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AN EXAMINATION OF THE FARM LEVEL DEMAND FOR PECANS

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AN EXAMINATION OF THE FARM LEVEL

DEMAND FOR PECANS

Abstract

Previous studies have indicated an elastic demand for pecans at the farm level. But these studies did not have the opportunity to directly incorporate storage information because these data were not published until 1970. Incorporation of stock changes into a pecan demand model produced a price flexibility estimate using mean values which indicated an inelastic farm level elasticity. An exact 95 percent confidence interval for this flexibility estimate did not include -1. Price predictions and an extension of an earlier optimal storage model were made using the price dependent equation estimated in this study.

AN EXAMINATION OF THE FARM LEVEL DEMAND FOR PECANS

The demand functions for most agricultural products at the farm level are generally believed to be inelastic [Brandow, George and King]. Thus an increase in supply would result in a decrease in total revenue to producers as a whole, ceteris paribus. This characteristic of demand functions for agricultural products provides the basis for many agricultural policy programs. Pecans, however, appear to be an anomaly. Price flexibilities estimated in previous studies indicate that the demand function for pecans at the farm level is elastic [Shafer and Hertel; Blake and Clevenger; Epperson and Allison; Fowler].

The purpose of this paper is to present an alternative model for investigating the price-quantity relationship for pecans at the farm level. This alternative model is, in the authors' opinion, superior to previous models used to estimate that relationship. Subsequent sections of this paper provide discussions of previous models applied to the price-quantity relationship, an alternative model, and implications.

Previous Models

There have been numerous studies that have had as one of their objectives the estimation of pecan prices. Although the estimation of price flexibilities for pecans was not the primary purpose of some of these studies, the results have been used by others for that purpose. Estimates of price flexibilities for pecans at the farm level have all indicated that the demand for pecans is elastic. An early study by

Fowler, and recent studies by Epperson and Allison, Shafer and Hertel, and Blake and Clevenger will be discussed in turn.

Fowler estimated the U.S. average farm price of pecans (cents per pound) as a function of the following variables: U.S. net supply of pecans, index of per capita disposable income, and time. The equation was fitted with data for the time period 1922-1956 and 78 percent of the variation in price was explained by the independent variables. Fowler calculated a price flexibility of -0.727. This flexibility, he noted, was almost identical to one estimated earlier by Lerner.

The primary purpose of the Epperson and Allison study was to estimate the impact of projected increased pecan production on pecan prices. Using data for the time period 1960 to 1976, Epperson and Allison estimated price of pecans at the farm level (deflated) as a function of the following variables: total U.S. production of pecans (in shell), total production of walnuts (in shell), total production of almonds (in shell), population, income (deflated) and time. The highest R^2 was obtained when a double log equation was used with 77.8 percent of the variation explained by the independent variables. Although Epperson and Allison did not calculate a price flexibility, it was calculated by the authors to be -0.43.

Shafer and Hertel introduced stocks as an explanatory variable in their model. Their model treated U.S. season average pecan prices as a function of: U.S. pecan production minus exports plus imports, annual disposable per capita income, and June cold storage of all nuts except peanuts. An arithmetic equation was fitted with data for the time period 1960-1977 with 83 percent of the variation explained. The calculated price flexibility was -0.58. When a logarithmic equation was used, a price flexibility of -0.59 was obtained. Shafer and Hertel state, "this is most unusual for agricultural commodities in that most are price inelastic at the farm level." They, however, did not present any rationale for this purported anomaly.

In a more recent study by Blake and Clevenger, the price of pecans was estimated using the variables: U.S. production of pecans, net change in stocks of all nuts, per capita income, net exports and per capita consumption. Although Blake and Clevenger did not estimate a price flexibility, an estimate of -0.76 was obtained by the authors using their equation and data.

Price flexibility estimates obtained varied from -0.43 to -0.76. Since the inverse of the absolute value of a price flexibility places a lower bound on the absolute value of own price elasticity [Houck, 1965], these estimates clearly indicate that the price elasticity of demand for pecans at the farm level is elastic. Although cited as being unusual for agricultural products by Shaffer and Hertel, this anomaly has not been pursued further prior to this study.

