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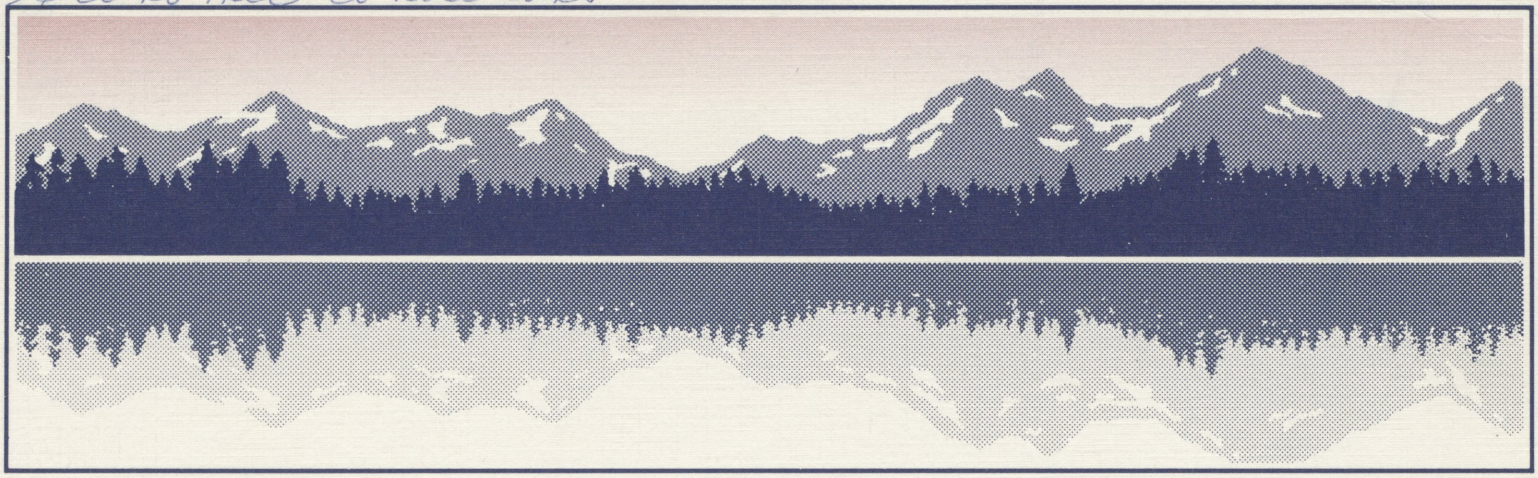

PROCEEDINGS

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GROWTH AND MARKET POTENTIAL IN THE PACIFIC NORTHWEST APPLE MARKETS

by

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INTRODUCTION

Increasing production of apples and changing consumption patterns of apples in both fresh and processed form have significantly affected the market outlook for apples. Recent declines in prices accompanied by declines in per capita consumption point to the need to evaluate the current level and trends in demand and to assess the benefits of different marketing strategies. In this study, the growth in market demand for fresh and processed apples and the effectiveness of better supply management control are evaluated.

Increased plantings and technological developments have resulted in dramatic increases in the production of Washington apples (Figure 1). in the early 1950s the level of apple production in Washington averaged 1149 million pounds (1950-1054). In the eighties, the level of apple production in Washington averaged 2710 million (Washington State Development of Agriculture, Statistical Reporting Service, 1987).

Exacerbating the problems associated with supply growth is the trend toward decreasing consumption of fresh apples and increasing consumption of apples in the processed form. Since, historically, the processed market has returned much less to the grower than has the fresh market, it is believed that in the long run Washington is in a weak strategic position by concentrating on the fresh market (O'Rourke and Harrington, 1973).

Confronted with increasing production, declining prices, and decreasing fresh apple consumption there is a need to formulate effective strategies in the market place to combat falling returns. Such strategies include increased promotion to expand current markets, identification of new markets, and better utilization supplies between fresh and processed markets. In this study, growth in production relative to growth in total demand (i.e., both fresh and processed demand), the growth in supply relative to fresh and processed demands, and the current utilization of existing supplies between fresh and processed markets in Washington apples are evaluated. The study points to the uses of supply control measures (e.g., grade standards) to obtain the maximum revenue and profits attainable from the existing crop and to compare those results through time with the actual market outcomes. The specific objectives of this study are:

1. To develop and estimate demand-based economic models for Washington apples in the fresh and processed markets:
2. To compare alternative measures of market size with actual production; and
3. To estimate the benefits of alternative strategies to improve returns to Washington Producers.

MODEL SPECIFICATION, ESTIMATION, AND RESULTS

Following the theory of demand, quantity demanded is explained in terms of price, prices of substitutes and complements, income and tastes and preferences. Fresh and processed supplies are taken to be exogenously determined (not responsive to current prices). Demand and exogenous supply equations are equated by the market clearing condition resulting in prices expressed in terms of quantities, income, and tastes and preferences. The price equations are, therefore, demand-based reduced form equations which are estimable by ordinary least squares.

