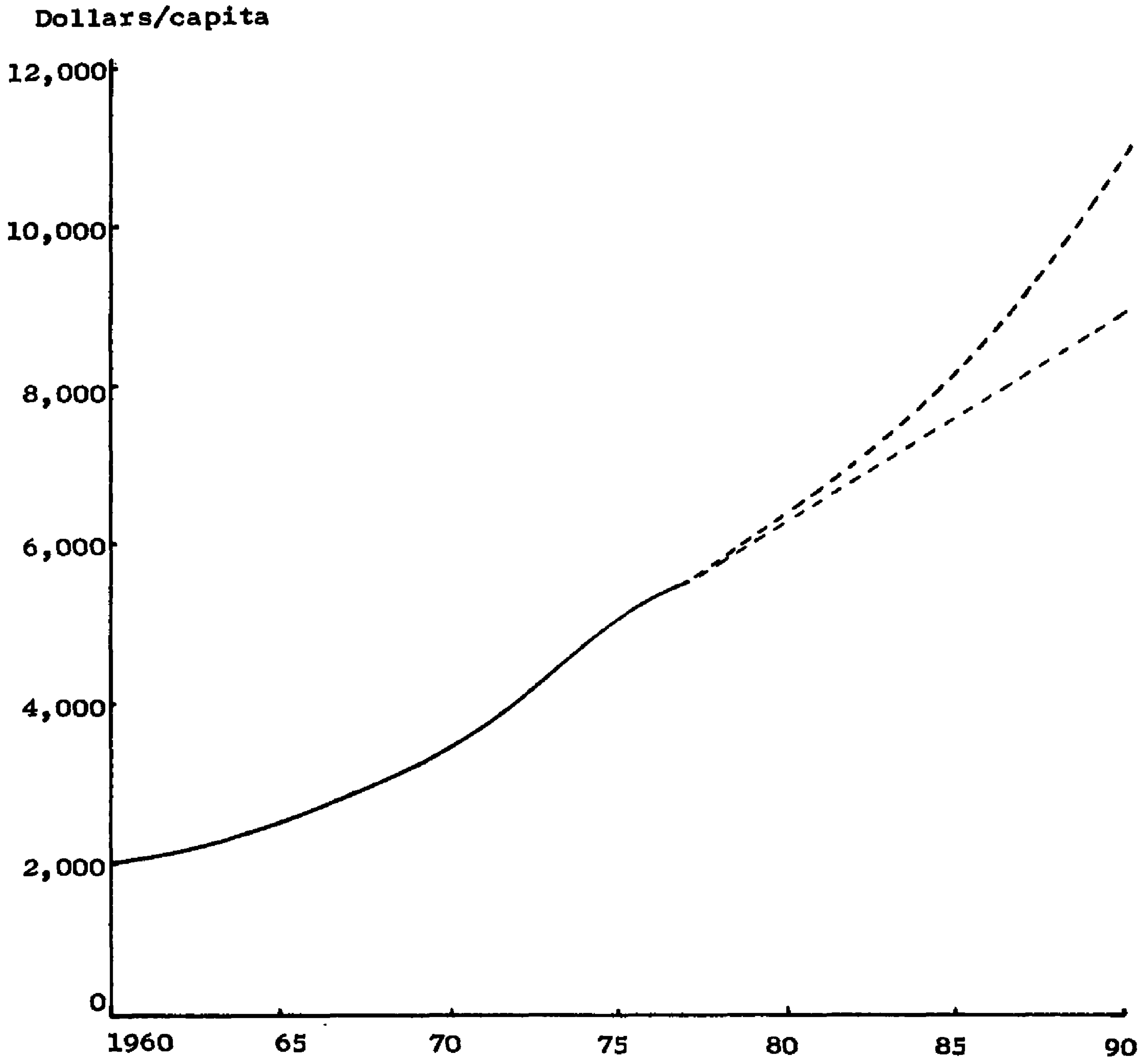

Figure 6.14 Per capita disposable income in the United States and projected to 1990

from the observed values represented by the equation

$$\text{Log(PDI)} = 7.14512 + (1.03)^{t} \log(2.10181) \qquad (6.13)$$

$$t = 0 \text{ in } 1954$$

where PDI is per capita disposable income in current dollars.

An alternative projection is to consider the effects of a less optimistic increase in income. Also, since no estimates are available regarding the relative income elasticities for tart cherries at the different income levels, a lower projection may be used to encounter the possibility that the income elasticity might fall as income increases.

The lower projection is set arbitrarily at 20 percent lower than the level using Equation (6.13) in 1990. The functional relationship becomes

$$\text{Log(PDI)} = 10.030 + (.97)^{t} \log(.057292) \qquad (6.14)$$

$$t = 0 \text{ in } 1954$$

Summary of the Model

It seems helpful, at this time, to summarize the supply, response, and demand models estimated in the preceding chapter along with the several variables estimated in this chapter for future projections.

A. Supply response model

$$A_t^t = 3.70482 + .00306\ \frac{1}{6}\sum_{i=6}^{11}(GM_{t-i}^t) - .00259\ \frac{1}{6}\sum_{i=6}^{11}(GM_{t-i}^a)$$

$$- .00304\ \frac{1}{6}\sum_{i=6}^{11}(GM_{t-i}^{sw}) + .90959\ (A_{t-1}^t) \qquad (4.4)$$

where:

A_t^t = bearing acreage of tart cherries in year t, in 1,000 acres;

$\frac{1}{6}\sum_{i=6}^{11}(GM_{t-i}^t)$ = six-year moving average of the grower gross margins of tart cherries per acre lagged six years from year (t-6) to (t-11), in dollars expressed in real terms (1967 dollars);

$\frac{1}{6}\sum_{i=6}^{11}(GM_{t-i}^a)$ = six-year moving average of the grower gross margins of apples per acre lagged six years from year (t-6) to (t-11), in dollars expressed in real terms (1967 dollars);

$\frac{1}{6}\sum_{i=6}^{11}(GM_{t-i}^{sw})$ = six-year moving average of the grower gross margins of sweet cherries per acre lagged six years from year (t-6) to (t-11), in dollars expressed in real terms (1967 dollars);

A_{t-1}^t = previous year's tart cherry bearing acreage, in 1,000 acres.

The projected equations for the variables,except for the lagged dependent variable,are listed as follows:

1. Gross margins of tart cherries

The gross margins of tart cherries have the following relationship:

$$GM_t^t = (P_t^t \cdot Y^t - C_t^t) / CPI_t$$

where P_t^t is the endogenous variable in the demand model.

(1) Consumer price index (CPI)

$$CPI_t = 1.5261 + .3779 \log(t) \qquad (6.1)$$

$t = 0$ in 1976

(2) Yield of tart cherries (Y^t)

a. Continue at the same growth rate

$$Y^t = 1.80237 + .01737(t) \qquad (6.2)$$

$t = 0$ in 1938

b. Assumed a higher growth rate from technology improvement

$$Y^t = 2.4624 + .0384(t) \qquad (6.3)$$

$t = 0$ in 1976

(3) Cost of growing tart cherries (C^t)

$$\log(C^t) = 2.8299 + .91395 \log(t) \qquad (6.4)$$

$t = 0$ 1938

2. Gross margins of apples

Alternative 1: The values are to be derived from the following projection:

(1) Yield of apples (Y^a)

$$Y^a = 9440.03 + 125,75(t) \qquad (6.6)$$

$t = 0$ in 1960

(2) Grower price of apples(P^a)

$$P^a = 5.579 - .0184(t) \quad t = 0,\ 1950 \qquad (6.7)$$

(3) Cost of growing apples (C^a)

$$C_a = 124.7314 + 12.6998(t) \quad t = 0,\ 1938 \quad (6.8)$$

Alternative 2: Assume to remain at the current level of \$51.928 per acre.

3. Gross margins of sweet cherries

(1) Yield of sweet cherries (Y^{sw})

$$Y^{sw} = 2.07954 + .00642(t) \qquad (6.9)$$

$$t = 0 \text{ in } 1954$$

(2) Grower price of sweet cherries (P^{sw})

$$P^{sw} = 248.502 - .752(t) \quad t = 0 \text{ in } 1954 \quad (6.10)$$

(3) Cost of growing sweet cherries (C^{sw})

$$C^{sw} = 348.271 + 10.577(t) \qquad (6.11)$$

$$t = 0 \text{ in } 1964$$

B. <u>Demand model</u>

$$\text{Log}(P_t^t) = -1.91053 - 1.22164 \log(Q_t^t) - .61837 \log(S_t^t)$$
$$- .02542 \log(Q_t^a) - .76869 \log(CPI_t)$$
$$+ .70083 \log(PDI_t) \qquad (5.1)$$

where, P_t^t = Price of tart cherries in time t, in dollars per ton

S_t^t = Tart cherry carryover stocks on April 1 in year t in the U.S., in tons per 1,000 people.

Q_t^a = Total value of frozen apples consumed in the U.S., in time t, in dollars per 1,000 people.

CPI_t = consumer price index in time t.

PDI_t = personal disposable income in time t, in dollars per capita.

Projected equations for the consisting variables

1. Consumption of tart cherries

The consumption of tart cherries per 1,000 people is to be projected from the following relationship:

$$Q_t^t = (A_t^t \cdot Y_t^t) / POP_t$$

where, A_t^t is the endogenous variable in the supply response model. Y_t^t is yield of tart cherries, and POP_t stands for the population.

2. Population

See Table 6.1

3. Carryover stocks of tart cherries

$$\log(S_t^t) = -1.405 + 1.23654 \log(Q_{t-1}^t) \qquad (6.12)$$

4. Consumption of frozen apples

It is assumed that the consumption of frozen apples will remain at the current level of 1.0269 pounds per person.

5. Per capita disposable income

a, Higher projection:

$$\log(PDI) = 7.14512 + (1.03)^t \log(2.10181) \qquad (6.13)$$

t = 0 in 1954

b, Lower projections:

$$\text{Log(PDI)} = 10.030 + (.97)^{t} \log(.057292) \qquad (6.14)$$

$t = 0$ in 1954

CHAPTER VII

FUTURE PREDICTIONS OF TART CHERRY SUPPLY AND DEMAND TO 1990

The supply and demand models as formulated in Chapter IV can be summarized as follows:

Supply model:

$$A_t^t = 3.70482 + .00306\ \frac{1}{6}\sum_{i=6}^{11}(GM_{t-i}^t) - .00259\ \frac{1}{6}\sum_{i=6}^{11}(GM_{t-i}^a)$$

$$- .00304\ \frac{1}{6}\sum_{i=6}^{11}(GM_{t-i}^s) + .90959(A_{t-1}^t) \qquad (4.4)$$

Demand model:

$$\text{Log}(P_t^t) = 1.91053 - 1.22164 \log(Q_t^t) - .61837 \log(S_t^t)$$

$$- .02542 \log(Q_t^a) - .76869 \log(CPI_t)$$

$$+ .70083 \log(PDI_t) \qquad (5.1)$$

In the supply model, the gross margin of tart cherries instead of the price of tart cherries is used as an independent variable. The hypotheses is that cherry growers make their planting decisions based on profit expectations rather than the prices of tart cherries alone because higher tart cherry prices usually result from poor crops as mentioned previously.

