Long-Run Equilibrium in Tart Cherry Production
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LONG-RUN EQUILIBRIUM IN TART CHERRY PRODUCTION

By Carleton C. Dennis

Michigan State University
Agricultural Experiment Station
Department of Agricultural Economics
East Lansing, Michigan

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By CARLETON C. DENNIS

Introduction

A CONSIDERABLE AMOUNT of research has been devoted to short-run tart cherry price analysis. Little or no thought has been given to the long-run price and production effects of present prices. This study has been made to partially fill that gap. .

Motivation for the study was twofold. First, it is part of a comprehensive study of the tart cherry industry which will include studies of production and processing costs in major producing areas, pricing, and interregional competition. Secondly, the experience of some producers of farm products in having surpluses as a result of high prices in earlier years raised the question of whether this might occur in the tart cherry industry. While contributing to the industry study, the specific objective of this analysis is to investigate the effect of farm price of tart cherries in a given period on production and price in a future period.

Theory

This is an attempt to analyze the effect of present prices received by Michigan producers of tart cherries on future production and prices. It is not an essay on price determination. Yet, a short discussion of price determination, as it applies to the analysis presented here, may help in understanding why certain procedures are followed.

The prices producers receive for their tart cherries determine to a large extent their profit or loss on this product. The amount of profit or loss in turn affects their decisions to attempt to produce less, the same, or a larger quantity of tart cherries in the future. The amount produced in the future will then have an effect on the price received at that time.

The equilibrium price of a product is said to be the price which calls forth exactly the quantity demanded at that price. It is diagrammed as in Fig. 1.

The supply curve slopes upward indicating that as price increases, suppliers will be willing to supply a greater quantity. The demand curve, on the other hand, slopes downward which means that as price increases, the quantities that consumers are willing to purchase become smaller.

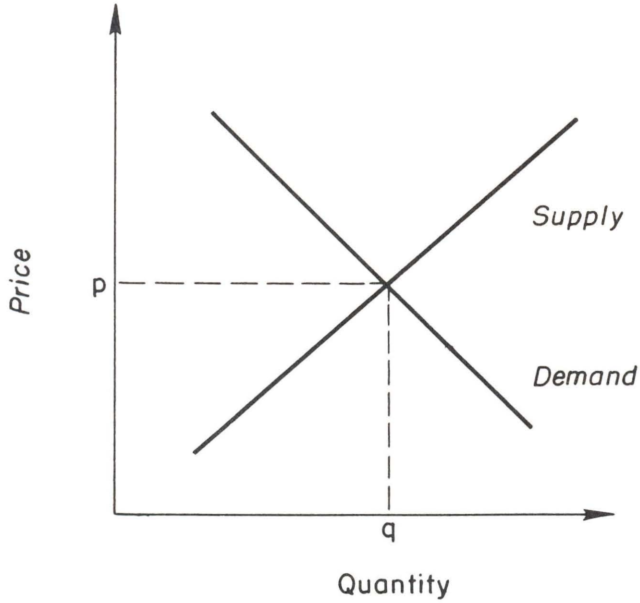

Fig. 1. Equilibrium price determination.

Equilibrium occurs at the point where the supply and demand curves intersect and results in a quantity of "q" and a price of "p."

This simple diagram assumes that sufficient time is given for action on decisions to produce or consume. Food consumption decisions are made in the relatively short run although tastes and preferences built up over time may change or influence future consumption decisions. This is considered to be "built into" a demand function.

Supply decisions, especially those involving agricultural production, are not primarily short-run decisions. That is, the decision to offer a certain quantity of product at a future date is made on the basis of expected future price which in many cases may be present price, but actual present production seldom results from present price. Diagrammatically, there are two very different supply functions involved, one a short-run function relating present price and quantity and the other a long-run function relating price and the quantity offered after time is allowed to make adjustments to that price. These are shown in Fig. 2.

In Fig. 2, S_{lr} and S_{sr} are long-run and short-run supply functions, respectively. The short-run function is drawn vertically, indicating that after the supply is produced it will be sold regardless of price received. Less slope — possibly no slope — would be given this function at a very

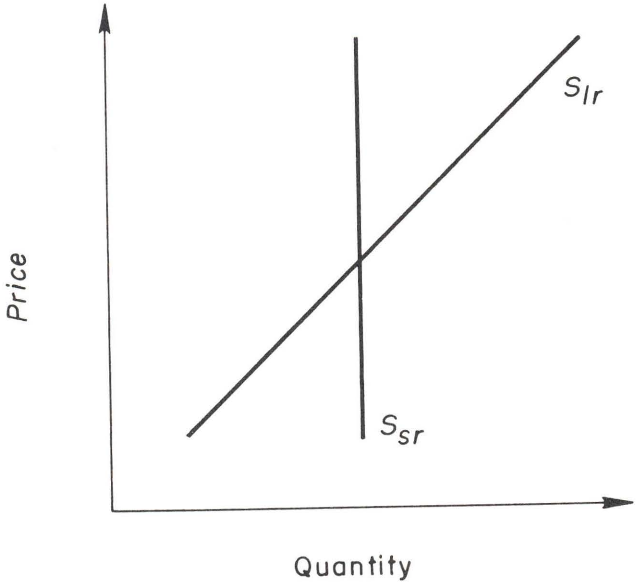

Fig. 2. Long-run and short-run supply curves.

low price, especially if selling costs were not covered. The long-run function is drawn with a gradual upward slope indicating that quantity offered will change greatly after time is given to adjust production to price expectation.

This study assumes that farmers base present production decisions on present prices. Since present production decisions result in production only at a future time, by allowing an appropriate time lag for the production process, the price received at the present time and quantity produced at a future time will be a point on the long-run supply curve. Thus, using a series of prices received and quantities produced, with appropriate time lags as price-quantity observations, enables estimation of the long-run supply function.

If the long-run supply function is determined in this manner and it is assumed that present price and future production are a point on this function, it becomes possible to estimate production in a future time period that will result from price in a previous time period. That is, in Fig. 3, if present price is p', future production can be estimated as q'.

Having an estimate of quantity to be produced in the future period and an estimate of future demand enables judgment as to the general level of prices that should be expected to result. Stated in another way, it

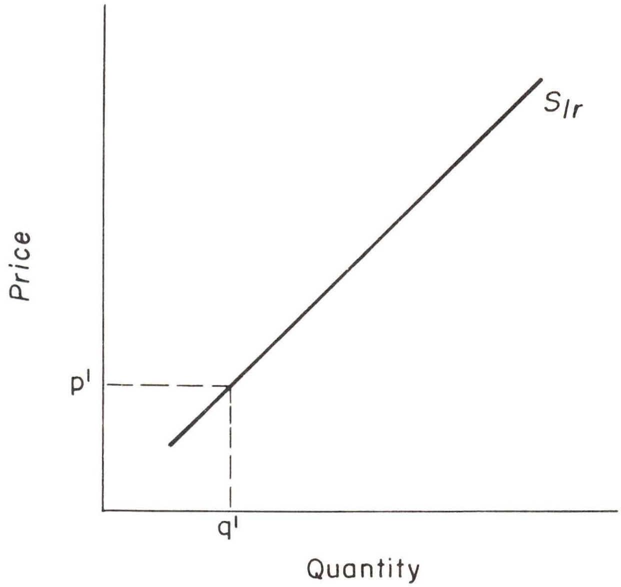

Fig. 3. Estimation of future production with present price given.

becomes possible to estimate the effect of present price on future price, as shown in Fig. 4.