Fresh Market Estimates

In the fresh market price equation a wealth of previous studies (McGary, Price, Price and Mittelhammer, Scott) and theory suggest that fresh prices can be explained in terms of fresh quantities produced in Washington, fresh quantities produced outside of Washington,[1], per-capita income, and changing tastes and preferences.[2] The model estimated is given by:

1. There is little if any evidence suggesting that other fruits (e.g., bananas) affect prices. Hence, the issue of whether to include these prices was treated empirically and no significant effects were found.
2. Tastes and preferences and other structural shifts (i.e., the introduction of controlled atmosphere apples) are captured in time trends and dummy variables. Other treatments (e.g., piecewise regressions, time dependent coefficients) were also explored.

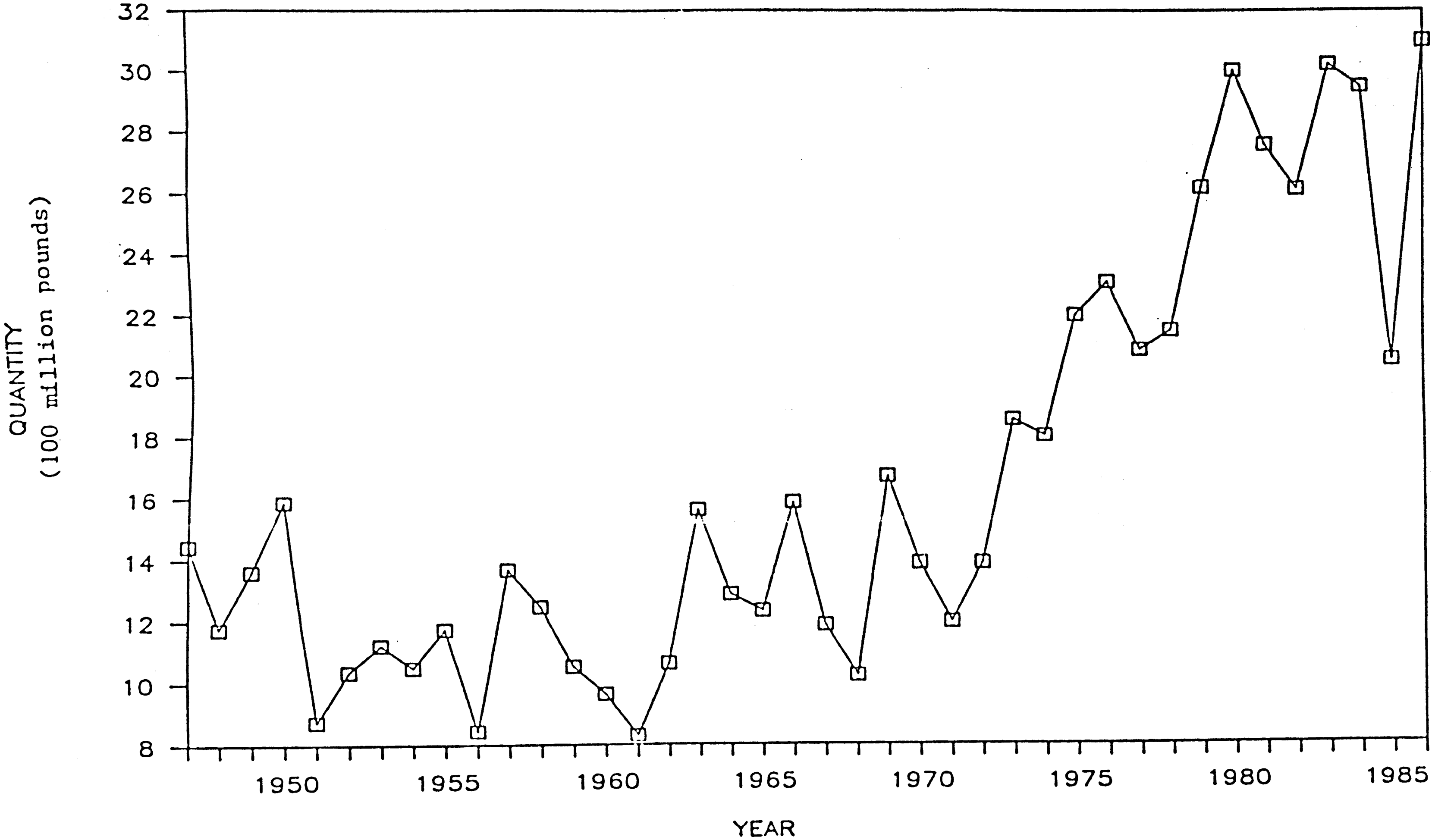

FIGURE 1. Total Washington Apple Production, 1947-86 (SOURCE: Washington State Department of Agriculture, Statistical Reporting Service. Washington Agricultural Statistics. Olympia, Washington, selected annual issues, 1947-86).

$$(1)\quad P_F - b_0 + b_1Q_F + b_2Q_o + b_3Y + b_4T + b_5Q_FD = b_6TD = B_7D$$

where:

P_F = annual weighted average PHD price of all Washington fresh apples in dollars per 42 pound box divided by the consumer price index (CPI)

Q_F = annual fresh sales of all Washington apples in 42-pound boxes per capita;

Q_0 = annual fresh sales of all other US apple production in 42-pound boxes per capita;

D = dummy variable; = 1 for crop years 1973-86 and 0 for otherwise;

T = a linear time trend, 1947, 1948, . . ., 1986; and

Y = real per-capita income.