In the demand model, the quantity of tart cherries is used as an independent variable rather than the acreage of bearing trees because tart cherry prices are directly associated with the quantity of tart cherries available for the market which is in turn highly influenced by weather conditions.

The two models cannot directly be combined into one model because neither of the dependent variables has been used as an independent variable of the other model. Some identity equations are required in order to link these two models together.

These identity equations include:

$$GM^t_{t-6} = (P^t_{t-6} \cdot Y^t_{t-6} - C^t_{t-6}) \;/\; CPI_{t-6} \qquad (7.1)$$

and $$Q^t_t = (A^t_t \cdot Y^t_t) \;/\; POP_t \qquad (7.2)$$

where, Y^t_{t-6} is the yield of tart cherries in year (t-6); C^t_{t-6} is the variable cost per acre of growing tart cherries. Other variables in the equations are as defined in the preceding section. Equation (7.1) indicates the relationship between the gross margins in the supply model and prices of tart cherries in the demand model. Equation (7.2) shows the relationship between the per capita consumption of tart cherries in the demand model and the bearing acreage of tart cherries in the supply model.

Tart cherry prices estimated from the demand model will then be used to eatimate the gross margins of the supply response model through Equation (7.1). While the bearing acreage estimated from the supply model will be translated into quantities of tart cherries and hence per capita consumption of tart cherries through Equation (7.2). These equations are thus formed to recursively generate future predictions of price and production levels of tart cherries.

An outstanding feature of the formulated model is the use of six-year lags in the exogenous variables which provides self generated predictions up to six years into the future. This corresponds to the reality of the cherry industry relative to plantings and future production levels. Another feature of the model is the capability of constructing the time path of the independent variables projected from year to year. For example, the prediction of the tart cherry bearing acreage for 1977 relies upon the acreage in 1976 and the six-year average of the observed gross margins of tart cherries, and that of apples and sweet cherries from 1966 to 1971. The 1978 acreage can be generated from the predicted 1977 acreage and the observed six-year average of the gross margins for each fruit from 1967 to 1972. This process can be continued to predict the acreage up to 1982 without having separate projections for the exogenous variables. However, as the recursive process continues, the possible errors involved in the projection may become cumulative and magnify into the more distant future as a result of the inclusion of the lagged dependent variable.

As described previously, the selected model provides a fairly reliable description of the historical structure and variation of the tart cherry demand and supply. They do not consequently lend themselves to reliable future projections. To reflect the models' reliability for future projections, certain assumption underlying future possible outcomes must be made.

There are numerous ways in which the projections can be made. The process can be greatly complicated with respect to the possible alternatives, and the results may be greatly diverse. Here only those alternatives will be selected that are most likely to occur under certain assumptions. It is especially important with respect to the assumptions. Following are some of them that need to be emphasized:

1. No significant change in the present government economic policies would take place,
2. No major deviation in the economic conditions,

such as war or depression would occur, and

3. The future change in the economic magnitudes related to the production and consumption of tart cherries will result from presently operating causes.

It should be noted here that the predicted price and acreage levels represent such levels that would be expected for normal or average crop years with normal weather conditions. The projected levels thus represent long term trends rather than actual levels observed in particular years. Actual price and acreage levels may differ from the projected long term trends due to fluctuations in weather and other uncontrollable random biological factors.

Nevertheless, the projection of the prices and acreage of tart cherries considers a range of possibilities based on several selected alternatives.

Variables that appear to be more certain as to their future trend, as discussed in the preceding chapter, have only one level of prediction. But those with special future uncertainties have alternative projections for their expected trends. The selected combination of these alternatives are as follows:

<u>Alternative 1</u>

Disposable income:	High projection, see Figure 6.13
Gross margins of apples:	Remain at the current average of $51.928 per acre
Population:	Series C, see Table 6.1

<u>Alternative 2</u>

Disposable income:	High projection, see Figure 6.13
Gross margins of apples:	Trend downward, see Figure 6.7
Population:	Series D, see Table 6.1

<u>Alternative 3</u>

Disposable income:	Low projection, see Figure 6.13
Gross margins of apples:	Remain at the current average of $51.928 per acre
Population:	Series C, see Table 6.1

<u>Alternative 4</u>

Disposable income:	Low projection, see Figure 6.13
Gross margins of apples:	Trend downward, see Figure 6.7
Population:	Series D, see Table 6.1

The mechanics of calculating the price and acreage predictions involve many steps: (1) Estimate the six year moving average of gross margins for tart cherries, apples and sweet cherries. (2) Plug the average gross margins estimated in (1) and the previous year's acreage into the supply model. (3) Compute the per capita (1,000 people) consumption of tart cherries from the predicted acreage along with the projected yield and population. (4) Insert the value obtained from (3) along with the projected values of carryover stock, consumption of frozen apples, consumer price index, and disposable income in the demand model to obtain tart cherry prices for each year. (5) Generate gross margins of tart cherries from the price obtained from (4) along with yield of tart cherries, cost of production and consumer price index, and repeat from step (1) for further predictions.

Price Predictions

As anticipated, a higher level of disposable income will bring about a relatively higher prediction in the price series. The predicted prices for each of the alternatives described above are presented in Table 7.1 and are shown graphically in Figure 7.1.

Table 7.1, Future Price Predictions for Michigan Tart Cherries, 1977 - 1990

Year	Alternative			
	No. 1	No. 2	No.3	No. 4
	Dollars per ton			
1977	593.14	588.19	592.93	587.98
1978	496.39	488.57	495.78	487.98
1979	501.18	489.50	497.20	487.54
1980	505.29	493.54	500.94	489.29
1981	514.21	500.18	506.51	492.69
1982	525.26	508.73	513.13	496.98
1983	534.01	515.18	516.43	498.22
1984	540.23	519.01	516.26	495.98
1985	546.04	521.19	515.09	491.26
1986	551.81	522.34	512.16	484.74
1987	555.95	522.27	507.62	476.43
1988	559.08	521.75	500.60	467.04
1989	565.24	524.08	495.64	459.39
1990	574.94	529.73	493.41	454.45

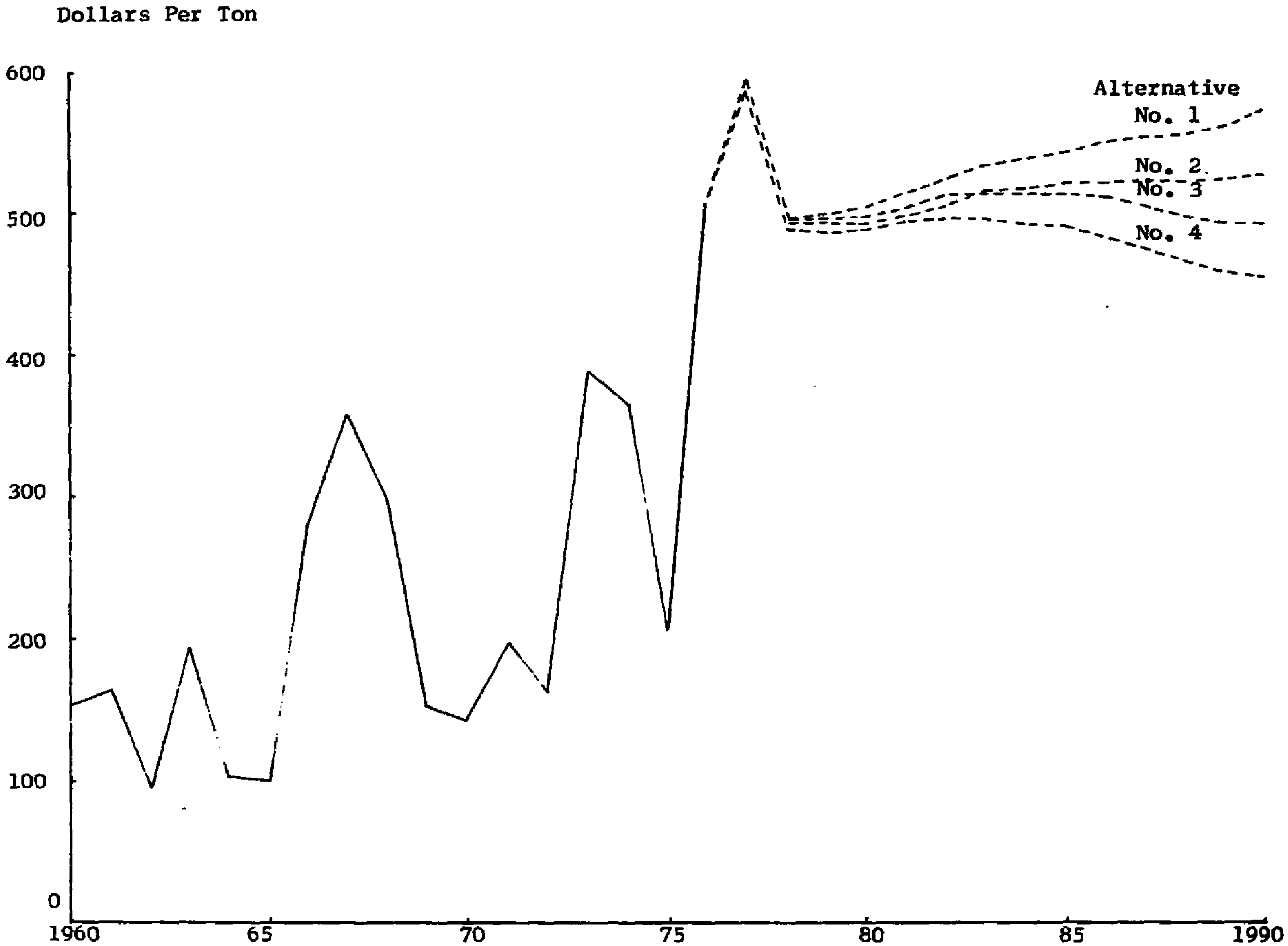

Figure 7.1, Average farm prices of Michigan tart cherries, projected to 1990

Note that the prices discussed here refer to current dollars. In all cases, the predicted prices for the first year (1977) all fall at or near \$590.00 per ton. This is essentially approximately on the level being observed currently. However, the actual average price for the year will not be available until the end of the crop season.

According to the model, this year's price is due mainly to the low carryover stocks from last year, because the 1976 crop was the record low during the past ten years. As shown in Figure 7.1, when the carryover stocks and other variables return to the projected "normal" levels, the price for 1978 drops about \$90.00 dollars per ton to near \$500.00 per ton.

Alternative No. 1 includes both high disposable income and high population (Series C) together with the constant gross margins of apples. This alternative is a very "optimistic" view which provides the highest series of price predictions of all selected alternatives.

