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PURCHASING DECISIONS

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Abstract:

Fixed search costs associated with locating and purchasing pecans invalidate the Tobit model. Factors such as perceived quality, ease of purchase, and familiarity with marketing outlets influence the fixed costs of pecan purchases. These factors have differing impacts on the probability of purchasing and the amount purchased based on the Heckman model. Failure to apply self-selectivity corrections produces misleading assessments of key variables influencing pecan purchases.

KEYWORDS: pecan demand, consumer quality expectations, Heckman model

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I. INTRODUCTION

Shelled nuts, a specialty item available year-round, enhance the flavor of many foods and are consumed as a main ingredient in snacks and desserts. Consumer quality expectations influence the purchase decision and the volume of nuts purchased. Shelled pecans sold at retail outlets represent over 20 percent of the total volume of shelled nuts produced in the U.S. Shelled pecans also reach consumers through wholesale distributors and gift packers. Florkowski and Hubbard (1992) confirmed that food manufacturers perceive pecans as a specialty item that must meet consumer quality concerns.

The influence of quality attributes and standards on industry price patterns was highlighted by Florkowski *et al.* Okunade and Cochran recognized that farm-level demand for pecans varies across varieties but research linking quality and consumer demand for pecans has been limited. Increased efforts to expand consumer markets by the pecan industry were advocated by Wood *et al.* to alleviate constraints on industry growth. As a result, the pecan industry focused marketing efforts on demonstrating the quality of pecan products to stimulate consumer demand.

We develop a demand model of the purchase decision of specialty goods such as pecans. Individuals may decide not to purchase pecans while others may consume pecans on a regular basis. The Tobit model is an appropriate econometric model to account for censoring of observed purchases at zero but this model imposes an implicit restriction on consumer behavior. In the Tobit model any factor that determines the probability of

purchase has the same impact on the amount purchased. We demonstrate that the Tobit model is deficient and fails to capture the key factors influencing the pecan purchasing decision.

Goods that have significant fixed costs or transaction costs associated with the purchase decision are not consistent with the Tobit model. Unpleasant experiences with the quality of pecans may lead consumers to avoid purchasing nuts. Consumer dissatisfaction lowers the probability of pecan purchases but may have no effect on demand from committed consumers who continue to purchase nuts. Factors such as ease of purchase, familiarity with marketing outlets and positive consumer product images are other factors which influence the fixed costs of consumption.

Cragg initially proposed relaxing the implied restrictions of the Tobit model, recognizing that search costs influence the decision to purchase goods but have a different impact on the quality and type of good purchased. Moffitt demonstrated that fixed costs may affect the participation decision and have no impact on the amount of participation and rejected the Tobit model as inappropriate in this case.

We examine an alternative to the Tobit model which accounts for fixed costs in the purchase decision. We compare the Tobit model against the general purchase model based on Heckman's method using data on pecan purchases and develop econometric tests for distinguishing between the models. The implications of the competing models for the implementation of effective pecan marketing programs are highlighted in the results.¹

II. SPECIFICATION OF THE DECISION FRAMEWORK

The Purchase Decision

Consumers incur fixed search costs in locating and purchasing specialty items such as pecans. Fixed costs affect the decision to purchase a product, but do not vary with the amount purchased. For example, locating premium quality pecans requires that the consumer identify reliable retail outlets. Given that dependable marketing outlets have been identified, the consumer can purchase an unlimited quantity.

A second cost associated with consumption varies with the amount of the item consumed. For example, household size influences the total variable costs incurred in consuming pecans. Given the decision to consume pecans, the larger household typically makes a larger dollar purchase. Variable costs are easily incorporated into demand analysis and enter the demand equation directly.

Let N represent the quantity of pecans purchased with unit price of p by a consumer with income, Y . The individual's utility function is given by

$$V = \begin{cases} U(X, \gamma N) - \psi, & \text{if } N > 0 \\ U(Y, 0), & \text{if } N = 0 \end{cases} \quad (1)$$

The parameter ψ is positive and accounts for the fixed costs associated with the purchase decision. The parameter γ is nonnegative and less than 1 and reflects the incremental costs of additional purchases of pecans. Individual consumption of other goods is represented by the composite commodity X with its price normalized to one. This utility function allows fixed and

variable costs to influence the purchase decision (Moffitt, Scott and Garen).