Alternative Model

Pecan production follows an "on-off" year production pattern. This can readily be observed in Figure 1. High production years are generally seen to be followed by low production years. With this high degree of production variability, one would expect that prices would be highly variable. A successful storage program would lessen price and revenue swings.

The following model attempts to capture the effect of storage on price. Earlier studies were unable to do so because of a lack of data. Epperson and Allison, however, pointed out that it is desirable to use

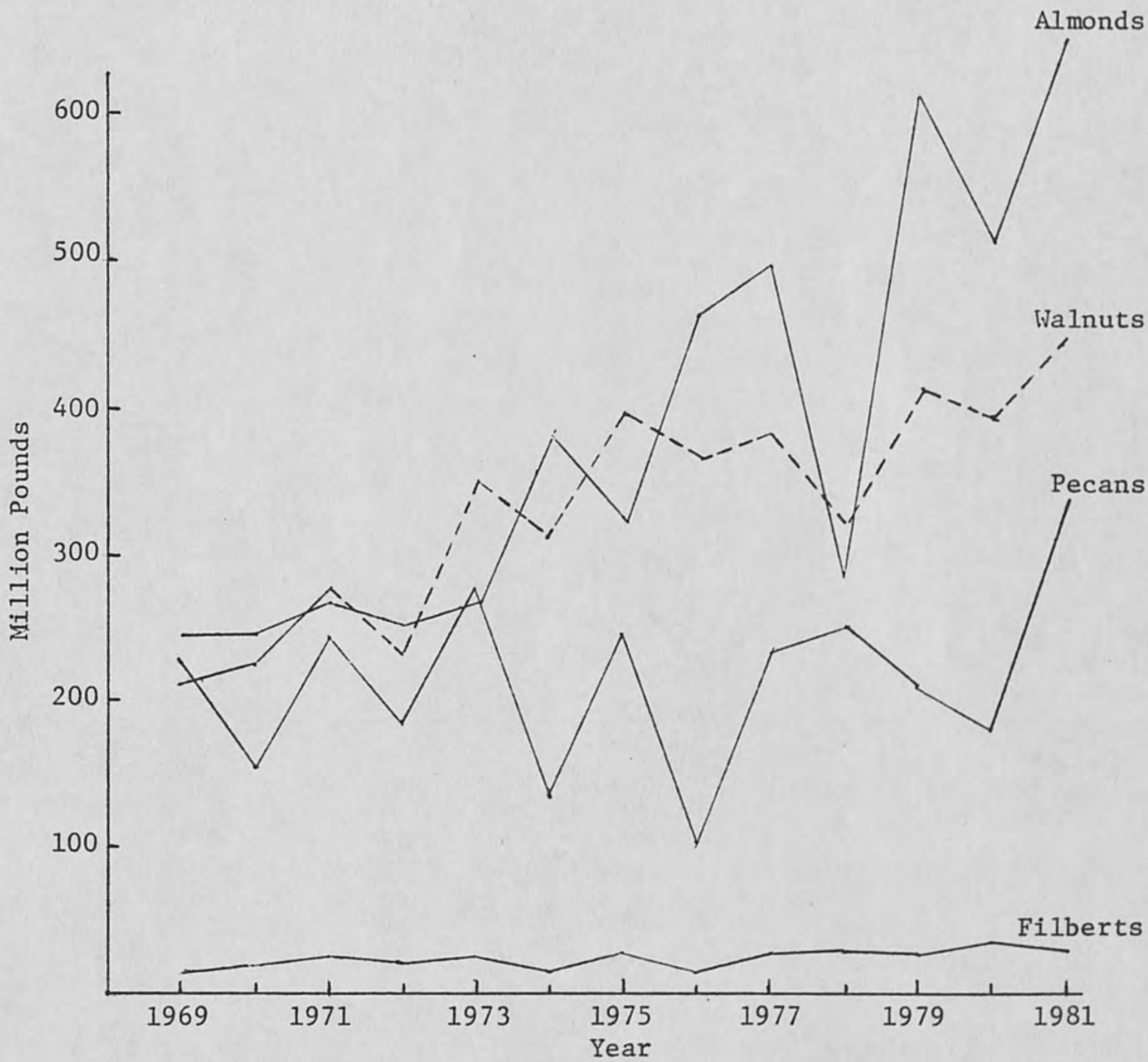

Figure 1. Pecan, Almond, Walnut and Filbert Production in Millions of Pounds for 1969-1981.