It might be somewhat overly optimistic because of the inclusion of both optimistic projections for disposable income and population. The results show that the price increases steadily from \$496.39 per ton in 1978 to \$574.94 per ton in 1990. This projection delineates the upper boundary to the projection of future tart cherry prices.

Alternative No. 2 involves the combination of high disposable income, low population (Series D) and a downward trend in the gross margins of apples. This alternative gives an intermediate level of projection. The predicted prices rise slowly from 1978 and taper off in 1988 then up slowly again and reach $528.00 per ton in 1990.

The combination of lower population and higher per capita disposable income appears to result in a fairly stable level of prices.

Alternative No. 3 differs from Alternative No. 1 in the level of personal disposable income, which is lower than that being used in Alternative No. 1. The result indicates the net effects of the change in income levels. As shown in Figure 7.1, the predicted prices rise moderately from 1978, reach a peak with $516.43 per ton in 1983 followed by steadily decreasing price levels toward 1990. In 1990 the predicted price is $493.41 per ton, situated at slightly lower than the mean of all predicted price series.

Comparing the results of Alternatives No. 1 and No. 3, the net impact on price levels form the change in disposable income is considerably large; from $574.94 per ton for high income level down to $493.41 per ton for low income level. A net decrease of $81.53 per ton can be realized resulting from using the lower income level.

Alternative No. 4 includes both low income and low population (Series D) and downward gross margins for apples. This is rather a "pessimistic" view in terms of the expected future situations. The projected prices make only a very small increase from 1978 toward a peak in 1983 with $498.22 per ton and decline relatively rapidly to $454.45 per ton in 1990.

As it has been expected, Alternative No. 4 delineates a lower boundary to the projection of tart cherry prices as shown in Figure 7.1.

Differences in predicted prices for the upper and lower boundaries amount to about $5.15 per ton in 1977, and slowly increase to about $120.50 per ton by 1990.

The analysis suggests that the most likely prediction appears to be either Alternative No. 2 or Alternative No. 3, or around the central part of the projected range.

As mentioned previously, Yield is the major factor that causes the upswings and downswings in the production as well as prices. This situation is unavoidable in view of the fact that tart cherries are sensitive to uncontrollable weather conditions. Prices of tart cherries are determined by many factors but among them the quantity produced is one.

Tart Cherry Gross Margin Predictions

As has been discussed in the preceding chapter, Tart cherry gross margins can be generated from one of the identity equations (Equation 7.1). The calculation procedure, using Alternative No. 3 as an example, is shown in Appendix D, Table D.3. The results generated from each of the Alternatives are presented in Table 7.2 and Figure 7.2.

The projected levels of the real gross margin have almost the same trending pattern as the projected tart cherry prices; Alternatives No. 1 and 4 delineate the upper and lower boundaries, respectively. The projections show around $500.00 per acre in 1977 and drop substantially to $350.00 to $360.00 range in 1978. By 1990, the projected levels range from $330.00 to $356.00 per acre, with an average of about $343.00 per acre.

Acreage Predictions

The projections of tart cherry bearing acreage calculated from the model for each of the four alternatives described in the preceding section are shown in Table 7.3 and graphically presented in Figure 7.3.

Table 7.2, Alternative Projections for Future Tart Cherry Gross Margins, Michigan, 1977 - 1990

Year[1]	Alternative No. 1	2	3	4
	Dollars per acre			
1977	503.50	497.18	503.24	496.92
1978	360.91	351.35	360.17	350.63
1979	348.74	334.95	344.05	332.66
1980	341.42	327.91	336.42	323.03
1981	341.61	325.80	332.93	317.35
1982	345.47	327.11	332.00	314.07
1983	347.66	327.01	328.39	308.42
1984	347.88	324.84	321.85	299.83
1985	348.27	321.51	314.94	289.28
1986	349.14	317.62	306.73	277.41
1987	348.71	312.90	297.32	264.16
1988	347.61	308.10	285.71	250.19
1989	350.01	306.61	276.63	238.41
1990	356.43	308.91	270.73	229.77

[1] Data for 1972- 1976 are observed values.

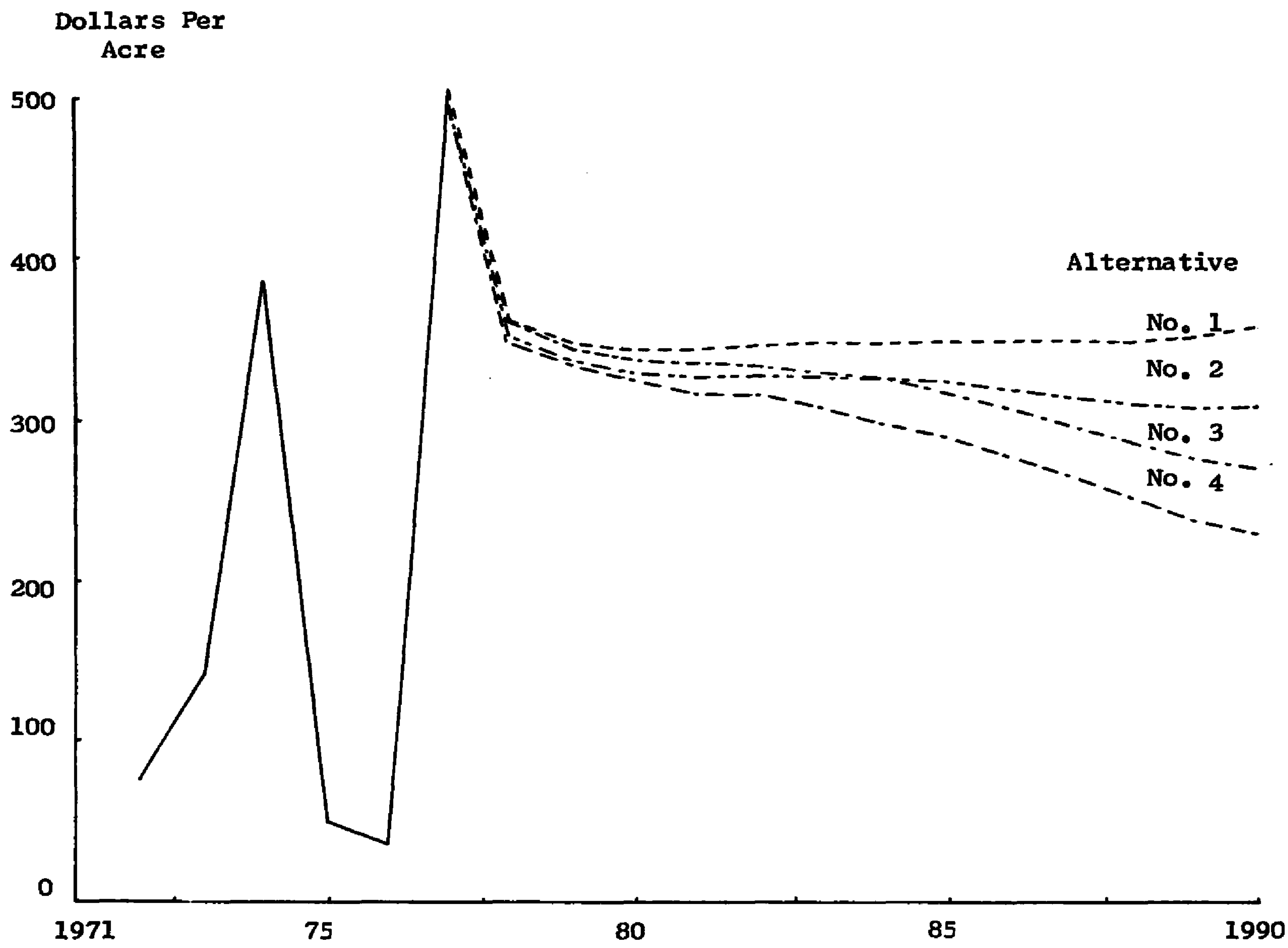

Figure 7.2, Alternative Projections for Future Tart Cherry Gross Margins, Michigan, 1977-1990

Table 7.3, Future Bearing Acreage Projections for Michigan Tart Cherries, 1977 - 1990

Year	Alternative			
	No. 1	No. 2	No. 3	No. 4
	Acres			
1977	37,607	37,607	37,607	37,607
1978	37,767	37,767	37,767	37,767
1979	38,059	38,059	38,059	38,059
1980	38,360	38,360	38,360	38,360
1981	38,572	38,572	38,572	38,572
1982	38,860	38,860	38,860	38,860
1983	39,363	39,352	39,363	39,352
1984	39,981	39,972	39,980	39,972
1985	40,635	40,700	40,632	40,698
1986	41,354	41,510	41,352	41,504
1987	42,201	42,421	42,184	42,406
1988	43,097	43,378	43,064	43,350
1989	43,849	44,188	43,792	44,182
1990	44,541	44,936	44,450	44,854

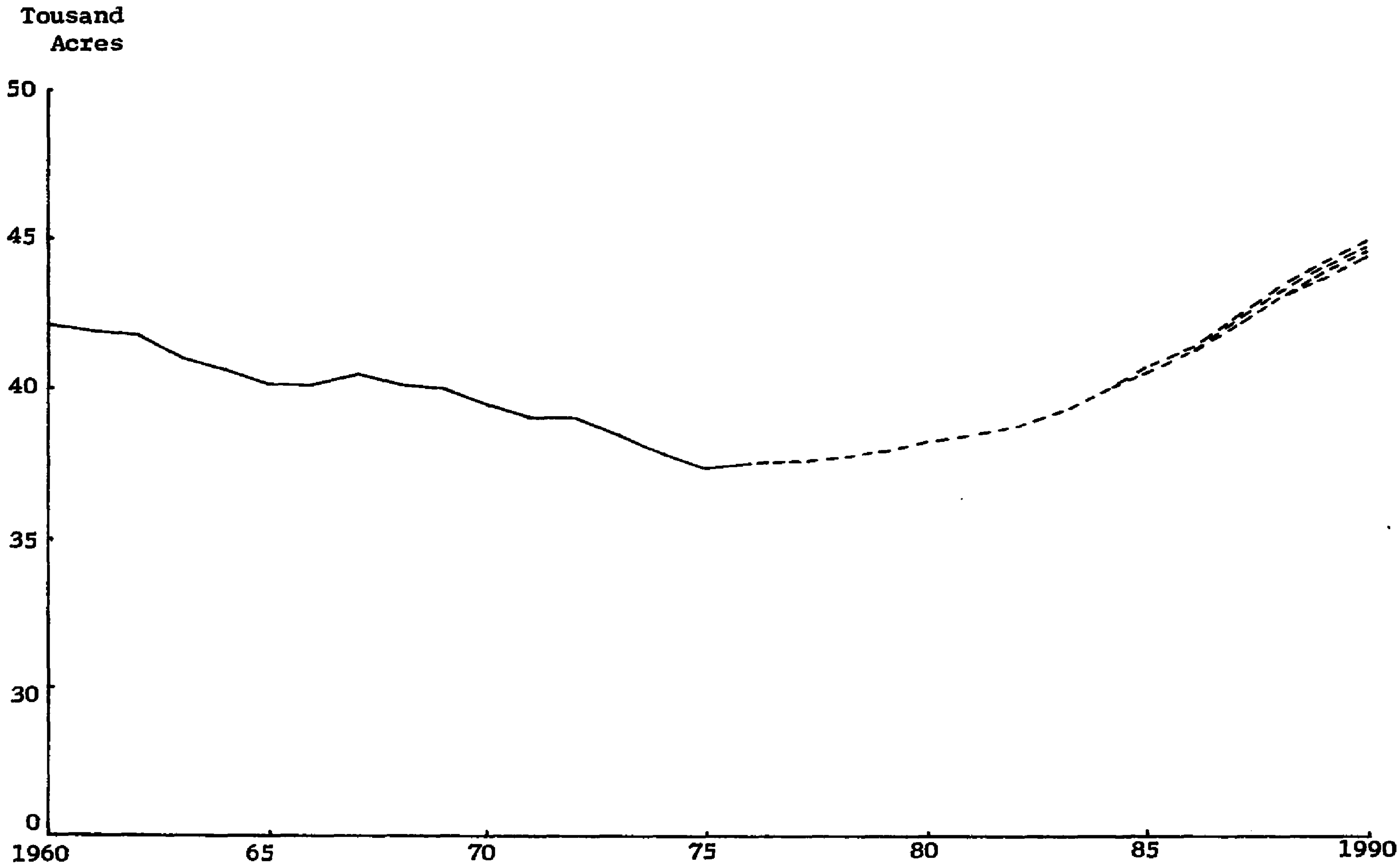

Figure 7.3, Future Bearing Acreage Prediction for Michigan Tart Cherries, 1977-1990