Consumers maximize utility by choosing both the amount of pecans N to purchase along with a composite set of other goods X , subject to the consumer's budget constraint. The standard unconstrained choice model ignores the effect of ψ on pecan consumption by treating it as a fixed parameter.

The consumer maximization problem yields the demand functions for purchased pecans N^* and the composite of other goods X^* . The optimal choices are functions of exogenous variables including income, the price of pecans, and other factors γ which influence pecan purchases. The optimal purchase of pecans $N^* = N(Y, p, \gamma)$ is censored at zero since negative purchases of nuts are ruled out. The Tobit model is appropriate for estimating the demand function for pecans in this situation.

In the more general case ψ is positive and represents the impact of fixed costs incurred in locating quality pecans. Fixed costs may constrain consumer purchases to zero even if the optimal purchases are positive, $N^* > 0$. The individual purchases pecans only if $N^* > 0$ and if

$$U(X^*, \gamma N^*) - U(Y, 0) - \psi > 0 \quad . \quad (2)$$

The consumer purchases pecans if the change in the utility given positive purchases exceeds the fixed search costs of the purchase.

We adapt Cogan's presentation to determine the purchasing decision when the consumer faced fixed costs. The reservation price, p^0 , is the highest price the consumer would pay to

purchase pecans. The reservation price is implicitly defined in the following equation

$$U[X(Y, p^0, \psi), N(Y, p^0, \psi)] - \psi - U[Y, 0] = 0 \quad (3)$$

The value of N at p^0 represents reservation purchases and is defined by $N^0 = N(Y, p^0, \psi)$.

Assume the actual market price of pecans is less than the reservation price, or $p < p^0$. Using expression (3), positive purchases of pecans result in a higher level of utility than zero consumption. If the actual price is higher than the reservation price, $p > p^0$, the individual attains a higher level of utility at N^* and no pecans are purchased. Here, $N^* < N^0$.

Positive purchases of N^* are observed when $N^* > N^0$. If $N^* < N^0$, then zero purchases of pecans are observed. The generalized purchase model recognizes that reservation demand for pecans may be positive when fixed purchasing costs exist, or when $\psi > 0$.

Specification of the Choice Model

The specifications of the consumer choice model with positive fixed costs and with fixed costs at zero result in different econometric models for estimation. We specify a linear model as a first-order approximation to the purchase decision when fixed costs are zero

$$N^* = \beta X + \varepsilon_1 \quad (4)$$

where β is the set of coefficients influencing the decision. The error term ε_1 is assumed to be normally distributed with zero mean and non-zero variance, σ_ε^2 .

Let d represent a dummy variable indicating purchases of pecans where $d = 1$ if the consumer purchases pecans and $d = 0$ if no purchase occurs. The probability that $d = 1$ is

$$Pr[N^* > 0] = Pr[\varepsilon_1 > -\beta X] = \Phi\left[\frac{\beta X}{\sigma_\varepsilon}\right] \quad (5)$$

and $\Phi(\cdot)$ is the cumulative standard normal. The Tobit model yields maximum likelihood estimates of the model

$$\begin{aligned} N &= \beta X + \varepsilon_1 & \text{if } N^* > 0 \\ N &= 0 & \text{if } N^* \leq 0 \end{aligned} \quad (6)$$

The consumer faces zero fixed costs or constraints on pecan purchases implying that ψ is zero.

The generalized purchase model accounts for factors constraining consumer purchases of pecans. Fixed costs may influence the probability of purchase so that ψ is positive. The consumer's reservation demand for pecans N^0 is positive or

$$N^0 = \alpha X + \varepsilon_0 \quad (7)$$

where α is the set of coefficients influencing reservation purchases of pecans. The error term ε_0 incorporates the effect of unobserved factors on the purchase decision and is assumed to be normally distributed with zero mean and non-zero covariance.

The probability that pecans are purchased ($d = 1$) is

$$Pr[N^* > N^0] = Pr[\varepsilon_1 - \varepsilon_0 > -\theta X] = \Phi\left[\frac{-\theta X}{\sigma_\eta}\right], \quad (8)$$

where $\theta = \beta - \alpha$, $\eta = \varepsilon_1 - \varepsilon_0$ with variance σ_η^2 . The model based on this decision structure uses N as the observed pecan purchases

$$\begin{aligned} N &= \beta X + \varepsilon_1 & \text{if } N^* > N^0 \\ N &= 0 & \text{if } N^* \leq N^0 \end{aligned} \quad (9)$$

The parameters of the model along with the cross-equation covariance of the disturbances are estimated following Heckman. The generalized purchase model relaxes the restrictions of the Tobit model linking the probability of purchase and the amount purchased.