Annual data for the 1947/48-1986-87 crop years are used to estimate the model.[3]

$$(2)\quad PF = \underset{(89.43)}{469.93^{***}} - \underset{(4.835)}{17.11Q_F^{***}} - \underset{(2.49)}{11.08Q_0^{***}} + \underset{(.0007129)}{.00247Y^{***}}$$

$$- \underset{(.0462)}{.238T^{***}} + \underset{(5.109)}{7.06Q_FD} + \underset{(.0293)}{.141TD^{***}} - \underset{(57.7)}{277.8TD^{***}}$$

$$R^2 = .58 \quad D.W. = 1.2177$$

Standard error values are given in parantheses, with a ***, **, and * indicating significance at the 1, 5, and 10 percent probability levels, respectively. All coefficients of the estimated coefficients were significant at the 99 percent confidence level except for the coefficient on QfD, and the sign of each coefficient agreed with theoretical expectations.[4]

Using equation 2, the implied fresh apple price models for the two time periods are:

$$(3)\quad \underset{(1947\text{-}70)}{PF} = 469.93 - 17.11Q_F - 11.08Q_0 + .00247Y - .238T$$

$$(4)\quad \underset{(1971\text{-}86)}{PF} = 192.06 - 10.05Q_F - 11.08Q_0 + .00247T - .0974T$$

The computed price flexibilities evaluated at the mean values were -1.08 and -0.74 for the 1947-70 and 1971-86 crop years, respectively. Hence, the price equation became more price inflexible in the later time period. One explanation for this result may be due to the advancement in storage techniques that has allowed the total quantity produced to be marketed more evenly throughout the season. As a result, the effect of a change in total quantity on prices may be reduced.

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3. The data are published in *Washington Agricultural Statistics*, published by the Washington State Department of Agriculture; *Annual Price Summary*, published by the Washington Growers Clearing House, Inc.; and *Agricultural Statistics*, published by USDA.

4. The D.W. test was inconclusive. However, the standard errors reported are corrected using the Newey-West (1987) autocorrelation consistent estimator.

Processed Market Estimates

Following the same logic underlying the fresh market, the following price equation was estimated for the processed market.[5]

$$(5)\ P_p - \beta_1 + \beta_2 Q_p + \beta_3 Y + \beta_4 T + \beta_5 Q_p D + \beta_6 YD + \beta_7 TD + D$$

where:

P_p = annual weighted average PHD price of all Washington processed apples in dollars per 42 pound box divided by the consumer price index (CPI).

Q_p = annual processed sales of all Washington apples in 42-pound box per capita;

D = dummy variable; = 1 for crop years 1073-86 and 0 for otherwise;

T = a linear time trend, 1947, 1948 . . ., 1986; and

Y = real per capita income.

To be consistent with the fresh model annual data for 1947/48 - 1986/87 were also used to estimate the processed model.[6] The results of the estimated model are as follows:

$$(6)\ P_p = \underset{(53.92)}{-142.060^{**}} - \underset{(6.182)}{14.54Q_p^{**}} - \underset{(.005182)}{.000813Y} + \underset{(.02812)}{.0749T^{**}}$$

$$+ \underset{(8.037)}{5.264Q_pD} + \underset{(.00082)}{.00221YD^{**}} - \underset{(.0358)}{.175TD^{**}} + \underset{(68.81)}{339.24D^{**}}$$

R^2 = .55 D.W. = 1.38[7]

Standard error values are given in parentheses, with a ***, **, * indicating significance at the 1, 5, and 10 percent probability levels, respectively.

The estimated coefficients have the expected signs except for real disposable income for the years before the breaking point (1947-72). However, that coefficient was not significantly different from zero. The interactive dummy-own quantity variable was also not different from zero. However, these variables were retained in the model.[8]

From Equation 6, the demand functions for Washington processed apples can be calculated as follows:

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5. As with the fresh equation, a variety of functional forms were examined and a variety of hypothesis tests on a more general model was used to specify the processed equation. As with the fresh equation, time dependent coefficients were employed but the dummy variable treatment is reported.

6. The sources of data were the same as in footnote 3, except that quantity data for Washington processed apples were obtained from *Washington Agricultural Statistics*, published by the Washington State Department of Agriculture.

8. Considerations other than statistical significance need to be viewed before deciding to drop a variable. If the income variable is dropped from the model when theoretical model dictates its inclusion, then the model was misspecified and problems of bias and serial correlation may arise. Furthermore, the negative sign and the insignificance of income coefficient is not uncommon to studies analyzing the demand for apples (Tomek, 1968; O'Rourke, 1974; McGary, 1984). However, these authors had retained this variable in the models rationalizing that this variable was important. The dummy-own quantity interactive variable was maintained due to strong prior reasoning that the structure of the Washington processed apple industry has changed over the last forty years. The magnitude of the estimate is quite large and would significantly affect the optimal allocations if ignored.

$$(7)\quad \underset{(1947\text{-}72)}{P_p} = -142.060 - 14.54Q_p - .000813Y + .07409T$$

$$(8)\quad \underset{(1973\text{-}86)}{P_p} = 197.184 - 9.276Q_p + .001397Y - .1009T$$

The price flexibilities calculated at the mean quantity and price were -.46 for the 1947-72 period and -.53 for the 1973-86 period. This indicated that the demand for processed apples became more price flexible in the later period. In theory, as long as the absolute flexibility of demand is less than 1 in magnitude, the total revenue could be increased by increasing quantities sold until the flexibility equal to 1 is reached.