Source: USDA. Noncitrus Fruits and Nuts. Various issues.
USDA. Fruit Situation. Various issues.
Shafer, C. E. and K. Hertel. "A Statistical Analysis of Pecan Prices, 1960-1977, with Storage Considerations." College Station, TX. Dept. of Ag. Econ. Paper, 50 pp. 1981.

pecan stocks for pecan demand analysis. Such data were not available prior to 1970, thus preventing an adequate time series for their study. Failure to appropriately incorporate stocks in the earlier pricing models has led to spurious conclusions about the nature of the demand function for pecans. Stock changes have either been omitted or, in some cases, they have been approximated by using stocks of all nuts excluding peanuts. Regardless, earlier models suffer from an apparent specification problem.

This problem can be handled by constructing a model that explicitly considers stocks. The cyclical pattern of pecan production allows easy introduction of the stock equation. From 1960 through 1981 only one year, 1978, did not follow the on-year off-year production pattern. Such a systematic pattern allows holders of stocks to base their expectations of retail price on the observed production pattern. This clearly would influence the holding of stocks. For example, a high pecan production year would be accompanied by an increase in stock holdings which would keep prices from falling as much as they would otherwise. Therefore, rather than dealing with price expectations directly, the following model will use a dummy variable approach to capture the effect of the expected systematic production pattern on prices (i.e., price expectations). The model follows:

$$C_t = f(P_t, Y_t) \tag{1}$$

$$Q_t = Q_{t0} \tag{2}$$

$$S_{t+1} = g(EQ_t^{t+1}) \tag{3}$$

$$S_t = S_{t0} \tag{4}$$

$$C_t = Q_{t0} - \Delta s_t \tag{5}$$

where

C_t = pecan consumption in period t;

Q_t = pecan production in period t;

Y_t = per capita income in period t;

P_t = pecan price in period t;

^{o} = denotes the variable as being exogenous;

S_t = carry in stocks in time period t;

EQ_t^{t+1} = expectations in period t of pecan production in period t+1; i.e., -1 in expected low production years, +1 in expected high production years; and

$\Delta s_t = S_{t+1} - S_t$, i.e., the change in stocks for time period t.

Carry in stocks are exogenous, therefore change in stocks, Δs_t, can be stated as

$$\Delta s_t = \ell(EQ_t^{t+1}, S_t{}^o) \ . \tag{6}$$

Taking advantage of this relationship and exogenous production, a two equation estimation model can be derived by making appropriate substitution for C_t and arranging the consumption equation to be price dependent. The model thus becomes

$$P_t = h(Q_t - \Delta s_t, Y_t) \tag{7}$$

$$\Delta s_t = \ell(EQ_t^{t+1}, S_t{}^o) \tag{8}$$

The above model was fitted with data for the time period 1970-1981. Data sources for prices, consumption, and production were Shafer and Hertel and USDA Noncitrus Fruits and Nuts, ESCS; storage data were taken from USDA Regional Cold Storage Holdings, ESCS.

The model was run using least squares with no restrictions placed on the coefficients. Least squares was used because of the recursive nature of the model. Restrictions were then placed on the estimated coefficients of Q_t and Δs_t. These restrictions, as indicated by the economic model, forced the coefficients of these two variables to sum to zero.