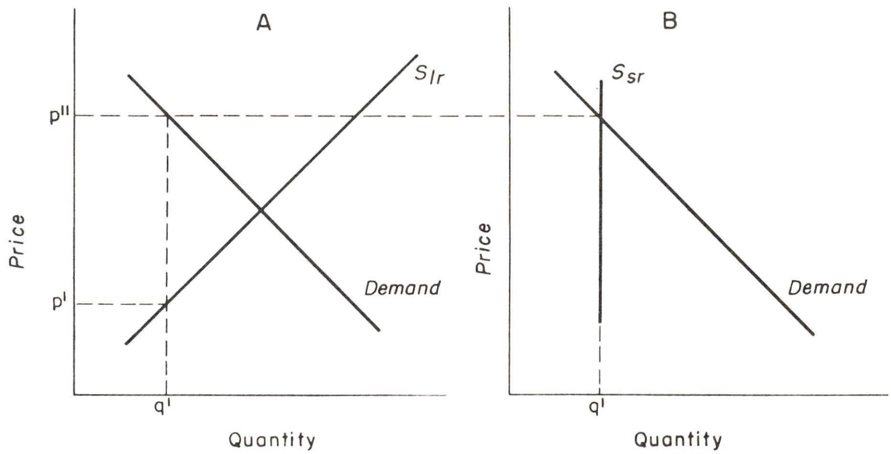

Fig. 4. Estimation of future price from present price.

In this figure, p' and q' are as in Fig. 3. In panel A of this figure, future short-run demand is shown with long-run supply. This, of course, is not proper. However, if the supply in the future period is considered to be the short-run supply of that period, and the premise that all that is produced will be sold is accepted, price determination will be as in panel B of Fig. 4. Extending this across through panel A of Fig. 4 demonstrates that the resulting price, p", can be read directly from panel A. This is done by using present price, p', moving horizontally to the long-run supply function, moving vertically to the demand function and again horizontally to the price axis where future price can be read as p".

Supply

The lag between the production decision and actual production is difficult to measure in nearly any type of agricultural production. It is perhaps most obvious when annual crops are involved, somewhat less obvious for crops having longer production periods, more difficult with livestock, and probably most difficult with tree fruits.

To arrive at the decision to produce, the potential producer must first react to the present price and future price expectation. Then, there is a waiting period of several years before any fruit is received from the trees planted and an additional period before the trees reach full production. Production then occurs for many years. Thus, production decisions have an impact on actual production only after several years have elapsed and then continue to affect production many years beyond. For tart cherries this time lag is estimated at approximately from seven to thirty years. Annual tart cherry production is very unstable reflecting physiological and natural variables which influence yield. The combination of a long production cycle and variable annual production from the same trees makes estimation of planned tart cherry production exceptionally difficult.

An alternative to consideration of planned production of fruit in a given year is to consider the planned number of trees in a given period and convert this to fruit production. This cuts the time lag between the production decision and measurement of results considerably and is the method of the present study.

The number of non-bearing tart cherry trees in Michigan is available from the census for 1940, 1950, 1955 and 1960. In addition, a reasonable estimate is available for 1935 since the census combines sweet and tart cherries and sweet cherries were a minor fruit in Michigan at that time. The average of 1940 and 1950 non-bearing tree numbers is used as the 1945 estimate. This is a total of six observations.

The non-bearing trees in any given year were planted over a period of several years so are the result of plans made over several years. The number of trees planted in these years would seem to depend largely on the farm price of tart cherries, the farm prices of other fruits that might be produced in place of tart cherries, and the cost of production. As will be seen in the following analysis, the prices of tart cherries and other Michigan fruits can explain a large part of the variation in non-bearing tart cherry tree numbers. While costs of production undoubtedly influence the quantity of tart cherry production, use of an index of costs to deflate prices received does not improve the analysis but does complicate use of the estimating equation. Production costs, therefore, are omitted from this report.

This omission is equivalent to making assumptions that (1) changing production costs affect production of tart cherries in the same manner as other fruits and (2) changes in fruit production are between kinds of fruit and not in total acres of fruit. These assumptions seem to be acceptable on the basis of statistical results obtained.

The farm prices of tart cherries and other Michigan fruits can be obtained from *Michigan Agricultural Statistics*[1] and are reproduced in Appendix Table 2.

Comparison of prices received for various fruits and later combination into an index of prices received for competing fruits requires that they be placed on a similar basis. This is accomplished by expressing all fruit prices as percentages of the average price for the years of 1925-60. These are given in Appendix Table 3.

Whether a producer sets tart cherry or other fruit trees would be expected to depend on the price of tart cherries relative to the prices of other fruits. The question immediately arises as to what fruits to consider and how to consider several at the same time. It is logical that all tree fruits important in Michigan—sweet cherries, apples, peaches, plums, and pears—should be included. Since, as will become evident, very few price-quantity observations are available, a multiple regression with

[1]Mich. Department of Agriculture, *Michigan Agricultural Statistics*, Lansing, Michigan (annual publication).

several independent variables would involve a critical loss in degrees of freedom. The problem is partially avoided by weighting their prices in an index in proportion to their non-bearing tree numbers (Appendix Table 1) in the nearest census year. For instance, weighting for the years 1938-42 is based on 1940 tree numbers. The index of tart cherry price is then divided by the index of "competing" fruit prices to obtain a number which represents the relationship of tart cherry to other fruit prices. This index is given in Appendix Table 4.

The number of non-bearing trees at any given time is determined by the number planted in recent years, the number of these that survive, and the length of time required to bring a tree into production. Determination of non-bearing tree numbers is complicated by the lack of definition as to the line between "bearing" and "non-bearing" trees. Ricks, Larson, and Wheeler[2] estimate that some production will be realized from a tart cherry tree in 3 years and full production will be accomplished in 11 years. Because of the inability to classify partially bearing but immature trees definitely as bearing or non-bearing, it is very difficult to determine which years' prices to include in the analysis.

Of the several alternatives tried, best results were obtained in this analysis when prices for the years from two to eight prior to the census year were included. That is, the average of the tart cherry relative price index (Appendix Table 4) for the years n-2 to n-8 was used to represent the price which influenced producers to plant the non-bearing sour cherry trees of a particular census year. Price-quantity observations thus obtained are given in Table 1. The following result was obtained from a regression of these tree number-price index observations.

$$T = -1{,}134{,}075 + 19{,}049.23\,I \qquad \text{(A)}$$

T = number of non-bearing tart cherry trees in Michigan

$$I = 1/7 \sum_{n-2}^{n-8} \frac{\text{index of farm price of tart cherries}}{\text{index of farm prices of other fruits}}$$

$R^2 = .8481$

$S = 139{,}870$

[2]Ricks, D. J., R. P. Larsen, and R. G. Wheeler, *Inputs and Relative Yields for Young Orchards*, Table 2, Fact Sheet for Agriculture, Cooperative Extension Service, Michigan State University, January, 1961.

The future number of non-bearing tart cherry *trees* expected to result from given indexes of relative tart cherry price can be estimated from the above equation or its graphic representation in Fig. 5.

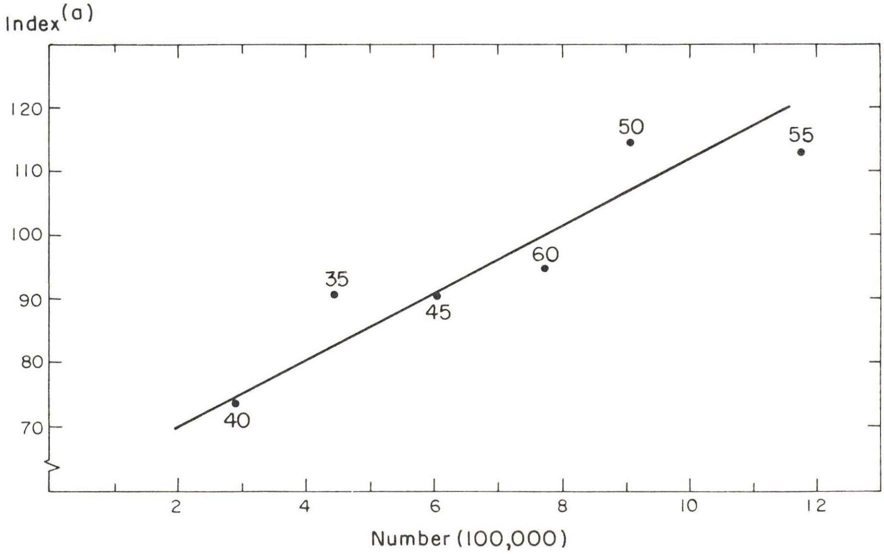

Fig. 5. Effect of relative tart cherry price on number of non-bearing tart cherry trees in Michigan.

(a) Index of farm price of tart cherries relative to other tree fruits (average of n-2 to n-8).