ALLOCATION BETWEEN FRESH AND PROCESSED MARKETS

Conceptual Framework

Washington apples are currently allocated to the fresh and processed markets by grade standards. Apples that do not meet the minimum grade requirements in the fresh market are channelled to processing outlets. Such a grade basis for allocation may not result in maximum producer revenue/profit attainable from that specific crop — the crop may not be utilized optimally. A price discrimination model can be used to determine the optimal quantities of apples to be supplied to each of the markets in order to maximize revenues (Tomek and Robinson, 1977). The approach is as follows. The optimal quantity to be optimal quantities to equal total production (i.e., existing supplies). The solution is obtained by equating marginal revenues across the fresh and processed markets, and is referred to as the constrained optimum solutions.

To obtain an estimate of the "potential" size in each of the markets, total production is assumed to be unlimited.[9] The potential size is measured under two different assumptions. The first measurement is the quantity associated with the unit elastic portion of the demand curve. This quantity is provided to summarize trends, can be easily calculated with existing data. It can be used to point to overproduction, and represents the quantity associated with the maximum revenue which can be obtained from each market. The results are referred to as the unconstrained optimum. In this analysis, there are cases where the constrained optimum solutions exceed the unconstrained optimum solutions. In such cases, revenues can be increased simply by discarded apples until quantities are lowered to the unconstrained optimum solutions. At this point the constrained and unconstrained solutions are equal.

The second size of market measure represents the maximum profit available from the market given the structure of costs. This measure is intended to guide planting/replanting decisions and policy prescriptions. In calculating this quantity, additional information in the form of the structure of long run costs and, in particular, long run marginal costs, is necessary. To the authors' knowledge no such information currently exist. However, tow recent studies of costs are available for 1985 and 1987 by Hinman, Hunter, and Tukey (1985) and Dickrell, Hinman, and Tvergyak (1987), which provide estimates of average costs in two locales for 1985 and 1987, respectively. The estimates provided by these two studies are used in conjunction with an assumption of constant returns to scale (marginal costs equalling average costs) to implement the theory. It is pointed out that the 1985 study applies to the Columbia Basin region, while the 1987 study applies to the Wenatchee region.

9. Potential size of the market refers to the maximum quantities that can be supplied to each of the markets to achieve the maximum revenue possible in each market. Supply exceeding these "maximums" would result in a decrease in total revenues.

RESULTS

The actual allocations, the constrained and unconstrained optimal quantities to be allocated annually to the fresh and processed markets, derived from the price discrimination model, are presented in this section. The profit maximizing point estimates are summarized in a later section.

The Constrained Case

Comparison between the actual quantities allocated to the fresh market the revenue/profit maximizing constrained solutions for each year are shown in Figure 2, while the corresponding results for the processed market are shown in Figure 3. The results show that in some years more apples should be place din the processed market, while in other years more should be placed in the fresh market so as to maximize total returns to growers.

In 19 years of the 23 years in the period between 1947-69, the results indicate that more apples should be placed in the processed market. However, since 1970, results show that in 11 of the 17 years more apples should be sold fresh. Therefore, it can be generalized that more of the apples should have been allocated to the processed market in the early time period of the data, while in the later period, the results suggest that more apples should have been allocated to the fresh market.

Scott (1971), using time series data for the period 1954-69, suggested that more of Washington apples should be allocated to processing outlets to increase revenues. The results of this study are consistent with Scott's findings for the same period. In 13 out of 16 years of the data that Scott used, increased quantities to the processed market would increase producer revenues. However, between 1970 and 1986, the results suggested that to achieve higher revenue, in only 6 of those years should more be sold processed, while in the other years more should go to the fresh market.

In percentage terms, however, the difference is small. Between 1973-86 an average of 24.7 percent of the apples were actually placed in the processed market. Constrained optimum solutions indicated that an average of 23.4 percent of production should be processed. Therefore, it appears that, in more recent years, the allocation mechanism currently practiced by the industry is performing well in allocating supplies to the fresh and processed markets. Thus the overall results through time are consistent with previous studies where Scott (1971) and O'Rourke (1974) suggested apples should be diverted to the processed market. However, since markets have changed significantly since then, that finding no longerholds and the industry is currently performing well in allocating supplies between the fresh and processed markets.

The Unconstrained Revenue Maximizing Size of the Market

Generally, the results indicate that revenue in the processed market can be achieved by increasing supply to the market (Figure 4).[10] This is true in all except for of the years between 1947-86, suggesting that the quantity supplied to the processed market has yet to reach the unitary elastic position of the demand curve, and revenue can be increased by increasing the quantity supplied to the market.

In the fresh market, the results are somewhat mixed. In 15 of the 40 years, the Washington apple industry oversupplied the fresh market (Figure 5). This is particularly true for the earlier time period. During those years, increased revenues/profits could have been obtained by restricting production or by discarding apples. In the 1970s, revenues to producers could have been increased by supplying more to the fresh market. However, the "trend" reversed in the early 1980s when revenue to producers could have been enhanced by supplying less

10. The unconstrained results showed an abrupt increase after the breaking point. This is due to the effect of the dummy variable. However, this should not obscure results since different empirical treatments of structural change (i.e., piecewise regression and splitting the data set into 2 periods and estimating separate demand functions) were also attempted. The estimated demand functions produced similar coefficients as the 0,1 dummy specification.