The above model differs from those discussed earlier in that the change in stocks variable is treated as an endogenous variable. It is also important to note that the stocks variable used here is a change in stocks as opposed to a carry-in variable which was used at one point by Shafer and Hertel. If price is influenced by the introduction or removal of pecans from the market, this would be reflected by changes in stocks as opposed to stock levels.

Another point that warrants discussion is the exclusion of competing nuts from the equation. The reason for doing this was based on previous research results and preliminary estimates in this study which have shown that competing nuts have not been statistically significant at conventional levels, or had signs inconsistent with theory. Fowler states, "Several analyses failed to yield any statistically significant relations between supplies of competing nuts and pecan prices" (p. 14). This was the same conclusion reached by Shafer and Hertel. Substitute commodities, in particular, tree nuts such as almonds, walnuts, and filberts, do not appear to have had a great deal of influence on pecan prices. Preliminary analysis using walnut and almond production in the current research confirmed Fowler's statement.[1]

An interesting line of reasoning may be postulated as to why this is the case. With a food item such as pecans, substitutes are many and varied (i.e., not limited to other nuts) so that over a given time period it might be impossible to identify any specific substitute or substitutes. That is, walnuts may be the subtitute of interest in some years while almonds or even some non-nut food may be the appropriate substitute in other years. This being the case, statistical analysis may find no appropriate substitutes. The problem may still exist if a food group index, such as tree nuts other than pecans, is used as the substitute in that the overall index may be a poor measure of the substitutability of members of the index for pecans. That is, if all the items prices in an index do not move together, the index may very well fail to adequately picture the collective impact of the items in the index. For example, if during a given year one index item declined in price and thereby became a more effective substitute for pecans while the other index items prices remained stable, the index would not reflect the situation. This often may be the case with items other than pecans.

Foreign markets, another aspect of the pecan industry, could have been included in the analysis. Exports and imports of pecans are a small part of the industry and net exports are very small in volume. Therefore, it was felt that the impact of this sector would be negligible.

Model results, with and without restrictions, are presented in Table 1. Signs for all of the coefficients are consistent with a priori expectations. The t values indicate that all variables are significant at or below the 0.12 level. The unrestricted model permits the test of the hypothesis that the coefficients for Q_t and Δs_t are of the same magnitude but opposite in sign. The t-statistic was calculated to be -1.37, which indicates, at usual significance levels, no difference in the two coefficients. Thus, the impact on price of releasing stored

Table 1. Least Squares Results of a Pecan Industry Model Using Data from 1970-1981.

I. With No Restrictions on Coefficients

$$P_t = \underset{}{78.30} - \underset{(0.07)}{0.36}\, Q_t + \underset{(0.10)}{0.30}\, \Delta s_t + \underset{(0.001)}{0.009}\, Y_t$$

$R^2 = 0.91$

$$\Delta s_t = 51.9 - \underset{(0.41)}{1.02}\, S_t + \underset{(9.5)}{16.03}\, EQ_t^{t+1}$$

$R^2 = 0.63$

II. With Restrictions Placed on coefficients for Q_t and Δs_t

$$P_t = 87.41 - \underset{(0.06)}{0.40}\, Q_t + \underset{(0.06)}{0.40}\, \Delta s_t + \underset{(0.001)}{0.009}\, Y_t$$

$R^2 = 0.89$

$$\Delta s_t = 51.9 - \underset{(0.41)}{1.02}\, S_t + \underset{(9.5)}{16.03}\, EQ_t^{t+1}$$

$R^2 = 0.63$

Notes: 1. Standard errors in parentheses.

2. Data from Shafer and Hertel and USDA, Noncitrus Fruits and Nuts ESCS; USDA, Regional Cold Storage Holdings ESCS; USDA, Tree Nuts SRS; and Comm. Dept. Survey of Current Business.

3. P_t is cents per pound; Q_t, Δs_t, and S_t are millions of pounds in-shell; Y_t is income ($) per capita; EQ_t^{t+1} is a dummy variable with -1 during expected "off-production" and +1 during expected "on-production" years.

pecans does not differ from that of increased production. As a result, the restricted model results will be discussed below.