TABLE 1—Price index-quantity observations used in Michigan tart cherry supply response analysis

Year	Non-bearing tart cherry trees	Tart cherry (a) relative price index
1935	445,467	90.94
1940	289,889	73.24
1945	598,223	90.51
1950	906,556	114.49
1955	1,173,336	112.96
1960	772,915	94.83

(a) Average of years n-2 to n-8 (Appendix Table 4).

However, production in *pounds*, not non-bearing tree numbers, is the matter of primary interest so appropriate adjustments must be made. Of course, today's non-bearing trees are tomorrow's bearing trees but "when does tomorrow arrive" and "how long will it be here" are very difficult questions. Six years seems to be an acceptable age as a dividing line between non-bearing and bearing trees on the basis of Michigan Department of Agriculture estimates and the price and planting time lag found most appropriate in this analysis.[3] A tart cherry tree lifetime of 30 years is generally accepted as reasonable. Some will produce beyond the thirtieth year but also some will be removed considerably before the thirtieth year. On this basis, a constant number of non-bearing trees should eventually result in four times as many bearing as non-bearing trees. Figure 5 can therefore be converted to show bearing trees in a future period by multiplying by four the numbers of non-bearing trees on the horizontal axis.

But bearing tree numbers are not the final figure desired. Production is needed. Bearing tree numbers can be changed to expected production, though, by multiplying bearing tree numbers by expected production per tree. In the 1951-60 decade, production per tree in Michigan averaged 46.243 pounds per tree. In more recent periods, the average has been slightly lower. However, there seems to be no logical reason to expect production per tree to decrease in the long run so the average of this decade is accepted as a long-run expectation.

On the basis of these estimates; (1) a 1 to 4 non-bearing to bearing tree ratio and (2) production of 46.243 pounds of tart cherries per bearing tree, equation (A) can be adjusted to estimate future annual production of tart cherries. This yields the following equation:

$$\underset{\sim}{Q}^{s} = 209.7721 + 3.52357\,I \qquad \text{(B)}$$

$\underset{\sim}{Q}^{s}$ = future annual production of tart cherries in million pounds

$$I = 1/7 \sum_{n-2}^{n-8} \frac{\text{index of farm price of tart cherries}}{\text{index of farm prices of other fruits}}$$

[3]Michigan Department of Agriculture estimates are on the basis of 6 year old trees counted as non-bearing and 7 year old trees counted as bearing. In this study, best results were obtained using prices for years n-2 to n-8. Census tree counts are taken in the early spring of the census year or fall of the previous year so the price in n-1 has not substantially affected plantings. Prices in n-2 would be expected to be the most recent ones affecting the tree count. It seems likely that prices of the last 2 years exert substantial influence on plantings. That is, prices in years n-7 and n-8 influence plantings in n-6. Those planted in n-6 are 6 years old in year n. Thus, the non-bearing tree count in year n consists of trees planted in n-1 through n-6, a period of 6 years and the prices of n-2 through n-8 influenced those plantings.

If the prices of competing fruits are at their 1925-60 averages, i.e., the price index of competing fruits is at 100, the effect of tart cherry price on future tart cherry production can be estimated directly from the tart cherry price index. This, however, is seldom the case. Consider, for example, the 1954-60 period—the period determining non-bearing tart cherry tree numbers in 1962. The average index of tart cherry price in this period was 119.01 and the average of the annual weighted indexes of competing fruit prices was 125.65. If the competing fruit price index were 100 in each of these years, the number of non-bearing tart cherry trees in Michigan could be estimated from equation (A) or Fig. 5 using only the tart cherry index of 119.01. However, the index of competing fruit prices differed considerably from 100 so it is necessary to use the average relative tart cherry price index (tart cherry index divided by competing fruit price index). This index is given in Appendix Table 2 and averages 94.80 for 1954-60. Using this index, equation (A) and Fig. 5 give estimates of about 626,000 non-bearing tart cherry trees in Michigan in 1962. Equation (B), using the same index number, indicates that if the price relationships of this period continued indefinitely, average annual production would be approximately 116 million pounds.

Therefore, to use equations (A) and (B) and Fig. 5, it is necessary to have the price indexes of tart cherries *and* competing fruits. To estimate the effect of a given tart cherry price on plantings and future production it is necessary to first estimate a price level for competing fruits. In the absence of contrary information, a logical assumption seems to be that relative prices of these fruits will remain approximately at the level of recent years. Table 2 gives the average price and average price index for selected Michigan fruits for the most recent 5-year period available at the time of writing.

From Table 2 it can be seen that all of the important Michigan tree fruits had above average prices (indexes of more than 100) in the 1956-60 period.[4] The tart cherry index of 113.2 indicates that the average of annual tart cherry prices in the years 1956-60 was 13.2 percent greater than the average of annual tart cherry prices in 1925-60. However, of

[4]When these prices are deflated by the index of prices farmers pay for production items, only plums, a comparatively minor fruit, have above average prices for the 1956-60 period. All others are considerably below average and the weighted average price index for the 5 competing fruits is only 84.9. The tart cherry deflated price index is only 79.7.

TABLE 2 — 1956-60 average price and average index of price for selected Michigan fruits

Fruit	Price (a)	Price index (b)
Apple	1.73/bu.	129.3
Peach	1.95/bu.	112.7
Pear	1.66/bu.	122.5
Plum	102.64/ton	146.7
Sweet cherry	242.00/ton	128.5
Above 5 fruits (weighted average) (c)	—	123.1
Tart cherry	144.60/ton	113.2

(a) Source of annual prices: Annual issues of *Michigan Agricultural Statistics,* Michigan Department of Agriculture, Lansing, Michigan.

(b) Average of annual index. 1925-60 = 100.

(c) Average of annual indexes obtained by weighting individual fruit price indexes by the number of non-bearing trees in the nearest census year.

the fruits competing for production only peach prices were lower than tart cherry prices relative to their prices in the longer period.

Assuming prices of this recent 5-year period represent prices with which the current tart cherry price must be compared, a tart cherry price of 123.1 percent of the 1925-60 average — \$157.22 — will equal 100 on the vertical scale of Fig. 5. The scale can then be converted from index numbers to current prices of tart cherries in the ratio of 157.22 to 100. In like manner, the independent variable (I) of equation (B) can be changed to tart cherry price by adjusting the coefficient. The following equation results from this adjustment:

$$\underset{\sim}{Q}^{S} = -209.7721 + 2.24117P \qquad \text{(C)}$$

P = current price per ton of tart cherries

$\underset{\sim}{Q}^{S}$ = future annual production of tart cherries in million pounds

Figure 6 is constructed from this equation with the vertical and horizontal scales converted from Fig. 5 as explained above.

Demand

Approximately 95 percent of the U.S. tart cherry crop is processed. Thus, the demand for tart cherries at the farm level is essentially derived from the demand faced by processors. The demand at the processor level would be expected to be influenced by the supply of competing products, population, income and consumer preferences. Extensive study of tart cherry demand,[5] however, has been unable to isolate the effect of individual demand determinants but good correlations have been obtained using only price and per capita quantity or price, per capita quantity and time. The demand for tart cherry processed products is found to have decreased over time when the 1947-60 period is analyzed. When only the 1955-60 period is studied, the time coefficient is found to be negative but not statistically different from zero at the 5 percent level. It seems apparent that we have had a decreasing demand for tart cherry products in the post World War II period but that the decline is being arrested.

The quantity figure to be used in each annual price-quantity observation is open to some debate. Three possibilities are readily apparent. The first is the production of the year in question, the second is the total supply available — production plus carry-in from the previous year's crop — and the third is the actual disappearance — production plus carry-in minus carry-out. The first of these is discarded because it fails to consider the very important effect of size of carry-in on the willingness of processors to actively seek supplies. The second is not used here because omission of carry-out would result in an upward bias of available supply. The third alternative is accepted because it correlates prices received with actual disappearance. In the long run, total production equals total disappearance. Therefore, in anticipation of the use of the demand function with long-run supply functions to estimate price, it is necessary that supply as used in the demand analysis be in terms of total disappearance.