III. SAMPLE AND VARIABLE DESCRIPTION

A nationwide mail survey examining the purchases of raw, unprocessed pecans (shelled or unshelled) was conducted in the summer 1993 based on a randomly drawn sample of consumers provided by marketing representatives from the pecan industry. A pretest of the survey design was conducted for a selected set of consumers prior to mailing the questionnaires. Post cards were mailed to the prospective respondents serving as a reminder to complete and return questionnaires and a follow-up mailing was completed two weeks after the reminder notice. Definitions of the variables used in the model and summary statistics are presented in Table 1 and the key variables are briefly described here.

Respondents revealed a high degree of familiarity with a wide variety of nuts including pecans, peanuts, almonds, cashews, walnuts and other common nuts. Over 90 percent of those surveyed could identify shelled pecans and over 95 percent had eaten these nuts in the previous twelve months. The number of pecan purchases during the previous six months was recorded for each respondent and is the dependent variable in the model. Pecan purchasers averaged approximately three purchases during the survey period.

Information about purchases of other kinds of nuts was also elicited. The average amount spent on nuts and nut products by pecan purchasers was over double the amount spent by non-purchasers. Pecans and other nuts are often received as gifts and consumers who receive nuts as gifts may change their demand for pecans. The types of nuts received as gifts during the last year was recorded for ten different nuts.

Nuts are consumed in a variety of foods and as seasonings in baking and flavored mixes including snacks, salads, cookies, and mixed with meat dishes and desserts. A variable indicating uses of nuts on a weekly basis for ten separate food categories was defined to measure nut consumption variety. On average respondents consumed nuts at least once a week in seven different food categories. Over 90 percent of both purchasers and non-purchasers of pecans used nuts or nut products in five or more food items.

The types of nuts with which respondents had an unpleasant consumption experience related to poor quality characteristics was recorded. Williams *et al.* documented that consumers often lack objective bases for evaluating quality of pecans and are unaware of pecan grading standards. Consumers are aware of personal incidents of quality defects in pecans and these events may affect the purchasing decision.

Poor quality nuts constrain purchases of pecans in two ways. First, consumers may develop an aversion to purchasing nuts and this stigma corresponds to a fixed cost which decreases the probability of purchase. Second, consumers must allot increased

resources and time to search for better quality pecans and to identify outlets with strict quality controls.

The pecan industry has emphasized the nutritional and quality characteristics of nuts in its marketing efforts. Dove *et al.* discussed the nutritional desirability of pecans due to their high amount of unsaturated oil which can positively influence serum lipids. The susceptibility of pecans to rancidity is also an industry concern since pecans are often stored at ambient temperatures for use in confections, bakery goods, cereals or snacks. Problems that consumers experienced with nuts were recorded including problems with shells, rancidity, small size, color, flavor, and insects. A variable measuring the total number of unpleasant consumer experiences in these categories was defined.

Consumers most frequently purchase raw, shelled pecans in grocery stores, through mail order businesses, in specialty stores, at fund raisers, road stands, and other type of outlets. The diversity of outlets where consumers purchased pecans indicates that consumers are willing to spend additional time and effort to identify a source with the product which meets their expectations.

The survey identified a set of positive factors which may promote purchases of nuts including convenience, health, taste, preferences of guests, and tradition. Both pecan purchasers and non-purchasers identified on average three positive reasons influencing their pecan purchases. Over 60 percent of both groups identified serving convenience, health, and taste as factors influencing the decision to purchase pecans. Information

on demographic variables for household income and race was also included in the model.

IV. MODEL ESTIMATION AND RESULTS

Empirical Results from the Tobit Model

Results from the Tobit model for the number of pecan purchases in the first column in Table 2 assume that fixed costs of purchase are zero and do not constrain the purchase decision. The coefficient on household income indicates that respondents with higher incomes purchase pecans more frequently. The total amount spent on all nuts and nut products by the household was a significant factor influencing pecan purchases. The quadratic specification in the amount spent on nut products reveals that the maximum number of purchases occurred at \$56 and declined for higher amounts. Targeting marketing efforts to consumers spending lower than this amount would increase pecan purchases.