The predicted acreage for the first six years from 1977 to 1982 are generated from the observed data so that they all appeared to be the same for all alternatives, because the explanatory variables in the supply model are lagged six years. During the first six-year period the acreage rises fairly slowly, averaging about 250 acres per year, from 37,607 acres in 1977 to 38,860 acres in 1982. Beginning from 1983 the rate of increase accelerates to and maintains at about 750 acres per year. By 1990 all predicted acreage climbs to near 45,000 acres.

All predictions appear to be very consistant with each other with very small deviations. The predicted levels for 1990 range from 44,450 acres from Alternative No. 3 to 44,936 acres from Alternative No. 2, each of which delineates the lower and upper boundaries, respectively. Alternatives No. 1 and No. 4 lie within the boundaries with Alternatives No. 4 slightly higher than Alternative No. 1.

Alternatives No. 2 and No. 4 result in a higher series of acreage predictions. It would seem they are significantly attributable to the downward trend of the gross margins of apples, as these two alternatives contain downward trend of apple gross margins, and the tart cherry acreage is negatively correlated with this variable.

The result of this projection is somewhat higher than the one projected by Ricks.[38] The exact difference between these two projections is hard to measure because Ricks projects the number of bearing trees based on the Agricultural Census data, while this study projects the bearing acreage based on the data published by the Michigan Crop Reporting Service.

Ricks' projection reflects expected tree removals during the next few years because of (a) a high proportion of old trees, and (b) the damage that has occured to old trees from mechanical harvesting - particularly with the earlier machines. Thus, the major difference appears in the upturn point in the projected trends. The upturn point in Ricks' projection appears in 1980, four years later than that projected in this study but its rate of increase after the upturn point is faster and hence both projections may be expected to merge sometime around 1990.

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[38] Ricks, Donald J., "U.S. Cherry Plantings and Production Trends," Staff paper No. 77-55, Department of Agricultural Economics, Michigan State University, June 1977.

Production Predictions

Tart cherry production can be generated from the predicted acreages by applying the relationship with annual tart cherry output, such as

$$Q_t^t = A_t^t \cdot Y_t^t$$

where, Q_t^t is the annual output of tart cherries, A_t^t is the predicted bearing acreage and Y_t^t is the predicted yield of tart cherries per acre. The calculated tart cherry output is shown in Table 7.4 and Figure 7.4.

The output trend for each of the alternatives is exactly the same as the acreage trend because of the same yield pattern. The estimated output levels for 1990 range from a low of 120,265 tons from Alternative No. 3 to a high of 121,580 tons from Alternative No. 2, a total difference of only 1,315 tons. It should be emphasized that the projected output represents the level that would be expected for a normal or average crop year with nomal weather conditions.

Table 7.4, Future production Predictions for Michigan Tart Cherries, 1977 - 1990

Year	Alternative			
	No. 1	No. 2	No. 3	No. 4
	Tons			
1977	93,257	93,257	93,257	93,257
1978	94,311	94,311	94,311	94,311
1979	95,700	95,700	95,700	95,700
1980	97,124	97,124	97,124	97,124
1981	98,330	98,330	98,330	98,330
1982	99,741	99,741	99,741	99,741
1983	101,715	101,686	101,714	101,686
1984	104,006	103,984	104,005	103,982
1985	106,414	106,584	106,405	106,577
1986	109,014	109,427	108,991	109,410
1987	111,981	112,563	111,934	112,525
1988	115,107	115,857	115,019	115,782
1989	117,876	118,788	117,724	118,654
1990	120,509	121,580	120,265	121,357

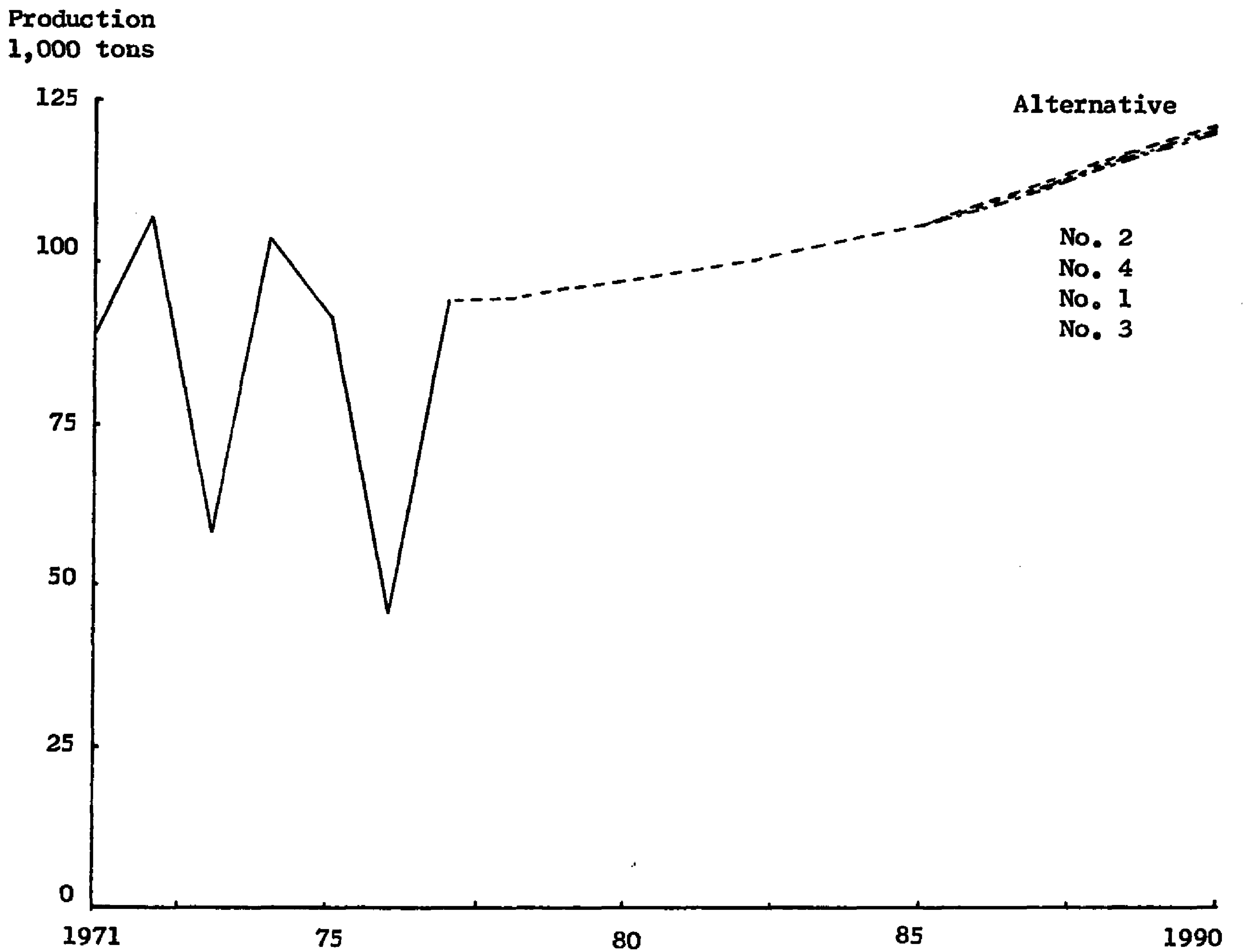

Figure 7.4, Future Production Predictions for Michigan Tart Cherries.

Impacts of a Higher Tart Cherry Yield on Production and Price Levels

An interesting phenomenon which appears to be quite important to observe is the response and impact upon prices and production due to yield changes. To demonstrate this, the yield of tart cherries is assumed to increase at a relatively higher rate than the predicted one as specified in Equation (6.3). The equation assumes that the yield will increase from the current average of about 2.5 tons per acre to 3.0 tons per acre in 1990 rather than 2.71 tons per acre as projected by estimated Equation (6.2).

For the purpose of comparison, an additional alternative in the future price predictions is made in contrast to Alternative No. 3. This relatively higher rate of increase in yield of tart cherries is to replace the lower yield rate while all other variables are held at the same level as in Alternative No. 3. The results show that the projected prices of tart cherries are substantially lower. The predicted prices in 1990 drop from $493.41 per ton for predicted yield level to $406.65 per ton for higher yield level, a total decline of about $87.00 per ton. The projected prices along with the projected acreage and production are shown in Table 7.5.

Table 7.5, Comparison of Future Predictions Between Altsrvatives No. 3 and the Higher Yield Level for Michigan Tart Cherries, 1977-1990

Year	Price		Acreage		Production	
	No. 3	Higher Yield	No. 3	Higher Yield	No. 3	Higher Yield
	$ per ton		Acres		Tons	
1977	592.93	586.86	37,607	37,607	93,257	94,047
1978	495.78	485.03	37,767	37,767	94,311	95,899
1979	497.20	477.74	38,059	38,059	95,700	98,100
1980	500.94	472.30	38,360	38,360	97,124	100,350
1981	506.51	470.25	38,572	38,572	98,330	102,384
1982	513.13	469.23	38,860	38,860	99,741	104,643
1983	516.43	465.15	39,363	39,372	101,714	107,533
1984	516.26	458.23-	39,980	39,986	104,005	110,745
1985	515.09	450.56	40.632	40,629	106,405	114,087
1986	512.16	442.35	41,352	41,328	108,991	117,635
1987	507.62	432.52	42,184	42,143	111,934	121,573
1988	500.60	421.77	43,064	42,990	115,019	125,668
1989	495.64	412.88	43,792	43,673	117,724	129,343
1990	493.41	406.65	44,450	44,277	120,265	132,831

The associated impact of adopting a higher yield rate is a lower level of acreage response, projected at 44,277 acres in 1990 or 173 acres lower than that using the predicted yield level. The derived total output in Michigan for 1990 is 132,831 tons, a total of 12,566 tons higher than the predicted level of 120,265 tons. This indicates that the rate of decline in acreage resulting from higher yield will not be fast enough to offset the rate of increase in the total production. This is the major factor contributing to the substantially lower prices.