Table 3 gives the price received by Michigan farmers for tart cherries and the U.S. per capita disappearance of tart cherries for the 1955 to 1960 period. A regression of these price-quantity observations gives the following results.

$$P = 193.1250 - 52.6834q \qquad \text{(D)}$$

where P = Michigan tart cherry price in dollars per ton (1947-49 price level)

q = U.S. per capita disappearance of tart cherries

R^2 = .8404

S = 5.7475

[5]See Oldenstadt, Dennis L., "Economic Relationships in Red Cherry Marketing, 1947-60," Department of Agricultural Economics, Michigan State University, East Lansing, Ag. Econ. Mimeograph No. 831, June, 1961.

This is the basic demand equation of the study. Except when otherwise stated, it will be assumed that the demand for tart cherries, at the farm level, will be the same in a future period as in this recent period.

To be useful, equation (D) must be converted to demand for cherries in a future period. Since present prices influence plantings which will be at peak production in 1980, demand is estimated for that year. U.S. population in 1980 is estimated at 252,695,000.[6]

Equation (D) then becomes

$$P = 193.12495 - .20849Q^d \qquad (E)$$

P = Michigan tart cherry price in dollars per ton (1947-49 price level)

Q^d = total U.S. production of tart cherries in million pounds[7]

TABLE 3 — Price and quantity observations used in tart cherry demand analysis

Year	Price (dollars/ton) (a)	Per capita quantity (b)
1955	105.68	1.75
1956	128.23	1.30
1957	109.82	1.62
1958	131.98	1.19
1959	100.32	1.59
1960	121.74	1.30

(a) Actual price as reported in *Michigan Agricultural Statistics,* Michigan Department of Agriculture, July, 1961, deflated by Consumer Price Index (1947-49 = 100).

(b) Production plus carryin minus carryout. Obtained from Oldenstadt, Dennis L., *Economic Relationships in Red Cherry Marketing, 1947-1960,* Department of Agricultural Economics, Michigan State University, mimeographed report No. 831.

The second conversion in the demand function is to state it in terms of demand for Michigan tart cherries. This is done by assuming that Michigan produces 60 percent of the U.S. supply, i.e., that any change in quantity supplied or demanded will be divided between Michigan and

[6] This is the average of estimates II and III given in U.S. Bureau of the Census, *Statistical Abstract of the United States, 1961,* Table No. 3, p. 6, U.S. Government Printing Office, Washington, D.C.

[7] Quantity is expressed in per capita terms in equation (D) and as total quantity in equation (E). The quantity coefficient is adjusted accordingly to compensate for this change. It is accomplished by dividing the quantity coefficient of equation (D) by 252,695,000, the estimated 1980 population.

all other producers in the ratio of 60/40. Equation (E) then becomes[8]

$$P = 193.12495 - .34748Q^d \qquad (F)$$

P = Michigan tart cherry price in dollars per ton (1947-49 price level)

Q^d = Michigan production of tart cherries in million pounds

The last conversion is to state the price in terms of the present price level and consists of multiplication by the Consumer Price Index which was estimated at 128 on January 1, 1962. Equation (F) then becomes

$$P = 247.20 - .44477Q^d \qquad (G)$$

P = Michigan tart cherry price in dollars per ton (1962 price level)

Q^d = Michigan production of tart cherries in million pounds

Projections

The remaining task is to estimate the price that would be expected to result in a future period from various prices received by farmers in the present period. Where a statement is made that a given price today is expected to result in a certain future production and price, it is intended to mean (1) that if prices averaged the given amount over many years (a complete production cycle) then the future production and price would result or (2) that if the given price exists today, the influence of that price will be *in the direction of* the stated future production and price.

Assumptions

In this analysis several assumptions have been made. These assumptions, some of which will be relaxed in portions of the analysis are:

(1) The farm level of prices of fruits competing for production in Michigan will remain in the relationship to tart cherry price as in the 1956-60 period.

(2) Farmers will react to fruit prices in the future as in the past by planting similar numbers of tart cherry trees as a result of similar fruit prices.

[8]The assumption that Michigan will produce 60 percent of the U.S. tart cherry production is equivalent to an assumption that a 1-pound change in Michigan production will be matched by two-thirds of a pound in non-Michigan production. The change in price received as Michigan production changed would therefore be greater than indicated by equation (E) which is for the United States. This is taken into account by adjusting the quantity coefficient (.20849 divided by .6 equals .34748).

(3) Production of tart cherries per tree will be the same as the average of the 1951-60 period.

(4) A tart cherry tree will bear during four-fifths of its life. Therefore, a constant number of non-bearing trees will result in a constant number of bearing trees four times as great as the non-bearing tree numbers.

(5) Michigan will produce 60 percent of the U.S. tart cherries in 1980.

(6) Exports and imports of tart cherries will remain at present levels.

(7) Tart cherry per capita demand at the farm level will be the same as in the 1955-60 period.

(8) United States population in 1980 will be 252,695,000.

The following analysis will attempt to show the probable effect of present prices on tart cherry production and price in 1980. This will be done through the use of several models, each based on different assumptions concerning supply response and/or demand. They are as follows:

Model I — Long-run equilibrium
Model II — Effect of changing percentage of the United States crop of tart cherries supplied by Michigan
Model III — Effect of increased exports of tart cherries
Model IV — Effect of population estimate
Model V — Effect of non-bearing to bearing tree ratio
Model VI — Effect of estimated production per tree

Model I — Long-run equilibrium

It has been shown that the short-run supply curve in a future period is essentially a vertical line through a point on the long-run supply curve. This point on the long-run supply curve is largely determined by decisions made in the present period. Therefore, future supply can be estimated on the basis of present decisions which in turn can be estimated from conditions existing with respect to certain important decision determining factors. The long-run supply curve for Michigan tart cherries, estimated on this basis, is given in Fig. 6.

Future tart cherry demand will depend on many presently unknown factors. A reasonable estimate of future per capita demand seems to be that it will be the same as present per capita demand. This belief is strengthened by the apparent stabilization of tart cherry demand after a period of decreasing demand. Demand in 1980 is therefore based on

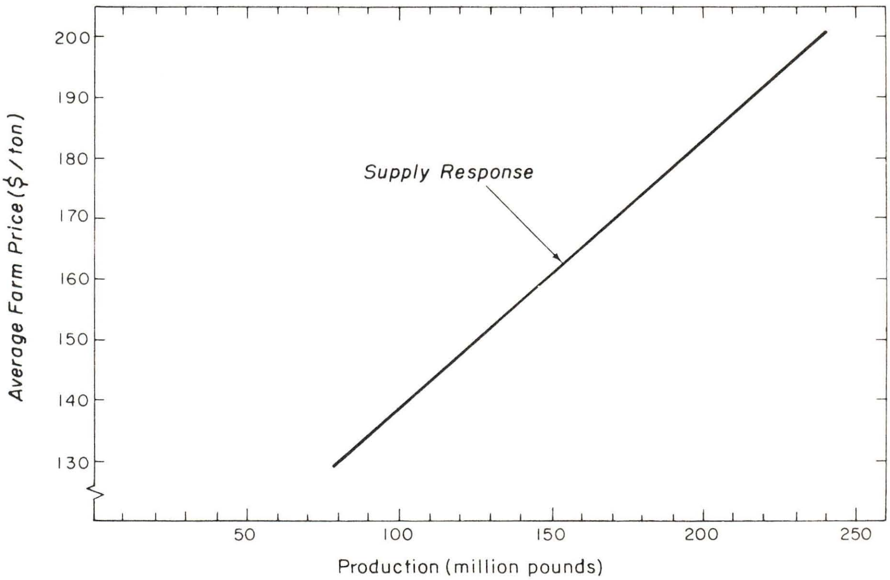

Fig. 6. Effect of tart cherry price on future production of tart cherries in Michigan.

present per capita demand and United States Bureau of the Census population projections.

Combining the future demand function and the present long-run supply function in one figure enables estimation of (1) future production and price that would tend to result if a given price were to continue over a complete production cycle or if the given price were to be averaged over the production cycle[9] and (2) the price in the present period that would tend to result in equilibrium of long-run supply and future demand. This is shown in Fig. 7.