Florkowski and Hubbard (1994) reported that consumers identified pecans along with almonds, pistachios, and macadamias as premium nuts indicating that consumers allocate expenditures on nut products among these competing nuts. Nuts processors also compete for market share of consumer purchases by monitoring and adjusting relative prices. Marketing efforts that encourage consumers to expand expenditures on nut products as a group increase the probability of pecan purchases.

The Tobit model showed that consumers who use nuts in a greater variety of foods tend to purchase pecans more frequently. The coefficient on the variety of foods in which consumers use nuts was significant. Additional information on how to use nuts

in alternative recipes and foods has a spillover effect on expanding demand for pecans along with other nuts.

Results from the Tobit model highlight the importance of marketing outlets in providing consumers with a convenient source for purchasing pecans. The total number of marketing outlets used by consumers had a significant influence on the frequency of pecan purchases. Marketing through grocery stores is a primary factor influencing pecan purchases.

Pecan purchasers are more aware of alternative marketing outlets for pecans than are non-purchasers and have a greater diversity of purchasing sources. Only 19 percent of non-purchasers use two or more marketing outlets as compared with 62 percent of pecan purchasers. Both purchasers and non-purchasers rely heavily on grocery stores and mail-order outlets. Specialty stores and fundraisers are important outlets for purchasers but are underutilized in attracting non-purchasers.

The Tobit model implies that 36 percent of the adjustments in pecan purchases in response to changes in the independent variables are due to marginal changes in positive purchases. The remaining 64 percent is linked to shifts in the probability of any purchases and represents the impact of new purchasers. The Tobit model highlights the role of new purchasers in expanding the demand for pecans and has implications for marketing campaigns by the industry. New consumers of pecans may need additional information on handling and storing pecans and advice on how to prepare pecans for recipes.

Empirical Results for the Generalized Model

The generalized purchase model for pecans is estimated following Heckman's method with the results for the probability of purchase model presented in the second column in Table 2. The purchase decision is generally influenced by the same set of significant variables that enter the Tobit model for pecan purchases. There are important differences in the implications of the models that are highlighted here. The probability of purchase increases with the total amount spent on nuts, reaching a maximum at \$66.70.

The coefficient on the variable measuring the total number of unpleasant consumer experiences was not significant in the purchase decision suggesting that unpleasant experiences do not constrain purchases. The survey results indicated that pecan purchasers do experience more problems on average with nut quality than those who did not purchase pecans. However, repeat experiences with poor quality does deter purchases, suggesting that producers must maintain high quality standards. Only four percent of respondents who had more than one experience with low quality nuts also engaged in repeat purchases.

The implications for pecan marketing efforts suggest that the industry focus on improving the main quality impediments identified by consumers. Rancidity was the major concern in quality perceptions of both purchasers and non-purchasers and this can be addressed by providing marketing information to consumers. Information on proper storage and its influence on the pecan quality can lower the incidence of quality defects by ensuring that consumers use pecans before the flavor is adversely affected by rancidity.

The estimates for the selection model of purchase decisions are presented in the third column of Table 2. These results reveal a set of factors that do not influence the selection model but which do appear in the Tobit model.

Gross household income and total marketing outlets used by pecan purchasers are not significant in the selection model. The Tobit model implies that gross household income and marketing outlets influence pecan purchases, both by increasing the probability of purchase and the amount purchased. The generalized purchase model reveals that only the probability of purchase is affected by these variables. Marketing programs that target consumers based on these variables will attract new purchasers of pecans but may not expand demand from current purchasers.

The selection model shows that the number of pecan purchases increases with higher total expenditures on nut products, reaching a maximum at \$53.68. The amount is lower than the level calculated for the Tobit model and indicates that marketing efforts to increase pecan purchases can focus on consumers with relatively lower levels of current expenditures on nut products.

The Tobit estimates suggest that the quadratic term in amount spent on nuts and the variety of nut usage have a significant influence on pecan purchases. The generalized purchase model reveals that the quadratic term in amount spent does not impact the probability of purchase but operates only on the amount of purchase, given the consumer has decided to purchase. The variety of nuts consumed has a major impact on the amount purchased from committed pecan consumers and a weaker

impact on the probability of purchase. Experiences with poor quality nuts act to decrease the probability of purchase but not the amount purchased, given the decision to purchase.