Will the growers be better off from a higher rate of increase in yield? Assuming the costs per acre for the higher yield are exactly the same as those for the projected (lower) yield, the gross revenue generated from the predicted yield is $1,233.15 per acre in the year 1990. This compares favorably with the revenue generated from the higher yield at $1,219.94 per acre or a decline of $13.21 per acre. Evidently, the efforts to increase yield should be carefully evaluated. Clearly, the revenue would be even lower if the adoption of new techniques or methods for a higher yield would be concomitant with higher production and handling costs, which they will be, particulary for harvesting, storing and selling costs.

The above analysis is just an indication, and might not be the case if the increase in yield would accompany favorable changes in other factors such as lower production and handling costs, and or market expansions, etc.

Those growers who are early adopters will probably gain from the adoption of the improved techniques or varieties for higher yields because they will likely be able to capture some profits before the price starts to fall. Other growers will likely suffer from lower prices than they use to receive after supplies increase. From the consumer's point of view, the lower market prices resulting from the increased supply may benefit them by enabling retail prices to be less for the cherries they consume. An increase in production may benefit cherry processors and marketers if such an increase in efficiency enables the industry to become more competitive in foreign markets.

In summary, we can ask - what rate of increase in yield will be the most appropriate? This is not an easy question to answer since the answer will depend heavily on the costs of production, particularly those related to the new technologies, and the interrelationship among variables and market situations. However, a possible answer may hinge on further analysis on the level of the growers' gross margins. The analysis in the following section may serve as an overall quideliene for answers to these questions.

Stability and Supply Response

Static economic theory suggests that in a competitive market an equilibrium is reached when the cost of production including depreciation and interest on investment is equal to the market price. At this point, the size of operations will remain unchanged over time. Further evaluation in the growers' gross margins in tart cherries should be of interest in exploring the empirical evidence in the current operation. This approach is essentially another way to examine the growers response to the changing profitability of growing tart cherries.

In doing so, a polynomial distributed lag model will be constructed using the annual net change of bearing acreages as the dependent variable and the gross margins as the independent variables.

Again the data are fitted to the polynomial distributed lag model as specified previously. The results are shown in Table 7.6.

The distributed lag length used ranges from six to twelve year periods. Of these alternative periods, the one with nine periods has highest R^2 values, with .79. The estimated student t values of each period in this equation

Table 7.6, Distributed Weights for Different Lag Periods[1]

Variable	Length of Distributed Lag						
	6	7	8	9	10	11	12
C	-.01914	-.13703	-.13220	-.29663	-.17937	-.09658	.02367
t-6	-.00050	-.00049	-.00038	-.00046 (1.16)	-.00035	-.00031	-.00022
-7	.00027	.00031	.00021	.00016 (.51)	.00006	-.00001	-.00004
-8	.00070	.00083	.00061	.00062 (1.89)	.00038	.00023	.00011
-9	.00080	.00105	.00085	.00091 (2.54)	.00061	.00040	.00022
-10	.00057	.00099	.00090	.00105 (2.81)	.00074	.00052	.00030
-11		.00064	.00078	.00103 (2.94)	.00078	.00058	.00036
-12			.00048	.00085 (3.01)	.00072	.00059	.00038
-13				.00050 (3.05)	.00058	.00053	.00036
-14					.00034	.00041	.00032
-15						.00023	.00024
-16							.00014
R^2	.7537	.7834	.7667	.7892	.7552	.7373	.7221
d.w.	2.338	2.279	2.482	2.371	2.337	2.182	2.120
$\bar{R}^2$	.7446	.7754	.7581	.7814	.7461	.7276	.7118
Average t value	.99266	1.73805	1.57534	1.94805	1.37943	1.02168	.64783

[1] The dependent variable = $(A_t^t - A_{t-1}^t)$; degree of polynomial = second, and zero restriction = last period.

ranged from .51 to 3.05 and averaged 1.95, indicating that the estimated coefficients are significantly different from zero at a 10 percent probability level.

The highest weight for the selected equation is observed in the (t-10) period, or five years prior to planting. The functional relationship of the selected equation can be denoted as:

$$\Delta A_t^t = -.296626 - .000457\ GM_{t-6}^t + .00016\ GM_{t-7}^t$$
$$+ .000618\ GM_{t-8}^t + .000915\ GM_{t-9}^t + .001052\ GM_{t-10}^t$$
$$+ .001029\ GM_{t-11}^t + .00085\ GM_{t-12}^t$$
$$+ .000503\ GM_{t-13}^t \qquad (7.1)$$

where, ΔA_t^t means the net change of tart cherry bearing acreage in year t, which is the difference of bearing acreage between t and (t-1).

The current year's bearing acreage (A_t) is determined by (1) the previous year's bearing acreage (A_{t-1}), (2) new bearing acreage that was planted six years ago (A_{t-6}), and (3) current year's removal of bearing acreage (R_t). The relationship is:

$$A_t = A_{t-1} + A_{t-6} - R_t$$

or, $$A_t - A_{t-1} = A_{t-6} - R_t$$

In years when there is no change in acreage, then

$$A_t - A_{t-1} = 0$$

So that $A_{t-6} = R_t$

From Equation (7.1), we can derive the long term equilibrium or the condition in which the tart cherry industry achieves its long term stability. One important condition to be maintained for that stability is when there is no expansion or contraction in the bearing acreage over the years while the growers' gross margins in each year are all equal. No expansion in the bearing acreage implies that the annual increase in the demand for tart cherries is equal to the annual increase in the yield of tart cherries.

By inserting this condition into Equation (7.1), the calculated equilibrium gross margin is $63.52 per acre in real terms. In other words, the empirical results generated from Equation (7.1) show that a static equilibrium real gross margin of $63.52 per acre over an indefinite period would be required to stablize the industry. When this equilibrium point is maintained the new bearing acreage equals the amount of acreage removed in that year, such that

$$A^t_{t-6} = R^t_t$$

Gross margins must cover all costs with any remainder being the profit. When the long run equilibrium is reached the amount of profit is equal to the level required to keep the resources employed. Note that in this discussion gross margins are referred to in real terms and are defined as the gross income less total costs, excluding the payment to the manager on his money capital and for his managerial talents.

To equalize the projected gross margins generated from different yield levels to the one at the equilibrium level one could approximate when the industry would reach the long run static equilibrium.

The projected gross margins generated from the two different yield levels are both considerably higher than the equilibrium level. This indicates that, ceteris paribus, the Michigan tart chery industry would not seem to reach the long run equilibrium in the foreseeable future.

To derive the tart cherry industry's long run dynamic equilibrium, a few assumption with respect to the annual growth rate of related variables must be made. They are: (1) the price of tart cherries, 5 percent, (2) per capita disposable income, 8 percent, and (3) the United States population, .8 percent. The remaining variables are assumed to be constant over time.

Using the above assumptions together with the elasticities of each variable derived from the demand model, the annual increase in the tart cherry acreage (ΔA_t) can be calculated. The calculation is shown in Appendix D Table D.4. The results show the annual change in tart cherry bearing acreage (ΔA_t) are 87.23 acres per year for the projected yield level, and 37.88 acres per year for the higher yield level.

Substituting the annual growth rates of acreage into Equation (7.1), the level of gross margins that is required to maintain the long run dynamic equilibrium can be derived. The results indicate that $82.20 of tart cherry gross margins per acre for the projected yield level, or $71.63 per acre for the higher yield level is required to achieve the long run dynamic equilibrium.

From this empirical analysis, it could be concluded that the projected yield (lower) level would seem to require a higher gross margins ($82.20 per acre) to secure the long run dynamic equilibrium than for the assumed higher yield level ($71.63 per acre).

CHAPTER VIII

SUMMARY AND CONCLUSION

This chapter is presented in two main sections. The first section describes the approaches used and the significant aspects of the results. The second section presents the implications drawn from the findings.

Summary of Study

The main objectives of this study were to theoretically formulate and statistically estimate the supply response and demand for Michigan tart cherries with respect to price or profit, and non-price variables. This study identifies the cause and consequence of tart cherry growers' supply response during the period from 1938 to 1976. The process involves the construction of acreage response models, demand models and projection of the exogenous variables contained in the models. Projections of future demand and supply of tart cherries in Michigan were made to 1990.

The analytical procedures and tools applied to develop the econometric models have been carefully chosen and are based on economic theory and the characteristics of the industry. The selected models for empirical analysis include the geometric distributed lag models and the polynomial lag models. For the geometric distributed lag models the adaptive price expectation and partial adjustment models formulated by Koyck and Nerlove were chosen for their simplicity and ease of comprehension.

The variables used in the estimation of the supply response model were adjusted by applying six year moving averages to eliminate the cyclical fluctuations due to the weather. This will also reflect the impact of the time span required for the growers to make the adjustment. In view of the biological process for a tart cherry tree to reach the bearing age, the gross margins in the model were then lagged six years.

The Ordinary Least Squares method and the Cochrane-Orcutt iterative techniques were applied. The Cochrane-Orcutt iterative technique is used in instances where presence of serial correlation errors.

It is difficult to evaluate the performance of the model, and no single criterion can adequately provide that evaluation. However, there are several commonly used measures and their combined results may give a reasonably reliable indication of the model's performance. These measures are: (1) size of the calculated R^2, (2) conformity to economic theory, (3) significance of coefficients, (4) Theil's inequality coefficient, and (5) the Dubin-Watson statistics. However, the Durbin-Watson test is not appropriate in instances where the lagged variable as an independent variable is used.

Many important quantified relationships were derived from the results of the estimated models. The selected supply response model, as discussed in Chapter IV, indicates that the level of tart cherry bearing acreage in Michigan is a function of the gross margins of tart cherries; apples and sweet cherries, and last year's tart cherry bearing acreage. The estimated function explains over 99 percent of the variation in the growers expectations of eventual tart cherry output. The estimated coefficient of adjustment of tart cherry acreage indicates that the growers require about 24 years to adjust their acreage to within ten percent of the long run equilibrium level.

For the polynomial lag models alternative length of lags were tried to examine the magnitude of weight distribution over the lagged periods. The optimum length of lag was found to be 12 periods. The distribution of the weights was centered around six years prior to tree plantings.

The model was expanded to include the grower gross margins of the major competing fruits. The results indicate a roughly symmetrical distribution of weights over the selected 12-year period for both tart cherry gross margins and these of the competing fruits. These empirical results provide some information about the growers decisions between competing fruit growing enterprises.

