# Demand and Quality Uncertainty in Pecan Purchasing Decisions

## Timothy A. Park and Wojciech J. Florkowski

ABSTRACT

A generalized Heckman model of purchase decisions incorporating perceived consumer quality attributes, ease of purchase, and familiarity with marketing outlets as factors influencing pecan purchases is estimated. Marketing efforts that encourage consumers to expand expenditures on nut products increase both the probability of pecan purchases and the amount purchased. Consumers who use all types of nuts in a wider variety of foods tend to purchase pecans more frequently. A diverse set of marketing outlets provides consumers with convenient sources for purchasing pecans and has a significant influence on the probability of pecan purchases but not the amount of pecans purchased.

**Key Words:** generalized Heckman model, pecan purchases, Tobit.

Increased efforts by the pecan industry to expand consumer markets were advocated by marketing analysts to alleviate constraints on demand and to promote industry growth (Wood, Payne, and Grauke). As a result, the pecan industry has developed marketing and promotional programs at national and regional levels to expand existing markets for pecans and to stimulate purchases beyond traditional consumer groups.

The National Pecan Marketing Council funded tie-in promotions with manufacturers of various baking ingredients to demonstrate the quality of pecan products and to target new consumer purchases. Regional organizations have prepared promotional efforts to increase the visibility of pecans and show their versatility in baking and cooking uses while emphasizing that healthy diets can include pe-

cans. The effectiveness of these promotion programs can be improved by investigating the key factors which influence the consumer decision to purchase pecans and the amount of pecans purchased.

The objective of this research is to specify and estimate an economic model which identifies factors influencing the initial purchase decision and the amount purchased. The economic model of pecan purchases accounts for the key quality factors and marketing outlets which impact purchasing decisions for this specialty item.

Pecan accumulators and shellers have consistently listed pecan quality as a critical consumer concern in purchasing patterns. Food manufacturers also perceive pecans as a specialty item that must meet consumer quality concerns. The influence of quality attributes and standards on industry price patterns was identified by Florkowski, Purcell, and Hubbard but research that explicitly links quality attributes and consumer purchasing patterns for pecans is lacking.

Individuals may decide not to purchase

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specialty items such as pecans while others may consume pecans on a regular basis. The Tobit model accounts for censoring of observed purchases at zero but imposes an implicit restriction on consumer behavior. Any factor that determines the probability of purchase has the same impact on the amount purchased. This study demonstrates that the Tobit model is deficient and fails to capture the key factors influencing the pecan purchasing decision.

We examine an alternative model, a generalized Heckman procedure, which accounts for transactions costs consumers may incur in identifying and purchasing high-quality specialty items, such as pecans. To distinguish alternative model specifications, econometric tests are used to compare the Tobit model against the general purchase model based on Heckman's method. The implications of the competing models for the implementation of effective pecan marketing programs are highlighted in the results.

## Specification of the Decision Framework

### The Purchase Decision

Goods that have significant transactions or search costs associated with the purchase decision are not consistent with the Tobit model. Cragg initially recognized that search costs influence the decision to purchase goods but may have a different impact on the quality and type of good purchased. However, the Tobit model implicitly imposes the restriction that any variable influencing the purchase decision has the same impact on the amount of purchase. Moffitt also demonstrated that fixed costs may affect the participation decision and have no impact on the amount of participation. He rejected the Tobit model as inappropriate in this case.

Consumers incur fixed search costs in locating and purchasing specialty items. 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. Consumers who identify reliable retail outlets are more likely to become repeat customers at that outlet. Repeat customers will tend to purchase pecans more frequently and to purchase greater quantities. Consumers who purchase pecans across a variety of outlets have invested search time to locate quality pecan products.

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, consumer familiarity with uses for nuts, established patterns in using alternative marketing outlets and positive consumer product images for pecans are elements which influence the fixed costs of purchases.