Equilibrium price according to Fig. 7 is approximately $171 per ton and the annual quantity produced in Michigan in 1980 would be approximately 172 million pounds. This means that if the price of tart cherries were to average $171 per ton at the present time, it would cause producers to plant trees at a rate which, if continued over time, would provide an amount of tart cherries in 1980 that would bring the same price.

The price of tart cherries has not in fact been $171 per ton. In the 1956-60 period, the price of tart cherries was only about $145 per ton.

[9]A production cycle is defined here to mean the time from the tree planting decision through a normal life period for the tree.

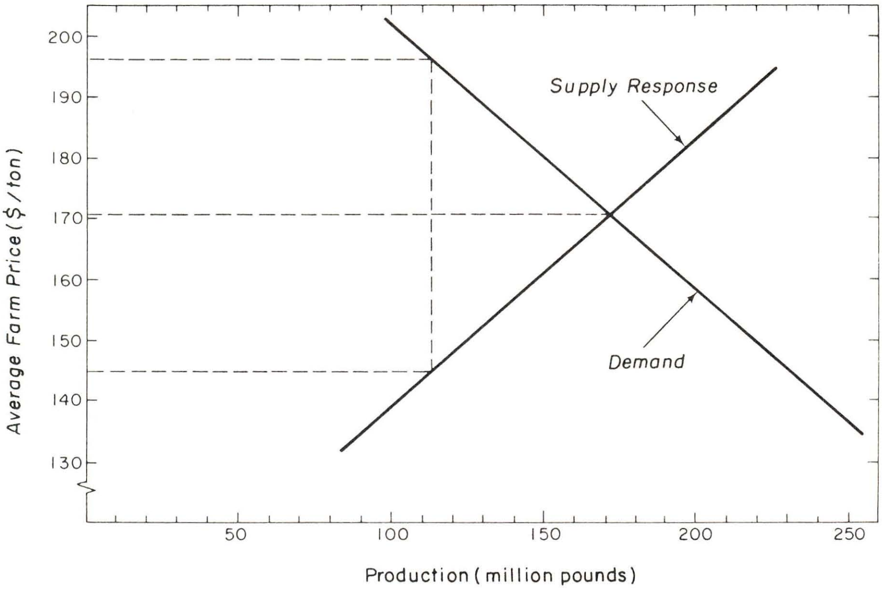

Fig. 7. Tart cherry long-run equilibrium price and effect of present price on future production and price.

This has important implications for future price. In Fig. 7, a dashed line is drawn from a price of $145 per ton to the long-run supply curve. This is the quantity that would be produced after a consistent price, over time, of $145 per ton. The price to be received for those tart cherries will be determined by the demand existing at the time of production. Therefore, a line is drawn vertically from the long-run supply curve intersection to the demand curve representing the demand assumptions of this model. From this intersection a line is drawn horizontally to the price axis and it is seen that a price of approximately $196 per ton could be expected.

This, of course, is only an indication of what would happen to price if tree plantings continued at the rate called for by the 1956-60 average price index. The point to be made is that these prices differ substantially from the equilibrium price. Therefore, tree plantings are below the equilibrium amount and as a result future production will be below the equilibrium amount and future prices will be influenced upward. It should be recognized, though, that as prices start to advance, plantings will start to increase and as soon as these plantings commence bearing there will be a modifying influence on price.

Model II — Effect of changing percent of United States crop of tart cherries supplied by Michigan

In Model I it was assumed that 60 percent of the United States crop of tart cherries would be produced in Michigan. This was approximately the situation in the late fifties and early sixties. Assuming that this situation will continue into the future is equivalent to assuming that tart cherry producers in other states will alter their production plans proportionately with Michigan producers—that all producers respond in the same manner to the price stimuli found to motivate Michigan producers.[10] It seems quite likely that producers outside Michigan will not expand or contract production plans precisely as their Michigan counterparts but it also seems probable that the variation will not be great. Michigan has expanded its percentage of the tart cherry crop greatly in recent years. However, in view of the 1955 to 1960 decrease in non-bearing tart cherry tree numbers in Michigan it does not seem probable that this expansion relative to the United States will continue. On the other hand, there is now little reason to expect a relative contraction in Michigan.

Relatively small changes in Michigan's percentage of the United States tart cherry crop can have considerable influence on the price Michigan producers receive for their tart cherries. If non-Michigan producers increase their production relative to that of Michigan producers, they will supply tart cherries to more consumers and the demand for Michigan tart cherries will decrease. If non-Michigan producers decrease their production relative to that of Michigan producers, the opposite effect will result. The amount of change can be quantified by adjusting the demand function (equation G).

If Michigan produces only 50 percent of the United States tart cherry crop, the demand function becomes:

$$P_1 = 247.20 - .53373Q^d \qquad \text{(H)}$$

where P_1 = price per ton of Michigan tart cherries

Q^d = Michigan production of tart cherries in million pounds

[10]This assumption has been utilized because insufficient data are available for similar analyses of other producing regions.

If Michigan produces 70 percent of the United States tart cherry crop, the demand function becomes:

$$P_1 = 247.20 - .28124Q^d \qquad (I)$$

where P_1 = price per ton of Michigan tart cherries

Q^d = Michigan production of tart cherries in million pounds

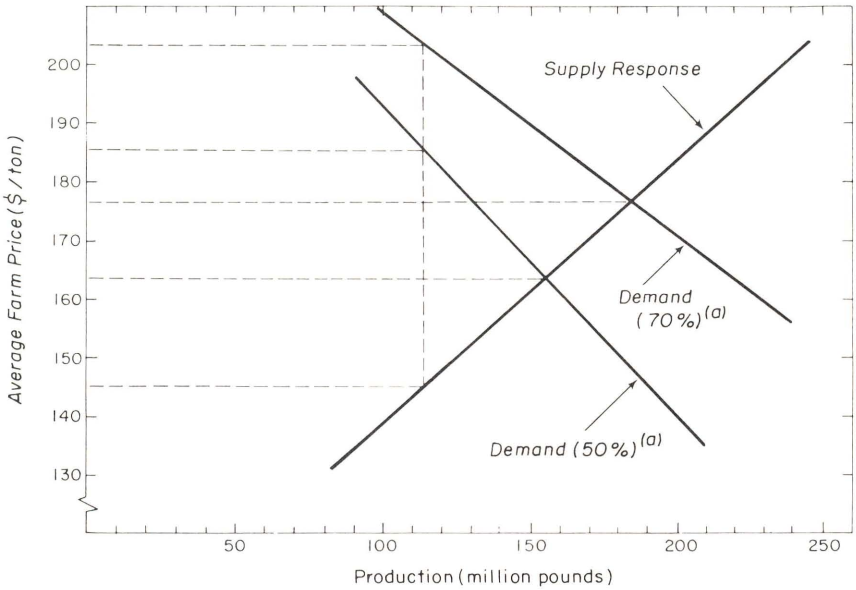

Fig. 8. Effect of changes in estimates of Michigan's share of U.S. tart cherry crop on (1) long-run equilibrium price and (2) future price effect of present price.

(a) Demand functions are based on assumptions of Michigan producing the indicated percentages of the U.S. tart cherry crop.

These functions are shown graphically in Fig. 8 with the Michigan supply function. The equilibrium prices are shown to be approximately \$164 and \$176 per ton if Michigan produces 50 or 70 percent, respectively, of the United States tart cherry crop.

The effect of present price on future price varies with the percentage of the crop Michigan will produce in the future. In Fig. 8, a dashed line is drawn from \$145 per ton to the supply curve, then up to the demand curves and back to the price axis. The resulting prices are shown to be approximately \$186 and \$203 per ton if Michigan produces 50 or 70 percent, respectively, of the United States tart cherry crop.

Model III — Effect of population estimate

In this study, demand has been estimated for 1980 by combining present per capita demand and estimated 1980 population. In all except the present model, 1980 population is estimated at 252,695,000. This is the average of the two middle estimates made by the U.S. Bureau of the Census.[11] The same publication lists high and low population estimates of 272,557,000 and 230,834,000. These estimates are used here to show the effect on equilibrium price of error in the population estimate.

With a population estimate of 230,834,000, equation (G) becomes

$$P = 247.20 - .48689Q^d \qquad (J)$$

and with a population estimate of 272,557,000, equation (G) becomes

$$P = 247.20 - .41236Q^d \qquad (K)$$

These functions are graphed in Fig. 9.