The estimated demand model indicates that the grower price of tart cherries is dependent on its own consumption, and consumption of the major competitve fruit-frozen apples, carryover stocks, disposable income and consumer price index. These independent variables explain about 96 percent of the variation in tart cherry prices.

The demand model was incorporated into the supply model together with two identity equations to facilitate future predictions. Before making the prediction it was necessary to estimate equations which resemble the future trends of each of the exogenous variables.

Projection of exogenous variables requires understanding of the past trends as well as special knowkedge about the future perspectives regarding each of the variables. Projections of some variables have been disaggregated into componenets in order to measure the various impacts under different conditions. For instance, the growers' gross margins were projected by using estimates of the functional relationship between the yield, price and cost of production as a endogenous variable.

If a variable appears to have a stable historical trend and a lower level of future uncertainty, its future course was represented by one equation. In contrast, alternative equations were estimated for those variables that are characterized as highly uncertain.

Four alternative projections for future tart cherry acreages and price levels were made depending upon selected combinations of conditions. The predicted acreage levels for 1990 range from 43,782 acres to 44,936 acres, whereas, the predicted prices range from $454.45 per ton to $574.94 per ton. The generated total Michigan tart cherry production ranges from 120,265 tons to 121,580 tons by 1990. This compares to the current annual average production of about 90,000 tons, a total increase of about 35 percent from the current level.

The projected tart cherry production and prices represent the levels that would be expected for a normal, or average condition and will not reflect the year to year fluctuations in response to weather variations. Since tart cherry production involves a long term investment, it will generally be the normal or average trend levels that will be the most important for decision making.

In order to perceive the consequences of alternative yield rate, an assumed higher rate of yield increase in tart cherries is tested in the future prediction. The assumed higher yield trend is to increase from the current average of 2.46 tons per acre to 3.0 tons per acre by 1990 in contrast to 2.71 tons per acre projected for 1990.

The results reveal that, other things being equal, the efforts for bringing about a yield trend higher than the projected level will result in,as would be expected, lower grower prices and, hence, lower farm income (Chapter VII).

The principal aim of the discussions throughout this study is to present evidence that will give the leaders of the industry and policy makers enough confidence in the model actually to forecast with it. Another purpose is to facilitate the intelligent use and further application of the methodology for similar studies in other fruit crops in Michigan as well as in the United States as a whole.

As discussed previously, Michigan has been the most important of the tart cherry producing states. As a result, production and price of tart cherries in the United States is heavily weighted by the production and price of those grown in Michigan. There are great similarities between the supply and demand patterns of Michigan and the U.S.; but the difference is in magnitude. It is realistic to assume that the formulation of structual relationships that are based on Michigan data can be applied to the United States as a whole.

Implications

The market outlook for Michigan tart cherries indicates that a gradual expansion in tart cherry bearing acreage up to a total of around 44,600 acres can be anticipated by 1990. This increase, which is nearly 20 percent over the current level of 37,500 acres would mean an increase of 35 percent in the total production as indicated by the empirical analysis.

The acreage adjustment, in response to the changing profitability is projected to be a continuous process. Attention must be given to the required capital, processing and storage capacity and other associated resources vital to achieve this successful adjustment.

The expansion of acreage may probably be made possible by an extension of the margin. An extension of the margin means to bring in new lands that are less suitable than that already under cultivation. Since the tart cherry crop is highly sensitive to weather conditions, a further expansion of the margin of such land will increase its vulnerability to uncontrollable factors unless the growers and the scientists counteract these influences. This would be done by means of improving technologies and by development of freeze resistant varieties.

However, it appears that part of the additional land for tart cherries could come from the area currently occupied by competitive crops, possibly from sweet cherries since this crop has shown a sign of declining acreage due to high competition with the western states.

It should be noted that an important factor that gears the rate of acreage adjustment is the availability of nursery stock. Nursery stock is usually planted one or two years prior to its sale. In addition, the trees will require an additional six years to reach the bearing age. The nurserymen would need to keep close estimates of the anticipated rate of growth in numbers of trees at least seven years in advance.

A sudden expansion of orchards may be tempered by the availability of nursery stock. It is quite difficult for nurserymen to decide how many trees are needed without knowing the future prospects of the cherry industry. Following are basic guidelines that would assist the nursery suppliers in making this decision.

First, the nurserymen must figure out the annual tree replacement rate required for the next year, or the one following based upon the life expectancy of tart cherry trees, i.e., the annual replanting rate will be 3.33 percent of the total trees if the life expectancy of these trees is 30 years.[39] This will enable the state's producers to maintain approximately 16.67 percent non-bearing trees, if the life expectancy of trees is 25 years, i.e., a shorter life expectancy resulting from the application of mechanical shakers (harvesters). The annual replacement rate will be 4 percent of the total trees. In this case the ratio of nonbearing trees to the total will be 20 percent.

Secondly, it is necessary to estimate the anticipated increase in the number of trees that will begin bearing 7 to 8 years from now, and to plant nursery stock accordingly along with those trees computed above.

The annual Objective yield Survey program carried out by Crop Reporting Service, and the Market Order administered by the Cherry Administrative Board has improved the tart cherry pricing and supply control mechanism on a short term basis. However, the industry leaders and decision makers need also to be aware of market conditions, production prospects for tart cherries, and to have some concept of

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[39] $$\text{Rate of annual replacement} = \frac{1}{\text{Years of life expectancy}} \times 100$$

the future demand for tart cherries in order to make satisfactory plans in relation to the more distant future. It is suggested that the cherry industry should emphasize the longer-term development of continuing markets for tart cherries based on the results of this study.

The study revealed that any policy towards an improvement in a yield substantially higher than the projected rate of increase would require careful forethought in order to avoid a drastic upward shift in supply. This might result in declines in grower price and income, unless the industry seeks to stimulate the consumption of tart cherries and to develop overseas markets for cherries.

There may be different views in the policy decisions in regard to the allocation of research funds, i.e., a higher priority to for yield improvement, or market development; or equal priority to both.

Another implication drawn from the findings of this study is that the need for interdisciplinary studies covering subjects of economics, marketing, horticulture, engineering, etc., is needed. These studies would ultimately reduce the uncertainty confronting the tart cherry industry through improved comprehension of forces that will shape the market in the distant future.

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APPENDICES

Appendix A.1, Nerlove expectation model

$$A_t = a + bP^*_t + e_t \qquad (a)$$

$$P^*_t - P^*_{t-1} = (1 - \lambda)(P_{t-1} - P^*_{t-1}) \qquad (b)$$

Equation (b) indicates that the change in expectations is determined by some fraction of the previous year's price forecasting error. Rearrange (b), thus

$$P^*_t = P_{t-1} - \lambda P_{t-1} + \lambda P^*_{t-1} \qquad (c)$$

Substituting (c) to (a)

$$A_t = a + b(P_{t-1} - \lambda P_{t-1} + \lambda P^*_{t-1} + e_t$$

$$= a + b(1-\lambda)P_{t-1} + \lambda bP^*_{t-1} + e_t \qquad (d)$$

Since $A_{t-1} = a + bP^*_{t-1} + e_{t-1}$

$$bP^*_{t-1} = A_{t-1} - a - e_{t-1} \qquad (e)$$

Substituting (e) to (d)

$$A_t = a + b(1 - \lambda)P_{t-1} + \lambda A_{t-1} - \lambda a - \lambda e_{t-1} + e_t$$

or,

$$A_t = a(1 - \lambda) + b(1 - \lambda)P_{t-1} + \lambda A_{t-1} + e_t - \lambda e_{t-1}$$

Therefore,

$$A_t = k_0 + k_1P_{t-1} + \lambda A_{t-1} + E_t$$

where $k_0 = a(1 - \lambda)$

$k_1 = b(1 - \lambda)$

$E_t = e_t - \lambda e_{t-1}$

and $(1 - \lambda)$ = price expectation adjustment coefficient.

Appendix A.2, Partial adjustment model

$$A_t^* = a + bP_{t-1} + e_t \qquad (a)$$

$$A_t - A_{t-1} = r(A_t^* - A_{t-1}) \qquad (b)$$

where $0 \leq r \leq 1$

From (b) we derive

$$A_t = rA^* + A_{t-1}(1 - r) \qquad (c)$$

Substituting (a) to (c)

$$A_t = r(a + bP_{t-1} + e_t) + A_{t-1}(1 - r)$$

$$= ra + rbP_{t-1} + A_{t-1}(1 - r) + re_t$$

Therefore,

$$A_t = k_0 + k_1P_{t-1} + k_2A_{t-1} + E_t \qquad (d)$$

where $k_0 = ra$

$k_1 = rb$

$k_2 = (1 - r)$

$E_t = re_t$

and r = the supply adjustment coefficient.

Equation (a) can be expanded to include other explanatory variables such as the price of competitive crops (P^c), stocks (S_t) etc. The result becomes

$$A_t = K_0 + K_1 P_{t-1} + K_2 A_{t-1} + K_3 P^c_{t-1} + K_4 S_{t-1} + E_t$$

Table B.1, Tart Cherry Statistics, Michigan 1938-1976

Year	Bearing acreage	Total value of production	Total cost[1]	Price received by growers
	1,000	$1,000	$/acre	$/ton
1938	25.0	1,273	88.80	67.00
1939	24.8	1,613	98.40	42.00
1940	25.1	2,645	72.00	58.00
1941	25.4	2,548	71.20	92.00
1942	25.2	4,650	160.80	100.00
1943	25.9	1,858	154.40	172.00
1944	26.1	7,800	124.00	156.00
1945	26.5	4,116	158.40	294.00
1946	26.9	18,029	222.40	298.00
1947	27.5	9,504	144.00	192.00
1948	28.1	12,489	158.40	181.00
1949	29.3	11,011	110.40	182.00
1950	30.1	12,610	260.80	130.00
1951	31.3	10,350	291.20	138.00
1952	32.2	7,080	192.80	119.00
1953	33.5	13,376	188.00	176.00
1954	34.8	10,560	199.60	220.00
1955	36.3	8,591	211.02	121.00
1956	37.7	8,195	162.38	149.00
1957	39.8	11,748	203.82	132.00
1958	41.3	8,068	226.12	163.00
1959	42.3	10,750	249.07	125.00
1960	42.1	12,320	236.89	154.00
1961	41.9	14,857	377.21	166.00
1962	41.7	10,516	287.54	95.00
1963	41.0	7,215	291.71	195.00
1964	40.6	15,150	333.56	101.00
1965	40.1	10,593	310.15	99.00
1966	40.1	15,260	213.77	280.00
1967	40.5	15,840	462.12	360.00
1968	40.1	30,000	427.86	300.00
1969	40.0	16,112	398.66	152.00
1970	39.5	11,297	394.40	143.00
1971	39.1	17,622	512.80	198.00
1972	39.1	17,227	346.40	161.00
1973	38.5	22,620	400.00	390.00
1974	37.9	37,801	432,80	367.00
1975	37.4	18,473	416.00	203.00
1976	37.5	22,815	545.84	507.00

Sources and footnotes, see p. 196.