A second cost associated with purchases 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, larger households typically make larger dollar purchases. 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

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

The parameter $\psi$ is positive and accounts for the fixed costs associated with the purchase decision; $\gamma$ is nonnegative and less than 1, reflecting the incremental costs of additional purchases of pecans. Individual purchases of other goods are represented by the composite commodity X with its price normalized to 1. 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 $\psi$ on pecan purchases 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 $\gamma$ 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 $\psi$ 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

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

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

Cogan's presentation is adapted to determine the purchasing decision when the consumer faces 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:

$$(1) \quad U[X(Y, p^0, \gamma), N(Y, p^0, \gamma)] - \psi - U[Y, 0]$$
$$= 0.$$

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 (1), positive purchases of pecans result in a higher level of utility than zero purchases. Here, N* > $N^0$. If the actual price is higher than the reservation price, $p > p^0$, the individual attains a lower level of utility at N* and no pecans are purchased. 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

$$N^* = \beta X + \epsilon_1,$$

where $\beta$ is the set of coefficients influencing the decision. The error term $\epsilon_1'$ is assumed to be normally distributed with zero mean and non-zero variance, $\sigma_\epsilon^2$.

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

$$Pr[N^* > 0] = Pr[\epsilon_1 > -\beta X] = \Phi\left[\frac{\beta X}{\sigma_\epsilon}\right],$$

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

$$(2) \quad N = \beta X + \epsilon_1, \quad \text{if } N^* > 0,$$
$$N = 0, \qquad \text{if } N^* \leq 0.$$

Equation (2) assumes that $\psi$ is zero, implying that the consumer faces zero fixed costs or constraints on pecan purchases.

The generalized purchase model accounts for factors constraining consumer purchases of pecans. Fixed costs may influence the probability of purchase so that $\psi$ is positive. The consumer's reservation demand for pecans $N^0$ is positive or $N^0 = \alpha X + \epsilon_0$, where $\alpha$ is the set of coefficients influencing reservation purchases of pecans. The error term $\epsilon_0$ incorporates the effect of unobserved factors on the purchase decision and is assumed to be normally distributed with zero mean and non-zero covariance with $\epsilon_1$.

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

$$\Pr[N^* > N^0] = \Pr[\epsilon_1 - \epsilon_0 > -\theta X] = \Phi\left[\frac{\theta X}{\sigma_\eta}\right],$$

where $\theta = \beta - \alpha$, $\eta = \epsilon_1 - \epsilon_0$ with variance $\sigma_\eta^2$. The model based on this decision structure uses N as the observed pecan purchases:

$$N = \beta X + \epsilon_1, \quad \text{if } N^* > N^0,$$

$$N = 0, \qquad\qquad \text{if } N^* \leq N^0.$$

The parameters of the model along with the cross-equation covariance of the disturbances are estimated following Heckman. A probit model is estimated for the pecan purchase decision generating estimates of $\theta$. The model for number of pecans purchased is estimated for those who reported purchases using a set of explanatory variables and the estimated inverse Mills' ratio. The lambda variable is defined as $\lambda = \lambda(\theta X) = \phi(\theta X)/\Phi(\theta X)$ where $\phi(\cdot)$ is the standard normal probability density function. The generalized purchase model relaxes the restrictions of the Tobit model linking the probability of purchase and the amount purchased.

## Sample and Variable Description

A nationwide mail survey examining the purchases of raw, unprocessed pecans (shelled or unshelled) was conducted in summer 1993 based on a randomly drawn sample of consumers provided by marketing representatives from the pecan industry. A pretest of the survey design including key variables influencing pecan purchases of interest to the pecan industry 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 the questionnaires. A follow-up mailing was completed two weeks after the reminder notice. The analysis is based on 430 returned questionnaires out of 831 initially mailed, representing a return rate of 59.7% after deleting undeliverable surveys. Complete information on the variables used in this analysis were obtained from 224 respondents. 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% of those surveyed could identify shelled pecans and over 95% had eaten these nuts in the previous twelve months. The number of pecan purchases during the previous six months for each respondent is used as the dependent variable in the model. Pecan purchasers averaged approximately three purchases during the survey period. We label respondents who did not purchase pecans during the previous six months as non-purchasers, recognizing that these non-purchasers do provide information on previous purchasing patterns for some key variables in the model.

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 and is expected to have a positive influence on the probability of pecan purchases. Pecans and other nuts are often received as gifts. The type of nuts received as gifts during the last year was recorded for ten different nuts. Consumer who receive nuts as gifts may increase their demand for pecans if they develop a taste for pecans. If gift pecans substitute for purchased pecans the receipt of gifts would reduce the demand for pecans.

Nuts are consumed in a variety of foods, including snacks, salads, and cookies; as seasonings in baking and flavored mixes; 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 and is expected to increase purchases of pecans. On average, respondents used nuts at least once a week in seven different food categories. Over 90% of both purchasers and non-purchasers of pecans used nuts or nut products in five or more food items.