The price flexibility estimates computed at each observation and the mean are shown for the restricted model in Table 2. As can be seen, each price flexibility point estimate, with the exception of 1976, yields a lower bound on elasticity in the inelastic range. Additionally, most years have a 95 percent confidence interval that does not include 1.[2] This lends added credence to the contention that the lower bound on elasticities is in the inelastic range for pecans. These results would call into question statements such as, "the elastic demand for in-shell pecans at the farm level results in large crops being worth more than small crops" (Shafer and Bailey, p. 16).

The following section will consider further implications of two of the previously mentioned studies, Epperson and Allison and Shafer and Hertel.

Implications

The objective of the Epperson-Allison study was to estimate the impact of projected increased pecan production on pecan prices. They predicted high, medium and low production levels for 1985. The high and low estimates representing the on-off year production cycle are reproduced in Table 3 along with the Epperson-Allison price estimates and price estimates using the restricted equation results presented in this study. Per capita income estimates from the third quarter of 1983, on- and off-year stock change estimates, and Epperson-Allison's production estimates were used in forming the restricted equation estimates. As can be seen, except for the high production estimate of Method I, the restricted equation predicts a higher price than presented in Epperson

Table 2. Pecan Price Flexibilities and Lower Bounds of Price Elasticities Calculated Using Production Values, 1970-1981 and at Mean Levels

Year	Flexibility*	Exact 95 Percent Confidence Interval of Price Flexibility	Lower Bound of Price Elasticity
	----------------------Absolute Values----------------------		
1970	1.448 (0.227)	1.991 to 0.933	0.691
1971	3.222 (0.719)	5.254 to 1.800	0.310
1972	1.948 (0.363)	2.870 to 1.172	0.513
1973	3.398 (0.763)	5.527 to 1.884	0.294
1974	1.038 (0.148)	1.373 to 0.681	0.964
1975	2.218 (0.393)	3.176 to 1.355	0.451
1976	0.530 (0.056)	0.647 to 0.384	1.886
1977	1.669 (0.256)	2.258 to 1.075	0.599
1978	1.614 (0.242)	2.169 to 1.047	0.620
1979	1.664 (0.327)	2.506 to 0.975	0.601
1980	1.061 (0.163)	1.441 to 0.683	0.943
1981	2.189 (0.407)	3.217 to 1.315	0.457
Mean	1.659 (0.267)	2.286 to 1.049	0.603

*Standard errors in parentheses.

Table 3. 1985 Price Estimates for On- and Off-Production Years, Given Three Production Estimations and Two Demand Studies

Production Estimation Method[a]	Estimated Production	On-Production Year Price Estimates: From Epperson-Allison[b]	On-Production Year Price Estimates: Current Study[c]	Estimated Production	Off-Production Year Price Estimates: From Epperson-Allison[b]	Off-Production Year Price Estimates: Current Study[c]
	million lb	-------¢/lb-------		million lb	--------¢/lb------	
I	432.6	59.42	43.90	115.7	101.15	122.66
II	364.3	63.50	65.07	145.7	92.08	118.66
III	354.9	64.40	67.99	163.3	88.00	99.88

a. Method I is based on an accounting method based on precicted tree counts and tree yields. Method II results from an equation of estimated production as a function of bearing and nonbearing trees and a yield variable. Method III results from a simple trend equation.

b. The Epperson and Allison demand equation was

$$\ln P = 9.403 - 0.434 \ln Q_p$$

where P = farm level price/kg deflated by Producer Price Index;
Q_p = total estimated production/1000 kg.

c. Current study results based on

$$P = 178.022 - 0.36Q + 0.40(\Delta S).$$

For On-Year Production, derived from Table 1 with Y = \$10,068 (1983 quarter III per capita income) and ΔS = 12.49% of estimated production (average ΔS for on-year production 1970-1981).