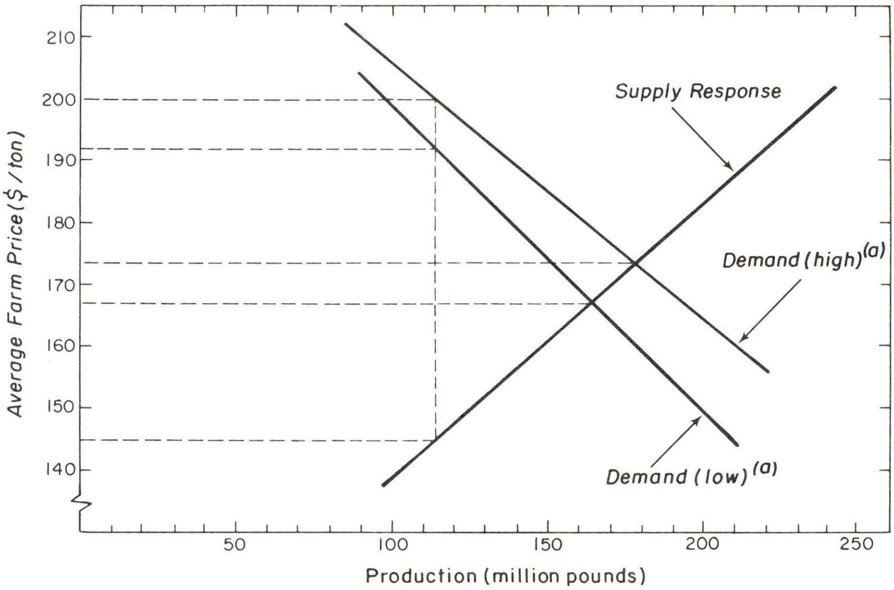

Fig. 9. Effect of changes in estimated 1980 population on (1) tart cherry long-run equilibrium price estimates and (2) future price effect of present price.

(a) "High" and "low" demand estimates are differentiated by high and low population estimates (1980 population: high estimate is 272,557,000 and low estimate is 230,834,000).

Equilibrium price was estimated in Model I to be $171 per ton. Using

[11] *Op. cit.*

the high population estimate of this model, it is found to be \$173 and using the low estimate it is \$167. The effect of population estimate on equilibrium price seems to be quite small.

In Model I, it was estimated that the present price of \$145 per ton would result in a future price of \$196. Using the high and low population estimates, future prices of \$200 and \$191 are estimated to result. The effect of population estimate on future price resulting from present price also seems to be quite small.

Model IV — Effect of increased exports of tart cherries

Exports have formed a minor but unknown portion of the market for tart cherries in past years. While Model I assumed that net exports would remain at the present level, there is currently much interest in the possibility of expanding foreign markets for United States tart cherries. It is hoped by proponents of increased efforts to expand the export market that a substantial price increase would result. If efforts to expand these markets are successful, a substantial price effect will result.

The effect of increased export quantities is to shift the U.S. supply function to the left. If it is assumed that 60 percent of the exports originate in Michigan, the supply function (equation C) can be adjusted to include increased exports by decreasing the constant term by 60 percent of the assumed export increase.

With an assumed export increase of 10 million pounds per year, the supply function is

$$Q^S = -215.7721 + 2.24117P \qquad \text{(L)}$$

where Q^S = future annual production of tart cherries for consumption in the United States (million pounds)

P = current price per ton of tart cherries

A supply curve representing the above equation is placed with the demand function in Fig. 10. The new equilibrium price is approximately \$172 per ton. Each additional 10 million pound export increment is estimated to increase price by \$1.35 per ton. The present price of \$145 would result in a future price of \$199 if continued for a sufficient period of time that all effective production decisions were based on the lower price.

An increased export of 10 million pounds per year may be an optimistic estimate. Since even this export quantity is estimated to result

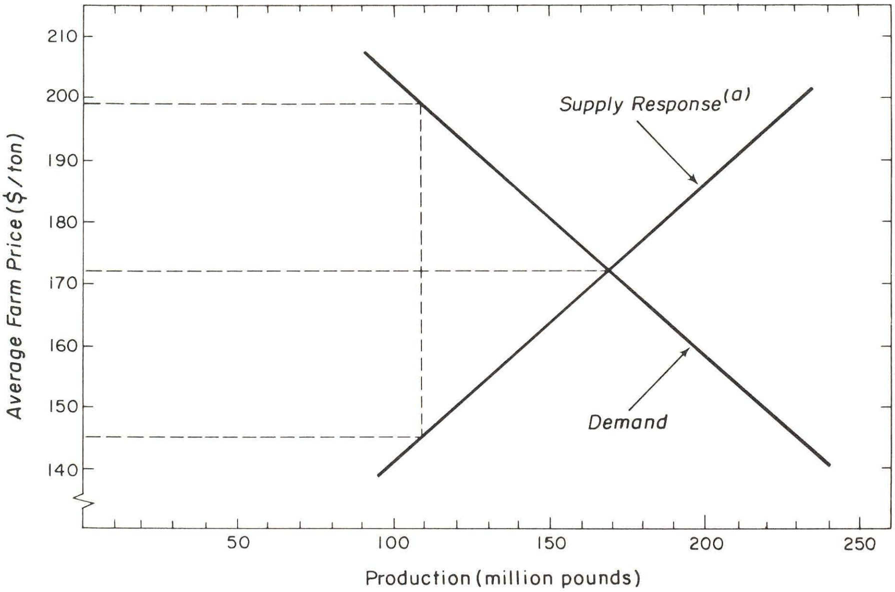

Fig. 10. Effect of increased tart cherry exports on (1) long-run equilibrium price and (2) future price effect of present price.

(a) Represents production available for U.S. consumption if U.S. exports increased 10 million pounds.

in a very small long-run price increase, it must be concluded that exports offer little hope for tart cherry price enhancement.

Model V – Effect of non-bearing to bearing tree ratio

Model 1 assumed that in the long run a stable number of non-bearing trees will result in four times as many bearing as non-bearing trees at any given point in time. The logic for this assumption was that tart cherry trees are expected to require 6 years to become bearing trees and are then expected to bear 24 years – a ratio of one to four.

There is no conclusive evidence of the correct non-bearing to bearing tree ratio to obtain stability. While one to four seems logical, the effects of changing to one to three and one to five are considered in this model to demonstrate the magnitude of price and quantity change associated with change in this estimate.

Changing the non-bearing to bearing tree ratio results in a changed supply function. With an assumed ratio of one to three, equation (C) becomes

$$Q^S = -157.33 + 1.68088P \qquad (M)$$

and with an assumed ratio of one to five it becomes

$$Q^S = -262.22 + 2.80147P \qquad (N)$$

These functions are graphed in Fig. 11. The equilibrium prices are

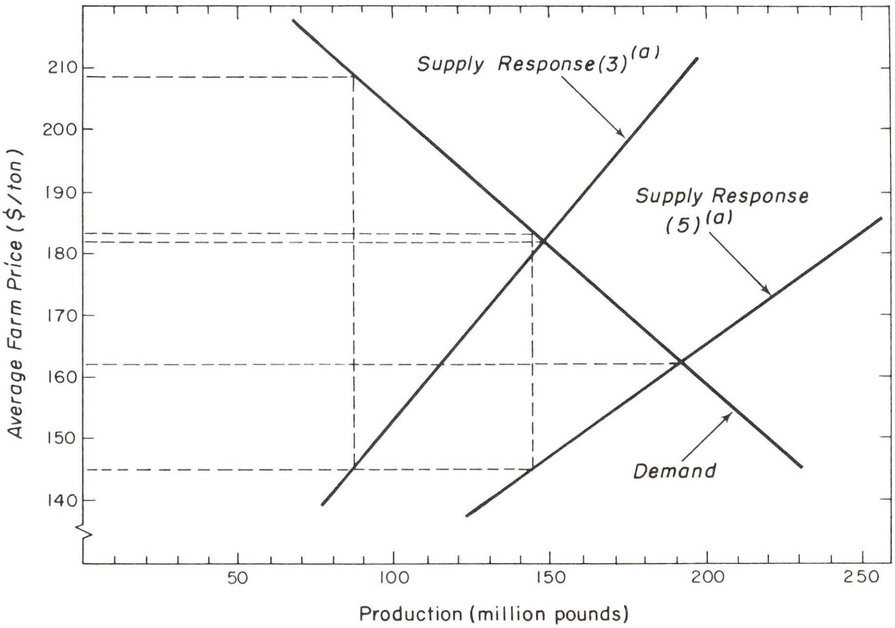

Fig. 11. Effect of changes in estimated non-bearing tree ratio on (1) tart cherry long-run equilibrium price estimate and (2) future price effect of present price.