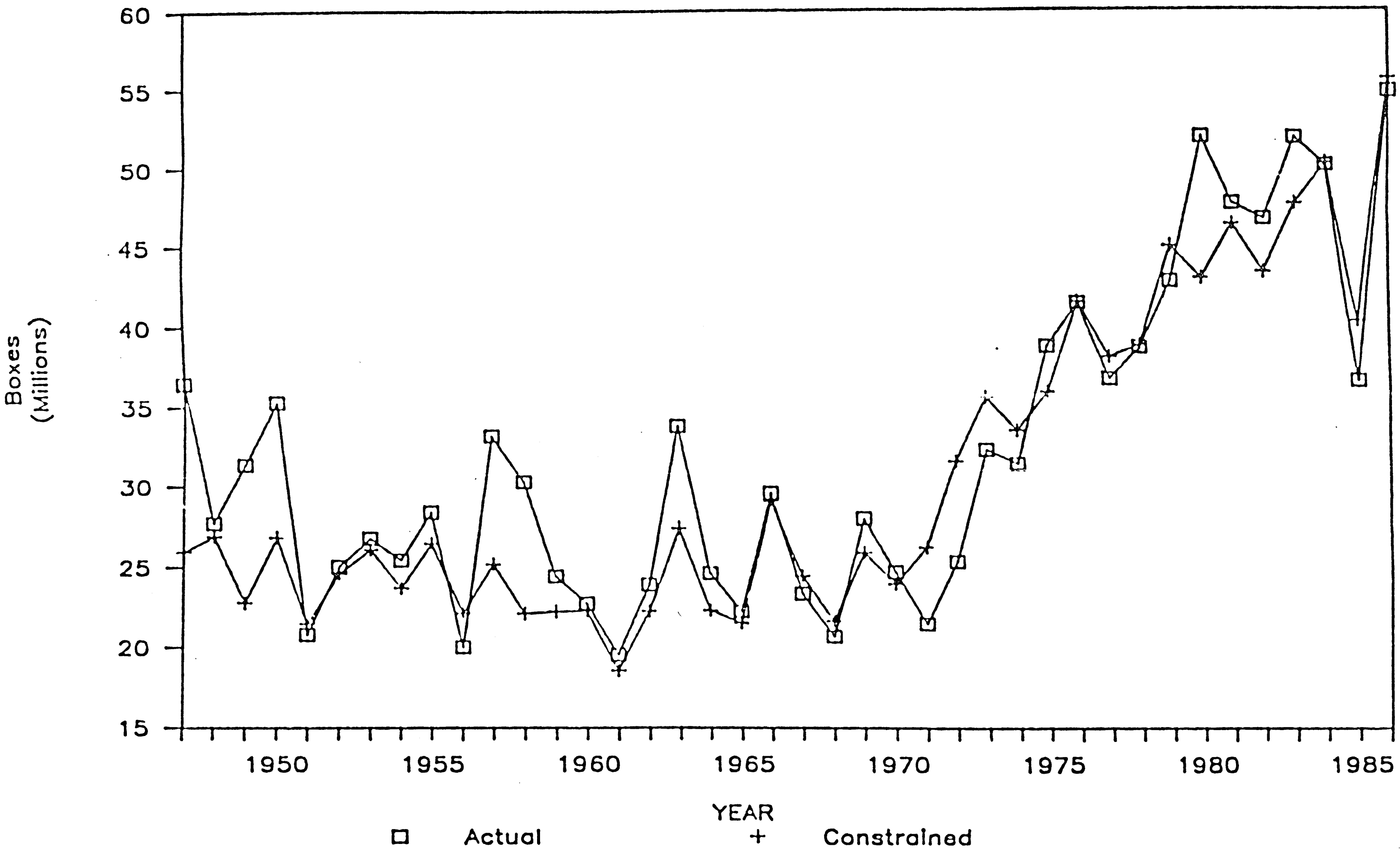

FIGURE 2. Actual Allocation and Constrained Optimal Solutions for Washington Fresh Apples, 1947-86