Table B.1, Tart Cherry Statistics, United States, 1955-1976 (Continued)

Year	Total production of value	Carryover stocks (April 1)
	Tons	
1955	149,070	26,400
1956	99,040	35,400
1957	146,670	22,050
1958	103,410	31,100
1959	137,958	29,100
1960	115,840	31,700
1961	164,670	20,500
1962	166,655	49,100
1963	80,790	58,750
1964	225,923	22,050
1965	161,414	69,200
1966	89,496	52,450
1967	88,990	20,650
1968	137,654	19,500
1969	152,230	39,050
1970	118,990	41,250
1971	139,260	33,350
1972	134,180	44,950
1973	87,020	35,100
1974	132,300	18,550
1975	123,070	38,250
1976	72,200	32,950

Source: USDA, "Fruit - Noncitrus: Production, Use, Value," and "Cold Storage", Statistical Reporting Service (various issues).

Table B.1, Tart Cherry Statistics, United States, 1938-1976 (Continued)

Year	Disposition			
	Fresh	Canned	Frozen	Other
	Tons			
1938	18,252	34,117	9,290	2,241
1939	20,879	55,047	17,025	3,009
1940	19,593	59,254	20,150	4,483
1941	16,632	37,822	22,301	2,945
1942	19,860	60,328	21,616	2,236
1943	14,020	12,649	13,136	474
1944	19,410	54,530	35,330	2,930
1945	10,550	25,320	9,025	755
1946	14,620	55,930	44,160	1,300
1947	12,840	40,470	35,530	1,540
1948	14,000	67,690	46,570	3,530
1949	12,650	58,625	35,575	1,440
1950	13,160	87,310	52,920	1,350
1951	12,659	84,256	49,895	1,250
1952	10,190	67,285	31,675	500
1953	10,385	61,330	59,035	740
1954	9,790	52,455	43,255	820
1955	9,350	79,363	58,689	1,668
1956	7,963	45,423	44,254	1,400
1957	8,624	66,104	71,042	900
1958	7,968	48,089	46,588	765
1959	7,413	71,225	58,320	1,000
1960	6,365	44,307	64,168	1,000
1961	7,677	62,563	93,870	560
1962	7,016	84,293	73,676	1,670
1963	4,880	30,845	44,350	715
1964	8,258	101,031	116,634	0
1965	6,495	69,918	85,001	0
1966	6,592	36,738	46,166	0
1967	4,662	30,374	53,954	0
1968	5,734	48,411	83,509	0
1969	5,691	63,357	83,182	0
1970	6,012	43,358	69,620	0
1971	5,620	41,280	92,360	0
1972	3,080	47,990	83,110	0
1973	2,630	26,900	57,490	0
1974	2,210	48,800	81,290	0
1975	3,600	40,770	74,640	4,060
1976	3,000	18,580	49,120	1,500

Source: USDA, "Fruit - Noncitrus: Production, Use,Value," Statistical Reporting Service(various issues).

Table B.2, Apple Statistics, Michigan, 1938 - 1976

Year	Bearing acreage	Total value of production	Total cost[1]	Price received by growers
	1,000	$1,000	$/acre	¢/lb
1938	76.6	4,600	105.60	2.05
1939	76.7	4,802	106.40	1.26
1940	76.8	5,245	84.00	2.07
1941	77.1	6,322	84.00	1.98
1942	77.5	9,406	130.40	2.83
1943	77.1	13,719	132.00	5.58
1944	76.3	11,798	169.60	5.10
1945	75.4	3,625	91,20	8.05
1946	74.4	12,474	240.80	5.00
1947	72.3	8,296	258.40	3.21
1948	69.4	10,626	246.40	5.24
1949	65.9	8,168	272.80	2.50
1950	62.2	10,541	309.60	3.33
1951	58.1	10,400	372.00	3.33
1952	55.4	14,012	284.80	5.12
1953	54.1	19,504	360.80	5.05
1954	53.2	15,794	378.69	4.98
1955	65.4	13,778	468.33	3.95
1956	65.4	22,440	400.66	4.45
1957	65.9	17,600	385.82	4.19
1958	61.6	19,558	506.90	3.67
1959	60.0	20.115	362.58	3.52
1960	59.5	22,713	349.78	4.79
1961	59.5	23,360	349.31	3.48
1962	60.5	24,050	325.94	4.40
1963	63.0	22,560	358.14	4.48
1964	63.2	24,948	342.87	3.67
1965	54.5	24,116	366.26	3.63
1966	55.1	25,350	349.34	3.77
1967	55.0	28,083	382.84	5.06
1968	55.5	29,082	402.26	5.24
1969	56.0	24,503	439.82	3.74
1970	56.0	25,703	487.20	3.79
1971	55.5	26,061	474.40	3.57
1972	54.5	31,390	483.20	4.30
1973	54.0	43,710	560.00	9.30
1974	53.5	41.540	662.40	6.20
1975	53.5	34,680	696.00	5.10
1976	53.5	40,500	708.00	8.10

Sources and footnotes, see p. 196.

Table B.3, Sweet Cherry Statistics, Michigan, 1938 - 1976

Year	Bearing acreage	Total value of production	Total cost[1]	Price received by growers
	1,000	$1,000	$/acre	$/ton
1938	2.5	302	88.80	108
1939	2.5	234	98.40	90
1940	2.6	364	72.00	104
1941	2.8	433	71.20	114
1942	3.0	452	160.80	116
1943	3.2	352	154.40	220
1944	3.4	1,113	124 00	220
1945	3.7	190	158.40	380
1946	3.8	1,274	247.20	275
1947	3.8	1,159	144.00	235
1948	3.9	1,297	158.40	260
1949	4.1	972	110.40	135
1950	4.2	1,212	289.60	146
1951	4.3	1,306	323.60	192
1952	4.5	1,320	192.80	145
1953	4.6	2,052	188.00	228
1954	4.7	2,420	200.00	275
1955	4.9	1,485	346.56	198
1956	5.1	2,100	101.72	270
1957	5.5	4,076	362.34	263
1958	5.7	3,172	523.87	235
1959	5.9	2,618	448.71	187
1960	6.2	3,570	334.77	255
1961	6.6	3,472	332.96	248
1962	7.3	4,389	336.40	231
1963	7.6	2,387	327.55	327
1964	8.1	4,070	457.23	185
1965	8.8	4,464	281.22	186
1966	9.3	4,590	291.10	240
1967	9.9	5,198	425.35	297
1968	10.4	7,480	464.22	340
1969	11.3	4,580	528.10	213
1970	11.4	4,242	340.00	202
1971	11.6	4,489	470.40	191
1972	11.7	5,460	442.40	195
1973	11.5	4,480	422.40	280
1974	11.5	9,180	380.80	360
1975	11.5	6,426	430.30	238
1976	11.5	3,948	481.94	376

Source and footnotes, see p. 196.

Table B.4, Population, Disposable Income and Consumer Price Index, United States, 1938-1976

Year	Total Population	Capita disposable income	Consumer price index(1976=100)
		Dollars	
1938	129.8	504	42.2
1939	130.9	537	41.3
1940	132.1	573	42.0
1941	131.8	695	44.1
1942	131.5	867	48.8
1943	128.9	976	51.8
1944	128.6	1,057	52.7
1945	129.1	1,074	53.9
1946	138.4	1,132	58.5
1947	142.6	1,178	66.9
1948	145.2	1,290	72.1
1949	147.6	1,264	71.4
1950	150.2	1,364	72.1
1951	151.0	1,469	77.8
1952	153.3	1,518	79.5
1953	156.0	1,583	80.1
1954	159.1	1,585	80.5
1955	162.3	1,666	80.2
1956	165.4	1,743	81.4
1957	168.4	1,801	84.3
1958	171.5	1,831	86.6
1959	174.5	1,898	87.3
1960	178.1	1,934	88.7
1961	181.1	1,976	89.6
1962	183.6	2,058	90.6
1963	186.4	2,128	91.7
1964	189.1	2,278	92.9
1965	191.5	2,430	94.5
1966	193.3	2,597	97.2
1967	195.2	2,740	100.0
1968	197.0	2,930	104.2
1969	199.1	3,110	109.8
1970	201.6	3,348	116.3
1971	204.2	3,588	121.3
1972	206.5	3,837	125.3
1973	208.1	4,285	133.1
1974	209.7	4,639	147.7
1975	211.4	5,060	161.2
1976	213.0	5,138	178.8

Sources: see p. 196.

Sources and Footnotes for Tables B.1, B.2 and B.3

All Michigan statistics except for costs - Crop Reporting Service, "Michigan Agricultural Statistics," Michigan and U.S. Department of Agriculture (various issues).

Total costs - Derived from "Farm Cost Accounts Reports," Department of Agricultural Economics, Cornell University, Ithaca, New York (various issues).

[1]See total cost items in Table B.5.

Sources for Table B.4

Population - USDA, "Agricultural Statistics, 1976," Economic Research Service, p. 557. Beginning 1960, includes Alaska and Hawaii. Data for 1938-1958 in 1972 issue Table 805.

Disposable income - Ibid. p. 466. Data for 1938-1958 in 1972 issue Table 685.

Consumer price index - Ibid. p. 567. Data for 1938-1958 in 1972 issue Table 816.

Table B.5, Tart Cherry Cost Items

(1) Growing costs:

Labor
Tractor
Truck, equipment, custom work, equipment rent
Orchard overhead
Fertilizer
Spray, dust material
Interest
Other

(2) Harvesting costs:

Labor
Tractor, truck
Equipment
Custom work, equipment rent
Other

(3) Storing and selling costs:

Labor
Tractor, truck, equipment
Building use
Direct selling cost
Other

Soruce: Darwin P. Snyder, "Farm Cost Accounts", Department of Agricultural Economics, Cornell University, Ithaca, New York, 1974, p. 17.