(a) Numerals indicate the estimated number of bearing trees for one non-bearing tree on which the supply curve is based.

shown to be approximately $181 with a one to three ratio and $162 with a one to five ratio. The present price of $145 is shown to result in future prices of $209 and $183 as contrasted with the $196 estimate obtained in Model I where a one to four ratio is used. The effect of changes in the non-bearing to bearing tree ratio is apparently moderate at this price and production level.

Model VI — Effect of estimated production per tree

Total production in a future period has been estimated in two steps from a function which relates non-bearing trees and price. This function estimates the number of non-bearing trees resulting from an average ratio of indexes of tart cherry to other fruit prices in prior years. The two steps are (1) conversion of non-bearing tree numbers to bearing tree numbers in a later period and (2) conversion of bearing tree numbers to production of pounds of tart cherries. The importance of step (1) is indicated in Model V. The importance of step (2) is indicated in the present model.

In the absence of evidence to the contrary, it is logical to estimate future production per tree at the same rate as in recent years. Therefore, in all except the present model the 1951-60 average annual production per tree is used to estimate future production per tree. In this model, arbitrary 10 percent adjustments of the estimate both up and down are made to show the importance of accuracy in this estimate.

With production per tree increased 10 percent (to 50.8673 pounds per tree), equation (C) becomes

$$\underset{\sim}{Q}^{S} = 230.7493 + 2.46529P \tag{O}$$

and with production per tree decreased 10 percent (to 41.6187 pounds per tree), equation (C) becomes

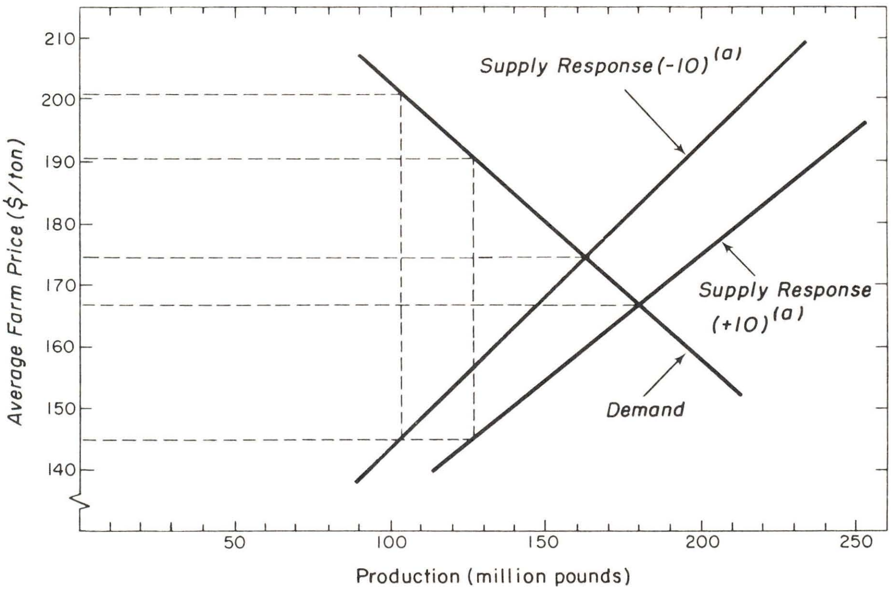

Fig. 12. Effect of changes in estimated production per tree on (1) tart cherry long-run equilibrium estimate and (2) future price effect of present price.

(a) Numerals indicate percentage increase or decrease of estimated production per tree from 1951-60 average of 46.243 pounds.

$$Q^S = 188.7949 + 2.01706P \qquad (P)$$

These functions are graphed in Fig. 12. The equilibrium prices are shown to be approximately $167 with a 10 percent increase in production per tree and $175 with a 10 percent reduction in production per tree. The present price of $145 is shown to result in a future price of $201 with the reduction and $191 with the increase in production per tree. These prices differ only a small amount from the prices of Model I indicating that the estimate of production per tree is not critical within a realistic range.

Summary and Conclusions

This study was made as part of a comprehensive study of the tart cherry industry. However, the analysis is aimed primarily at the question of the effect of the present price of tart cherries on future production and price.

A supply function was obtained by first estimating the effect of the farm price of tart cherries relative to other Michigan fruits on plantings of tart cherry trees. Census tree counts and an average index of relative tart cherry prices in previous years were utilized in this analysis. The price index and non-bearing tree relationship was then converted to price index and quantity of production by assuming that a ratio of one non-bearing tree to four bearing trees would result in stability and that the average production per bearing tree would be as in the 1951-60 decade.

The per capita demand for tart cherries decreased somewhat in the post World War II years until about 1954 but was quite stable from 1955 through 1960. In the belief that the demand decrease has stopped, the 1955-60 relationship was accepted and used to estimate future per capita demand. The demand function applicable to this period was adjusted to 1980 on the basis of U.S. Bureau of the Census population projections.

The equilibrium price with the given assumptions (p. 16) was estimated to be $171 per ton at the current price level. At the same price level, the average price from 1956-60 was estimated at only $145, a difference of $26 per ton.

Several adjustments in assumptions were made to demonstrate their effect on demand, supply, and equilibrium price estimates. One of the basic assumptions of the study was that Michigan would continue to produce 60 percent of the U.S. tart cherry crop. Changing to 50 or 70 percent changed the equilibrium price approximately 6 dollars per ton. Changing the assumption with respect to exports indicated that a 10 million pound increase of annual exports over the present level would raise the equilibrium price about $1.35 per ton. Changing the 1980 population to the high and low estimates of the U.S. Bureau of the Census changed the equilibrium price estimate only $3 per ton indicating that the price estimate is relatively insensitive to reasonable changes in population estimate.

The estimate of future supply involved estimates of the non-bearing to bearing tree ratio and the production per bearing tree. Therefore, the importance of precision of these estimates was investigated. It was found that changing from a ratio of one to four to either one to three or one to five resulted in a 9 or 10 dollar change in the estimate of equilibrium price. A 10 percent increase or decrease in the yield per bearing tree resulted in a change of 4 dollars in the estimated equilibrium price. Equilibrium price was therefore considered to be relatively insensitive to both of these estimates within realistic ranges of error.

Tart cherry prices in recent years have been considerably below the estimated equilibrium price. It is apparent that unless tart cherry demand decreases greatly or price increases substantially in the near future, the tart cherry supply and demand situation by 1980 will be such that an average price much higher than equilibrium will prevail. It is little comfort to a producer of today — especially an elderly producer — to be told that low prices in the present period will bring high prices in 1980. Nevertheless, this is a likely result and for the producer who can plan ahead to 1980, this may be significant. It is also an indication that the individual producer should plant tart cherry trees during an era of low tart cherry prices because those trees would then be bearing when the tart cherry price was high. This is a principle that is well recognized in livestock production but probably less well recognized in fruit production.

Several needs for future research are suggested by this study. Most obvious is the need to investigate the assumptions made and partially studied here. For instance, what is the correct non-bearing to bearing tree ratio? Should trees be expected to produce in 1980 at the same rate as in the 1950's? Is present per capita demand a reasonable estimate of 1980 per capita demand?

Only the Michigan producer's response to fruit prices has been considered. While Michigan does produce a substantial portion of the tart cherry crop, the response of tart cherry producers in other areas should be similarly analyzed to enable better judgment concerning future tart cherry production and prices. Studies, such as the one presented here, are needed for other deciduous fruits. The more important could be studied individually, but perhaps, since they are interrelated, several major fruits could be studied simultaneously.