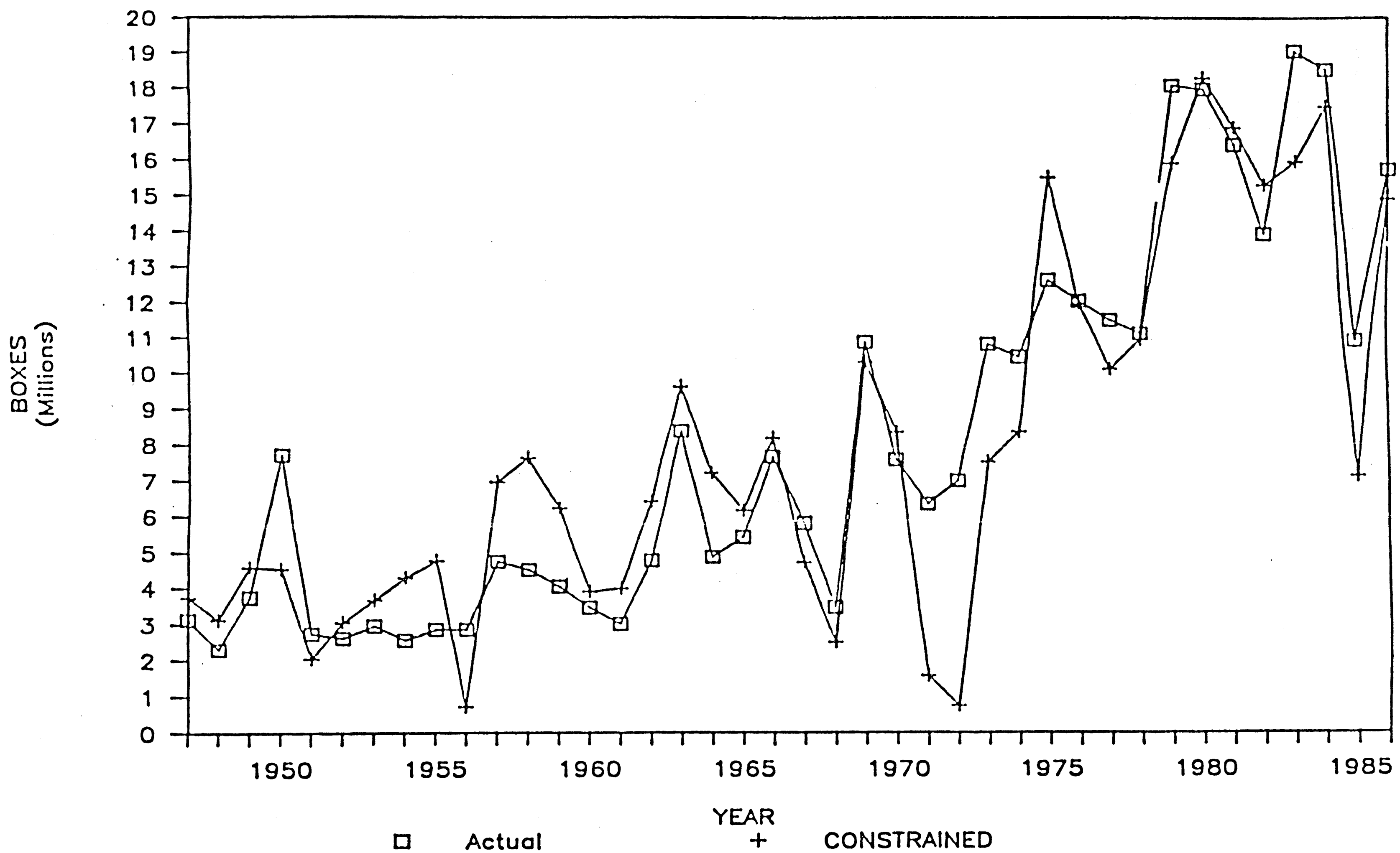

FIGURE 3. Actual Allocation and Constrained Optimal Solutions for Washington Processed Apples, 1947-86