Table C.1, Second Degree Polinomial Lag Model of Michigan Tart Cherry Bearing Acreage Response

	Distributed Lag						
Variable	8	9	10	11	12	13	14
C	36.6737	36.3607	36.0289	35.6424	35.2387	34.9147	34.4433
t-6	-.00749	-.00250	-.00565	-.00450	-.00344	-.00275	-.00182
-7	.00301	-.00286	-.00255	-.00201	-.00143	-.00105	-.00044
-8	.00046	.00013	-.00001	.00007	.00028	.00040	.00076
-9	.00292	.00236	.00196	.00174	.00167	.00161	.00176
-10	.00436	.00385	.00337	.00298	.00274	.00256	.00256
-11	.00479	.00458	.00422	.00381	.00350	.00327	.00318
-12	.00421	.00456	.00450	.00422	.00395	.00373	.00360
-13	.00261	.00379	.00422	.00421	.00408	.00394	.00382
-14		.00227	.00338	.00378	.00389	.00391	.00356
-15			.00197	.00294	.00339	.00362	.00370
-16				.00168	.00258	.00309	.00335
-17					.00145	.00231	.00280
-18						.00128	.00206
-19							.00113
R^2	.4042	.4590	.5012	.5131	.5239	.5506	.5637
d.w.	.2379	.2030	.1580	.1246	.0953	.0854	.0712
$\bar{R}^2$	.3601	.4189	.4643	.4770	.4886	.5173	.5314

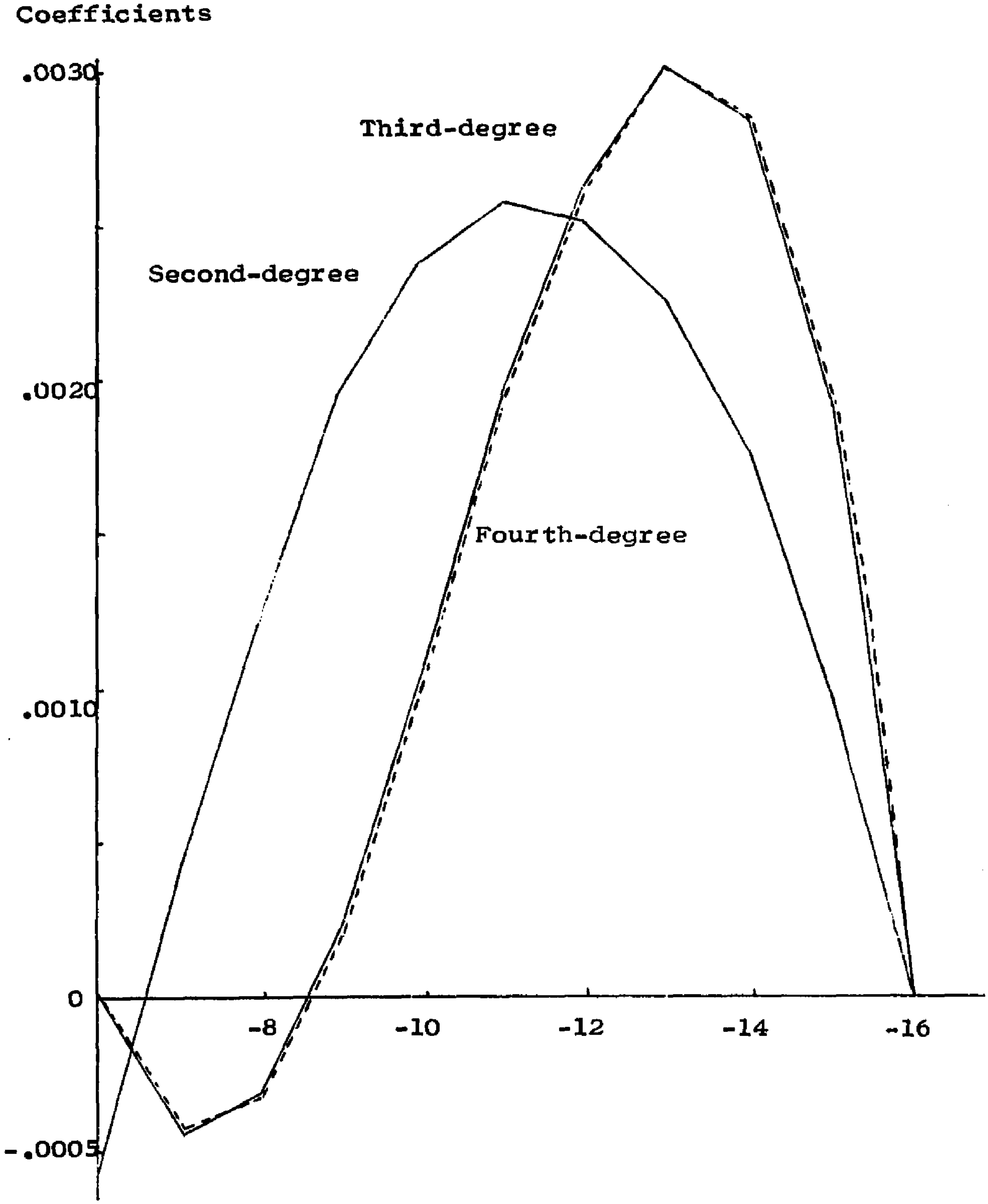

Figure C.1, Distribution of Correlation Coefficients With Different Degree of Polynomial

Table C.2, Simple Correlation Metrix for Variables in the Supply Model

	A^t	GM^t	GM^a	GM^{sw}	T
A^t	1.000				
GM^t	-.441	1.000			
GM^a	.520	.112	1.000		
GM^{sw}	-.001	.455	.116	1.000	
T	.657	-.084	.698	-.204	1.000

Table C.3, Simple Correlation Metrix for Variables in the Demand Model

	P^t	Q^t	S^t	Q^a	CPI	PDI	T
P^t	1.000						
Q^t	-.798	-1.000					
S^t	-.392	-.142	1.000				
Q^a	.289	-.278	.034	1.000			
CPI	.652	-.518	-.177	.258	1.000		
PDI	.651	-.501	-.164	.353	.978	1.000	
T	.625	-.481	-.124	.447	.942	.983	1.000

Table D.1, Calculations for Projection of Apple Grower Gross Margins, Michigan, 1977-1990

Year	Yield	Price	Total Cost	Gross margin[1]	CPI	Deflated gross margin
	Lb/acre	¢/lb	$/acre	$/acre	1967=100	$/acre
1977	12835	5.0822	620.02	32.291	194.13	16.634
1978	12961	5.0638	632.72	23.597	205.00	11.511
1979	13087	5.0454	645.42	14.856	213.43	6.961
1980	13213	5.0270	658.12	6.071	220.32	2.755
1981	13338	5.0086	670.82	-2.762	226.15	-1.221
1982	13464	4.9902	683.52	-11.641	231.19	-5.035
1983	13590	4.9718	696.22	-20.566	235.64	-8.728
1984	13715	4.9534	708.92	-29.538	239.62	-12.327
1985	13841	4.9350	721.62	-38.555	243.23	-15.851
1986	13967	4.9166	734.32	-47.619	246.51	-19.317
1987	14093	4.8982	747.02	-56.729	249.54	-22.733
1988	14219	4.8798	759.72	-65.886	252.34	-26.110
1989	14344	4.8614	772.42	-75.089	254.95	-29.452
1990	14470	4.8430	785.12	-84.337	257.39	-32.766

[1] Gross margin = (Yield x Price) - Total Cost

Table D. 2, Calculations for Projection of Sweet Cherry Gross Margins, Michigan, 1977-1990

Year	Yield	Price	Total Cost	Gross[1] margin	CPI 1967=100	Deflated gross margin
	Ton/acre	$/ton	$/acre	$/acre		$/acre
1977	2.2272	230.45	485.77	27.495	194.13	14.163
1978	2.2336	229.70	496.35	16.713	205.00	8.153
1979	2.2400	228.95	506.93	5.922	213.43	2.775
1980	2.2465	228.20	517.50	-4.856	220.32	-2.204
1981	2.2529	227.45	528.08	-15.667	226.15	-6.928
1982	2.2593	226.69	538.66	-26.487	231.19	-11.457
1983	2.2657	225.94	549.23	-37.317	235.64	-15.836
1984	2.2721	225.19	559.81	-48.157	239.62	-20.097
1985	2.2786	224.44	570.39	-58.984	243.23	-24.250
1986	2.2850	223.69	580.97	-69.842	246.51	-28.33
1987	2.2914	222.93	591.54	-80.711	249.54	-32.34
1988	2.2978	222.18	602.12	-91.590	252.34	-36.30
1989	2.3042	221.43	612.70	-102.477	254.95	-40.19
1990	2.3107	220.68	623.27	-113.352	257.39	-44.04

[1] Gross margin = (Yield x Price) - Total Cost

Table D. 3, Calculations for Projection of Tart Cherry Gross Margins, Alternative No. 3, Michigan, 1977-1990

Year	Yield	Price[1]	Cost[2]	Gross[3] margin	CPI 1967=100	Deflated gross margin
	Ton/acre	$/ton	$/acre	$/acre		$/acre
1977	2.4798	592.93	493.42	976.93	194.13	503.235
1978	2.5072	495.78	504.68	738.35	205.00	360.169
1979	2.5145	497.20	515.92	734.30	213.43	344.045
1980	2.5319	500.94	527.13	741.20	220.32	336.423
1981	2.5493	506.51	538.32	752.92	226.15	332.931
1982	2.5667	513.13	549.49	767.56	231.19	332.004
1983	2.5840	516.43	560.64	773.81	235.64	328.386
1984	2.6014	516.26	571.77	771.22	239.62	321.853
1985	2.6188	515.09	582.88	766.02	243.23	314.938
1986	2.6361	512.16	593.97	756.12	246.51	306.731
1987	2.6535	507.62	605.04	741.93	249.54	297.318
1988	2.6709	500.60	616.09	720.95	252.34	285.707
1989	2.6882	495.64	627.12	705.26	254.95	276.629
1990	2.7056	493.41	638.13	696.83	257.39	270.728

[1] Projected from the demand model.

[2] Total costs.

[3] Gross margin = (Yield x Price) - Total Cost

Appendix D. 4, Calculations of the Long Run Dynamic Equilibrium Gross Margins

The Carryover stocks of tart cherries, the per capita consumption of frozen apples, and the consumer price index are assumed to remain unchanged over time, while the annual growth rates of the price of tart cherries(P^t), and the per capita disposable income(PDI) are assumed to be 5 percent, and 8 percent, respectively. The effect of the consumer price index is assumed to be negligible because the estimated coefficient is insignificant. The annual growth rate of the consumption of tart cherries, as calculated in the following table, is .5 percent.

Variable	Growth rate (%)	Elasticity	Growth factor
P^t	5.0	-.819	-.041
PDI	8.0	.574	.046
Quantity of tart cherries (Q^t)	-	-	.005

In addition, the annual growth rate for the United States population(POP) is assumed to be .8 percent. The growth rates for the yield of tart cherries are 1.737 percent per year for the projected yield level and 4.0 percent per

Year for the assumed higher yield level. Substituting the above growth rates to the identity equation

$$Q^t = (A^t \times Y^t) / POP, \text{ or } A^t = (Q^t \times POP) / Y^t$$

The annual increase in the tart cherry acreage based on the projected yield level is

$$A^t = (.005 \times .008) / .01737 = .0023, \text{ or } .23 \text{ percent}$$

and the annual increase in the acreage (ΔA^t) is

$$.0023 \times 37.88 (\text{average acreage}) = .08723 \text{ (in 1,000 acres)}$$

Substituting the A^t value to Equation (7.1) and solve for the level of the gross margin, thus

$$GM^t = (.08723 + .296626) / .00467 = 82.20 \text{ (dollars)}$$

Therefore, the long run dynamic equilibrium gross margin for the projected yield level is $82.20 per acre. Using the same procedure, the level of the gross margin required to maintain the long run dynamic equilibrium for the assumed higher yield level is $71.63 per acre.