These results highlight the differing interpretations provided by the Tobit and the generalized purchase model about the critical factors influencing pecan purchases. The restrictions implicit in the Tobit model may distort the impact of key variables on the purchase decision.

Evaluating the Competing Models

The validity of the generalized demand model is examined in two ways. First, the restrictions of the Tobit model are tested. Second, the empirical results of the two models are compared to evaluate the implications for marketing of pecans. The Tobit model imposes the restriction that the factors influencing the probability of purchase and the amount purchased are identical and that these variables have the same impact on both decisions. We test the validity of the Tobit model against the generalized purchase model.

Scott and Garen develop a Chow-test of these restrictions by estimating the probit model and imposing the Tobit restrictions on the second-stage ordinary least squares model. The sum of squared residuals from regression model with the Tobit restrictions imposed is 361.81 and the unrestricted sum of squares is 287.56. The calculated F-statistic is 2.07 which exceeds 1.90, the critical value at the 5 percent level for the F-distribution with 11 and 88 degrees of freedom. The restrictions imposed by the Tobit model are rejected.

The statistical test confirms the validity of the generalized purchase model. We focus on the information this model provides for effective marketing of pecans. Marketing efforts by the industry should be targeted to identify key factors influencing the decision to purchase pecans separately from factors that expand the number of consumer purchases.

Although the restrictions of the Tobit model are rejected, a key issue is to examine how the competing models assess the impact of important explanatory variables on expected pecan purchases. If the Tobit and generalized purchase model provide similar values for these marginal effects, the empirical implications of the models are the same. The Tobit model may perform adequately in identifying the factors that influence purchases.

McDonald and Moffitt decompose effects from the Tobit model into two elements: effects on the probability of being above zero and effects conditional on positive observations of the dependent variable. The impact of any explanatory variable on expected pecan purchases is:

$$\frac{\partial E(N)}{\partial X_i} = Pr(N^* > 0) \left[\frac{\partial E(N^* | N^* > 0)}{\partial X_i} \right] + E[N^* | N^* > 0] \left[\frac{\partial Pr(N^* > 0)}{\partial X_i} \right]$$

These elements are computed for both the Tobit and Heckman models using the estimated parameters for each model and are shown in Table 3. The first component on the right-hand side measures the change in the probability of pecan purchases and is presented in column A of Table 3. The second component on the right-hand side measures the change in expected pecan purchases for consumers who currently purchase pecans and is shown in column B of Table 3.

The total effects from the Tobit and Heckman models (in column C) yield substantially different measures for the impact of a given explanatory variable on expected pecan purchases. A sample of these results reveals that the Tobit model underestimates the effects of household income, variety of uses for nuts, and total marketing outlets on pecan purchases. The role of grocery stores in stimulating pecan purchases would be overlooked in a marketing campaign based on the Tobit model. The generalized purchase model identifies grocery stores as the key marketing outlet to stimulate demand for pecans. The Tobit model also neglects the impact of positive qualities that consumers indicate influence pecan consumption.

The Heckman model allows the impact of an explanatory variable to have different impacts on the conditional effect (column A) and the unconditional effect (column B). The types of nuts received as gifts and the number of unpleasant quality experiences with nuts have different effects on the probability of purchase versus the number of purchases. The Tobit model lacks this flexibility.

V. CONCLUSIONS

Heckman's approach for estimating censored regression models offers an alternative to the single-equation approach based on a Tobit model. Fixed search costs associated with locating and purchasing a specialty item invalidate the applicability of the Tobit model. Factors such as perceived quality, ease of purchase, familiarity with marketing outlets and positive consumer product images influence the fixed costs of pecan purchases. These factors may have differing impacts on the probability of purchasing and the amount purchased and can be modelled using the Heckman approach.

The validity of the sample selection model does not depend on a statistically significant estimate of the selectivity parameter. Hensher and Milthorpe noted that even if the selectivity variable is not statistically significant, "its inclusion is necessary to detect and account for the magnitude of selection bias on *individual* parameters." Application of the Tobit model and the failure to apply self-selectivity corrections based on the Heckman model can produce misleading assessments of the key variables which influence pecan purchases.

FOOTNOTE

1. Pudney presented modifications of the Tobit model that relax the model's implied restrictions including the double-hurdle model. He noted that the double-hurdle model lacks a solid foundation in choice theory. The economic model based on fixed costs of purchasing requires testing the Tobit model against the Heckman model.

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