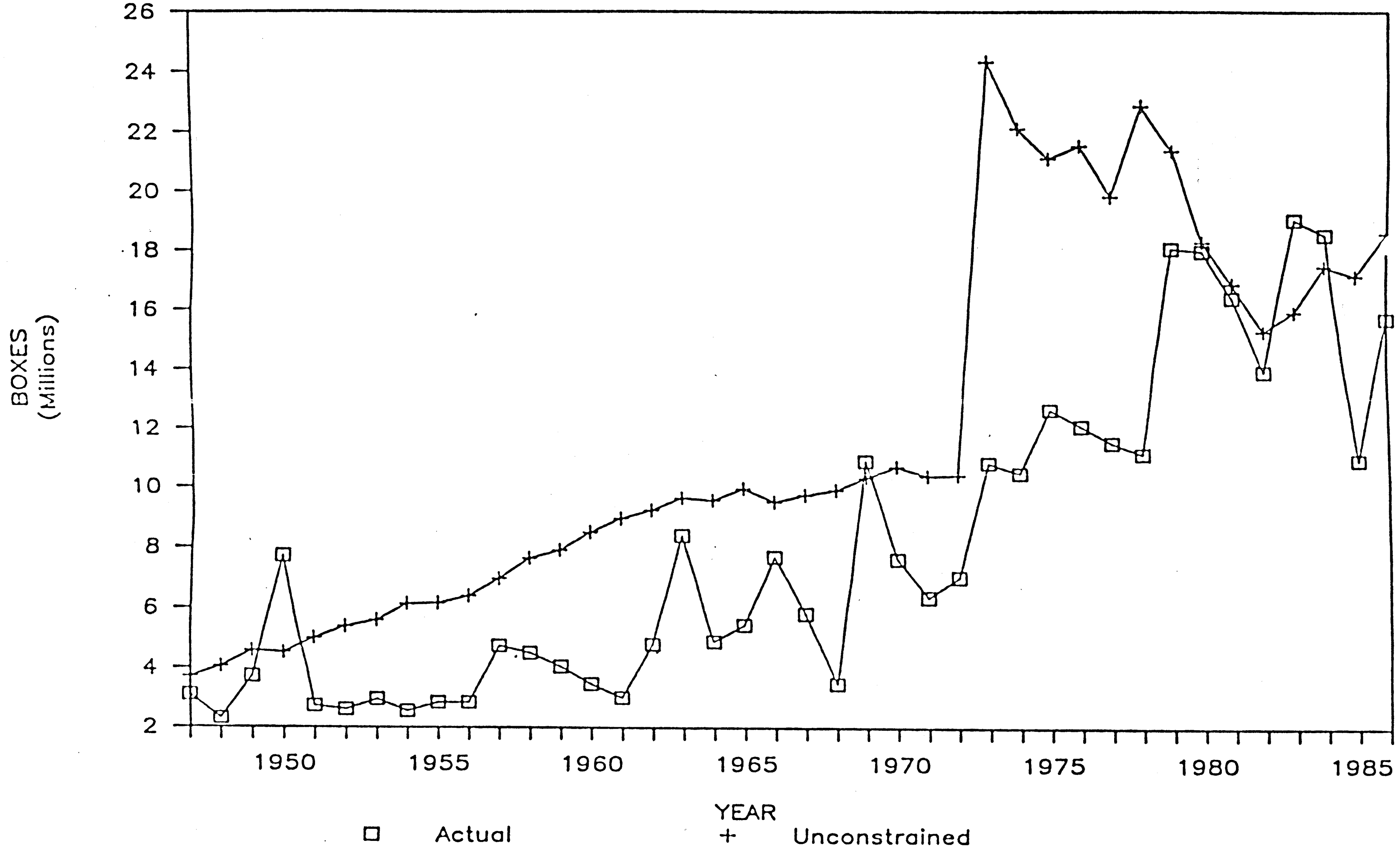

FIGURE 4. Actual Allocation and Unconstrained Optimal Solutions for Washington Processed Apples, 1947-86

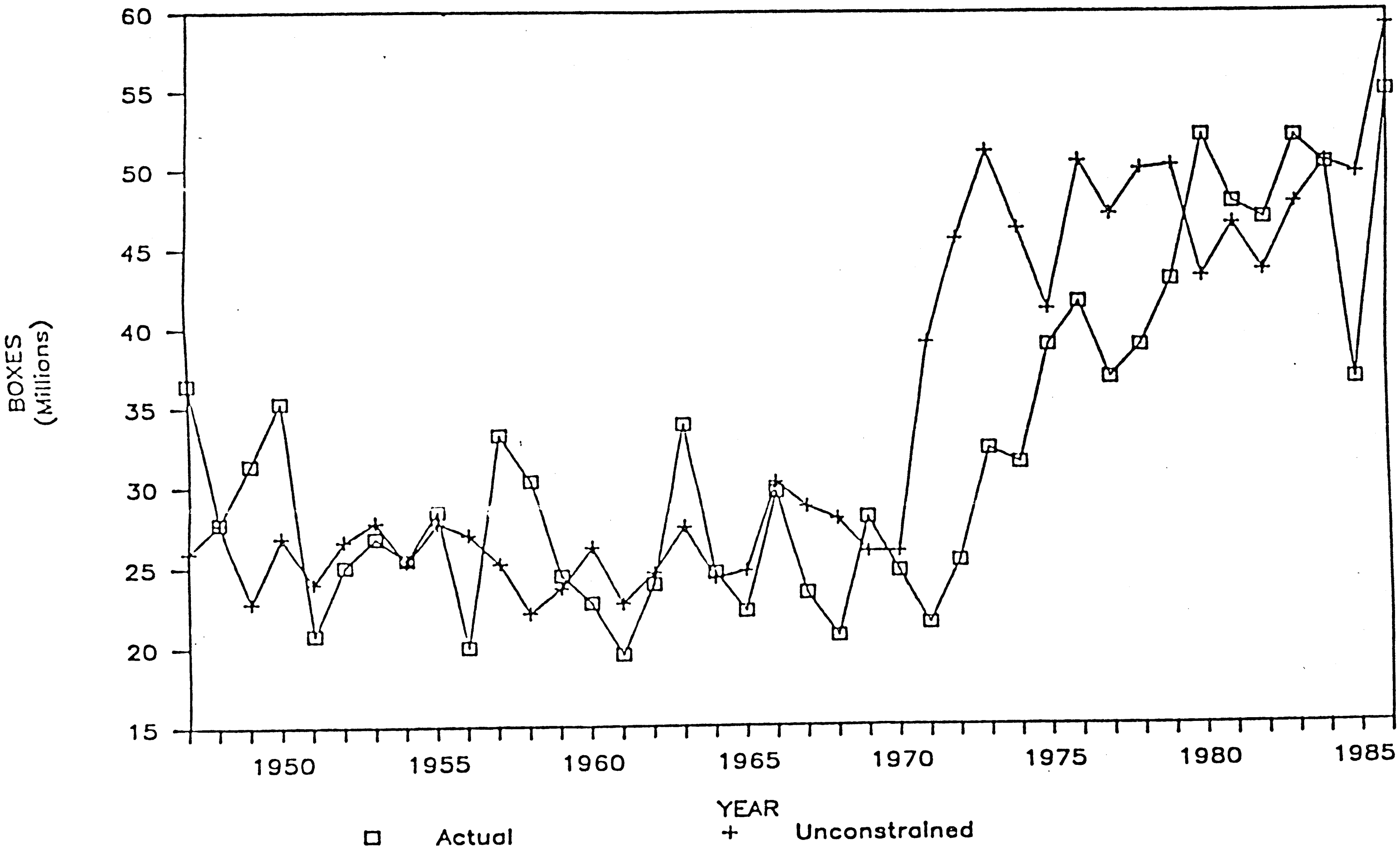

FIGURE 5. Actual Allocation and Unconstrained Optimal Solutions for Washington Fresh Apples, 1947-86

to the market, while in the last three years (1984-1986), revenues to the industry could have been enhanced by supplying more to the market. Hence, no general statement can be made pertaining to the supply of apples to the fresh market. Year-to-year analysis is necessary to obtain the optimum quantities that would maximize producer revenues.