APPENDIX TABLE 1 — Census estimates of non-bearing fruit trees in Michigan

Year	Sour cherry	Sweet cherry	Apple	Peach	Plum	Pear
1925	500,000 (a)	80,000 (b)	1,871,434	1,978,196 (c)	118,631 (c)	189,885 (c)
1930	909,786 (d)	85,000 (b)	1,393,611	1,173,238	83,383	148,517
1935	445,467 (d)	90,000 (b)	1,027,674	940,506	77,812	125,070
1940	289,889	96,508	1,040,528	1,764,623	136,666	218,991
1945 (e)	598,223	99,608	861,661	1,333,851	122,879	226,347
1950	906,556	102,707	682,793	903,079	109,091	223,703
1955	1,173,336	102,840	498,831	610,506	90,060	197,584
1960	772,915	310,812	698,639	725,637	136,458	258,868

(a) Not available so estimate based on descriptive material in *Michigan Agricultural Statistics*.

(b) Rough estimates based on 1940 - 1950 change.

(c) Calculated from total tree numbers on basis of 1930 non-bearing to total tree ratio.

(d) Estimated by subtraction of sweet cherry estimate from total non-bearing cherry tree numbers.

(e) Not available so non-bearing tree numbers estimated by interpolation of 1940 and 1950 numbers.

APPENDIX TABLE 2 – Prices received for Michigan tree fruits, 1925-1960

	FRUIT					
Year	Sour cherry ($/ton)	Sweet cherry ($/ton)	Apple ($/bu.)	Peach ($/bu.)	Plum ($/ton)	Pear ($/bu.)
1925	105	200	.95	2.20	37.80	1.15
1926	125	230	.78	1.00	23.40	.80
1927	170	290	1.40	2.10	41.40	1.25
1928	135	250	1.12	1.55	37.80	.95
1929	135	240	1.34	1.80	49.00	1.35
1930	110	195	.99	1.50	36.00	1.05
1931	33	60	.54	.60	25.00	.65
1932	33	55	.65	.70	21.00	.45
1933	50	85	.70	1.75	34.00	.80
1934	45	80	.84	1.75	35.00	.65
1935	55	125	.64	.85	30.00	.70
1936	60	110	.99	1.50	37.00	.75
1937	81	140	.56	.95	35.00	.70
1938	67	108	.86	1.30	45.00	.75
1939	42	90	.53	.70	32.00	.65
1940	58	104	.87	1.05	38.50	.80
1941	92	114	.83	.80	36.50	.85
1942	100	116	1.19	2.00	66.00	1.30
1943	172	220	2.33	4.15	164.00	2.85
1944	156	242	1.65	2.40	130.00	1.70
1945	294	380	2.90	2.00	140.00	2.50
1946	298	283	1.65	2.00	95.00	2.00
1947	192	252	1.35	1.80	106.00	2.15
1948	181	282	2.20	1.90	81.00	2.35
1949	182	135	.87	1.20	57.50	1.20
1950	130	146	1.44	1.70	89.90	1.75
1951	138	192	1.30	3.00	111.00	1.80
1952	119	145	2.26	1.75	82.00	1.60
1953	176	228	2.12	2.10	96.70	1.65
1954	220	275	2.09	1.95	95.70	1.80
1955	121	198	1.66	2.50	97.00	1.55
1956	149	270	1.87	2.10	110.00	1.70
1957	132	263	1.76	2.00	86.00	1.60
1958	163	235	1.54	1.80	85.60	1.55
1959	125	187	1.49	1.80	99.60	1.65
1960	154	255	2.01	2.05	132.00	1.80

Source of data: Michigan Department of Agriculture, *Michigan Agricultural Statistics*, Lansing, Michigan (annual publication).

APPENDIX TABLE 3—Indexes of prices (a) received by Michigan farmers for certain fruits

	FRUIT					
Year	Tart cherry	Sweet cherry	Apple	Peach	Plum	Pear
1925	82.21	106.20	70.85	127.12	54.02	84.83
1926	97.87	122.13	58.17	57.78	33.44	59.01
1927	133.10	153.99	104.42	121.35	59.16	92.21
1928	105.70	132.75	83.53	89.56	54.02	70.08
1929	105.70	127.44	99.94	104.01	70.02	99.59
1930	86.13	103.54	73.84	86.68	51.44	77.46
1931	25.84	31.86	40.27	34.67	34.72	47.95
1932	25.84	29.20	48.48	40.45	30.01	33.20
1933	39.15	45.13	52.21	101.12	48.59	59.01
1934	35.23	42.48	62.65	101.12	50.01	47.95
1935	43.06	66.37	47.73	49.12	42.87	51.64
1936	46.98	58.41	73.84	86.68	52.87	55.33
1937	63.42	74.34	41.77	54.89	50.01	51.64
1938	52.46	57.35	64.14	75.12	64.30	55.33
1939	32.88	47.79	39.53	40.45	45.73	47.95
1940	45.41	55.22	64.89	60.67	55.02	59.01
1941	72.03	60.53	61.90	46.23	52.16	62.70
1942	78.30	61.59	88.75	115.67	94.31	95.90
1943	134.67	116.82	173.78	239.80	234.35	210.24
1944	122.14	128.50	123.06	138.68	185.77	125.41
1945	230.19	201.77	216.29	115.57	200.06	184.42
1946	233.32	150.27	123.06	115.57	135.75	147.54
1947	150.33	133.81	100.69	104.01	151.47	158.60
1948	141.72	149.74	164.08	109.79	115.75	173.35
1949	142.50	71.68	64.89	69.34	82.17	88.52
1950	101.79	77.52	107.40	98.23	128.47	129.09
1951	108.05	101.95	96.96	173.35	158.62	132.78
1952	93.17	76.99	168.56	101.12	117.18	118.03
1953	137.80	121.06	158.11	121.35	138.28	121.72
1954	172.25	146.02	155.88	112.68	136.75	132.78
1955	94.74	105.13	123.81	144.46	138.61	114.34
1956	116.66	143.37	139.47	121.35	157.19	125.41
1957	103.35	139.65	131.26	115.57	122.89	118.03
1958	127.62	124.78	114.86	104.01	122.32	114.34
1959	97.87	99.29	111.13	104.01	142.33	121.72
1960	120.58	135.40	149.91	118.46	188.63	132.78

(a) Prices given in Appendix Table 1 placed on an index basis, 1925-60 = 100.

APPENDIX TABLE 4—Indexes of prices of tart cherries, competing fruits, and tart cherries relative to competing fruits

Year	Tart cherry (a)	Competing fruits (b)	Tart cherry relative price index (c)
1925	82.21	97.94	83.94
1926	97.87	58.54	167.18
1927	133.10	111.44	119.44
1928	105.70	85.89	123.06
1929	105.70	101.52	104.12
1930	86.13	79.48	108.37
1931	25.84	38.01	67.98
1932	25.84	43.32	59.65
1933	39.15	72.52	53.99
1934	35.23	76.60	45.99
1935	43.06	49.10	87.70
1936	46.98	76.82	61.16
1937	63.42	49.35	128.51
1938	52.46	69.30	75.70
1939	32.88	41.10	80.00
1940	45.41	61.51	73.83
1941	72.03	53.02	135.85
1942	78.30	103.24	75.84
1943	134.67	210.87	63.86
1944	122.14	134.26	90.97
1945	230.19	161.46	142.57
1946	233.32	122.99	189.71
1947	150.33	110.93	135.52
1948	141.72	137.69	102.93
1949	142.50	70.86	201.10
1950	101.79	105.44	96.54
1951	108.05	138.60	77.96
1952	93.17	125.37	74.32
1953	137.80	134.62	102.36
1954	172.25	133.43	129.09
1955	94.74	130.58	72.55
1956	116.66	131.58	88.66
1957	103.35	123.20	83.89
1958	127.62	113.03	112.91
1959	97.87	110.26	88.76
1960	120.58	137.48	87.71

(a) From Appendix Table 2.

(b) Index numbers of Appendix Tabie 2 weighted by tree numbers of Appendix Table 3 (all fruits except tart cherry).

(c) Tart cherry index divided by weighted index of competing fruits.