For Off-Year Production, ΔS = -11.85% of estimated production (average ΔS for off-year production 1970-1981.)

and Allison's study. The discrepancy for the high production estimate of Method I results because the log linear demand of Epperson-Allison tends to limit the price response in the downward direction. For the low production levels, the price estimates diverge greatly. Much of this can be attributed to the difference in flexibility estimates in the two studies. But the differences are not insignificant in that the Epperson-Allison study paints a bleaker future for the pecan industry.

One objective of the Shafer and Hertel study was to develop an optimal storage model for 1972-1977. They regressed the log of prices against the log of consumption (production adjusted for changes in stocks). The new equation resulted in an estimated inelastic lower bound on price elasticity. Table 4 contains Shafer and Hertel's total revenue estimates assuming optimal storage, total revenue given actual storage levels during 1972-1977 and predicted total revenue given no change in storage from 1972-1977 (i.e., change of stocks equal zero). The first two revenue estimates were made by Shafer and Hertel, while the latter estimates were made using the restricted least squares equation from Table 1.

The optimal storage pattern resulted in a 20.24 percent increase in revenue over predicted revenue assuming no-storage activity. This compares to a 12.12 percent increase for the actual storage situation from the no-storage activity situation. Thus, optimal storage is predicted to increase revenue 8.12 percent beyond what has occurred without the added coordination required for the optimal storage model to be effective. Shafer and Hertel go on to suggest that a federal marketing order ". . . could provide supply management and market promotion to stabilize pecan supplies from year-to-year and, possibly reduce price variation"

Table 4. Predicted Optimal Storage Revenues, Actual Total Revenues Given Actual Storage Patterns and Predicted Revenue Given No Change in Storage Activity, 1972-1977

Year	Predicted Optimal Storage Revenue[a]	Actual Total Revenue[a]	Predicted Revenue With Constant Storage Level Using Restricted Least Squares Equation[b]
	---------------------Million Dollars---------------------		
1972	74.31	77.64	85.70
1973	83.83	101.21	36.59
1974	99.85	64.56	99.32
1975	108.96	98.20	78.60
1976	114.87	83.98	96.62
1977	120.96	136.46	104.47
Total	602.78	562.05	501.30

a. From Shafer and Hertel. The demand function was $P = 3410.88\ Q^{-1.02}$ where P = U.S. pecan price in cents per pound deflated by the Producer Price Index and Q = an index of pecan consumption (production plus change in stocks) with 200.28 million pounds = 100.

b. Change in stocks in the restricted least squares equation of Table 1 was set equal to zero and the resulting price estimate was multiplied by production to estimate total revenue.

(p. 38). While this may be true, cost estimates of such a centrally planned marketing system would first need to be calculated. However, what is clear is that storage activity at actual levels accounts for the bulk of the gain (60%) when comparing no storage activity with optimal storage activity.

Summary

This study presented an improved model for investigating the price-quantity relationship for pecans at the farm level. Previous models, generally because of a lack of data, omitted changes in stocks from consideration. As a result, these previous models estimated functions indicating elastic farm level demand. However, the introduction of stocks into the price model completely alters these conclusions. With stocks incorporated into the model, the resulting price flexibility indicates that the demand for pecans at the farm level is, indeed, inelastic. Thus, the appearance of elastic demand functions in previous studies is due to the moderating effects on producer price and revenue from the holding of stocks by groups such as shellers. The relatively low variation in price and crop value is due not to an elastic demand function for pecans, but to the manner in which pecan stocks are held and released. Fortunately, producers benefit from this price smoothing activity in much the same way as would be the case if the demand were elastic. This clearly has implications for profit to the pecan producer and efficiency for the industry.

Footnotes

[1]Two criteria of judging this to be the case were used. The first was the t values of the coefficients. None were significant at the 10 percent level. The second looked at the level of the price flexibility of income. Houck (1966) shows that if all other important goods are included in the model and there is homogeneity of degree zero in prices, the price flexibility of income should be +1. In the problem at hand, the estimate calculated at mean values is 0.99. The 95 percent confidence interval for this income flexibility included 1. Detailed results are available from the authors.

[2]The methods of calculating the standard errors and confidence intervals for the point elasticities are described in Miller, et al.

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