Revenue Impact of Better Allocation

The potential revenue gains to producers through better utilization and optimal allocation of supplies ranges from negligible gains in 1976 and 1978, to 13.2 million in 1947, in real dollars. For example, in 1985 Washington apple production was at 47.7 million boxes, with 36.7 million boxes channelled to the fresh market and 11.0 million boxes channelled to the processed market. Maximum revenue given existing crop sizes could have been attained with 40.5 million boxes allocated to the fresh and 7.2 million boxes allocated to the processed. The difference between the actual revenue received and the optimal constrained solution was 1.14 million in real dollars. With the unconstrained solutions, the maximum revenue available from the market, the potential revenue gain was much greater. Unconstrained solutions showed that 49.7 million boxes should have been supplied to the fresh market and 17.2 million boxes to the processed market. The difference between the actual and the unconstrained revenue maximizing solution is about $8.6 million. The represents more than 8 percent of the actual returns to producers in 1985.

Profit Maximizing Size of Market

Another measure of market size is that quantity associated with highest attainable profit. In calculating these quantities only two years of cost information is used. Those studies are taken to represent nominal long run marginal cost estimates (or at least closely approximate those values) which are deflated to real values. All values are reported in Table 1. The results suggest that total profits to the industry can be increased by dramatic reductions in the size of the industry. In the 1986/87 crop year production was about 55 million boxes of apples, while the industry profit maximizing level of production was only about 35 million boxes based on average costs in the Wenatchee region. In the 1984/85 crop year production was about 50 million boxes, while the industry profit maximizing level of production was only about 34 million boxes based on average costs in the Columbia basin. The difference between real actual and real maximum profits is about $10 to $15 million, while in nominal terms these figures run from about $35 million in 1985 to $54 million in 1987.

Table 1. Profit Maximizing Quantities, Cost Estimates, and Profit

	Columbia Basin 1985	Wenatchee 1987
Nominal Cost Per Acre	4910	4108
Real Cost Per Acre (1967$)	1578	1251
Boxes (42 pound) per Acre	1125	625
Real Cost per Box	1.04	2.002
Profit Maximizing Boxes (1000)	33,884	35,085
Actual Boxes (10000)	50,339	54,923
Real Maximum Profit (1000)	$48,454	$51,189
Real Actual Profit (1000)	$37,884	$34,838
Real Profit Difference (1000)	$10,570	$16,351
Nominal Profit Difference (1000)	$32,883	$53,698

SUMMARY AND CONCLUSIONS

Increased production and falling real prices of apples point to the need for identifying alternative strategies to improve returns of Washington apple producers. A supply control strategy via better allocation of Washington apple production to the fresh and processed market was explored in this study. It was hypothesized that producer revenue could be improved by optimally allocating apply supply between the fresh and processed markets. To test this hypothesis, demand models were developed and estimated for all Washington fresh and processed apples. In fitting the models, annual data for the 1947/48 - 1986/87 crop years were used. These estimated demand relationships were used in conjunction with the price discrimination model to determine the optimal allocation between fresh processed markets that maximizes revenues for Washington apple producers.

Empirical evidence suggested that the demand structures for both Washington fresh and processed apples have changed. These changes may be due to the effects of controlled atmosphere storage (CA storage), which has extended the marketing season for fresh apples, thereby creating an expansion in the fresh apple market, and changing tastes and preferences of consumers. Zero and one dummy variables were used in the demand functions to allow for changes in slope of the parameters to be empirically measured.

Generally, results of the price discrimination model indicated that, for the period 1947-1970, more of Washington apple production should be allocated to the processed market to increase producers' revenues. However, for the 1971-86 period, more of the total supply should be allocated fresh. In the 1980s, the potential gains that could have been realized by producers were as much as $3.51 million in 1980 and as little as $40,000 in 1984 (in real terms). In more recent years, the allocation of supplies between the fresh and processed markets, currently practiced by the industry does not deviate much from the optimal, indicating that, in general, the industry's present allocation mechanism is allocating well between the two markets. Previous authors suggested that increased allocation to the processed market would be required to maximize revenues. The findings of this study are consistent with their analysis for the relevant time period. However, the markets have changed significantly since then, and that finding no longer hold in more recent years.

Results also indicated that expanding supplies in the processed market could have benefited producers. For the fresh market, mixed results were obtained. Although for many of the years from 1971 to 1986 revenues could be increased by expanding fresh supplies, this was not true for the early 1980s where the quantity supplied fresh has exceeded the unit elastic portion of the demand curve. Restricting fresh apple supply could have increased revenues in the fresh market during those years.

In the final section, the optimal crop size from a joint profit maximization perspective was calculated. The results suggest that total industry profits could be enhanced by removing a substantial portion of the current crop. Specifically, if crop sizes were reduced in 1985 and 1987 by 33 and 36 percent, industry profits would increase by estimated figures of $33 to $54 million dollars based on Columbia Basin and Wenatchee Valley economic-engineered costs.

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