Williams, LaPlante, and Williams documented that consumers often lack objective bases for evaluating quality of pecans and are unaware of pecan grading standards. Consum-

**Table 1.** Variable Description and Summary Statistics

| Variable | Description | Mean | |
|---|---|---|---|
| | | Entire Sample | Pecan Purchasers |
| PURCHASE | Number of pecan purchases in previous six months | 1.196 (1.931)[a] | 2.680 (2.093) |
| GRINCOME | Gross household income[b] | | |
| | Less than $10,000 | 1.8 | 1.0 |
| | $10,000–$19,999 | 7.6 | 5.0 |
| | $20,000–$29,999 | 10.3 | 8.0 |
| | $30,000–$39,999 | 16.5 | 17.0 |
| | $40,000–$49,999 | 14.3 | 14.0 |
| | $50,000–$59,999 | 11.6 | 10.0 |
| | $60,000 or more | 37.9 | 45.0 |
| AMTSPT | Amount spent (in dollars) on nuts & nut products in previous month | 8.041 (10.419) | 11.135 (13.262) |
| AMTSPT-SQ | Amount spent squared | 172.710 (724.610) | 298.110 (1060.100) |
| NUTGFTS | Number of different kinds of nuts received as gifts | 1.094 (1.410) | 1.230 (1.607) |
| VARUSE | Variety of uses for nuts & nut products | 7.371 (2.003) | 7.870 (1.829) |
| BADEXP | Number of unpleasant experiences with purchased nuts | 0.424 (0.760) | 0.460 (0.834) |
| MKTOUTLT | Number of outlets where pecans are purchased | 1.406 (0.757) | 1.800 (0.779) |
| GROCST | = 1 for grocery store purchases; = 0 otherwise | 0.607 (0.489) | 0.800 (0.402) |
| POSQUAL | Positive qualities associated with pecans | 3.103 (2.381) | 3.260 (2.325) |
| RACE | = 1 for Caucasian; = 0 otherwise | 0.951 (0.217) | 0.970 (0.171) |
| N | Sample size | 224 | 100 |

[a] Numbers in parentheses are standard deviations.
[b] Percentage of respondents in each category.

ers are aware of personal incidents of quality defects in pecans and these events may decrease the probability and the amount of pecan purchases.

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, uncertain of quality, 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, Worley, and Dove 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 con-

fections, bakery goods, cereals, or snacks. The types of nuts with which respondents had an unpleasant experience—including problems with shells, rancidity, small size, color, flavor, and insects—were recorded. The total number of unpleasant experiences in these categories is included in the model as an explanatory variable.

Summary statistics on the prevalence of each of the seven identified problems indicate that most of the quality concerns were cited by less than 10% of purchasers. Problems with shells and small sizes of nuts were noted by about 3% of respondents while flavor concerns were reported by 5%. Slightly over 20% reported dissatisfaction with rancidity, the most frequently cited problem.

Consumers most frequently purchased 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 have purchased pecans suggests that consumers are willing to spend additional time and effort to identify a source with the product which meets their expectations. Consumers who have familiarity with a diverse range of marketing outlets for pecans are expected to purchase more pecans.

The survey identified a set of factors, including convenience, health, taste, preferences of guests, and tradition, which are expected to have a positive impact on purchases of nuts. Both pecan purchasers and non-purchasers identified on average three positive reasons influencing their pecan purchases. Over 60% of both groups identified serving convenience, health, and taste as factors influencing the decision to purchase pecans. Demographic variables such as household income and race are also included as explanatory variables.

The variables which are hypothesized to influence the fixed costs of purchasing pecans include nuts received as gifts, the variety of uses for nuts, unpleasant consumption experiences, marketing outlets, grocery stores, and positive factors in purchasing decisions. If fixed costs play a significant role in the purchasing decision, the implied restrictions of the Tobit model will be rejected.

## Model Estimation and Results

### Empirical Results from the Tobit Model

The first column of Table 2 shows the results from the Tobit model. 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 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. Nut 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 shows 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 previously 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 have a greater diversity of purchasing sources than non-purchasers. Only 19% of non-purchasers had experiences

**Table 2.** Estimates for Pecan Purchases and Frequency of Purchase Based on Tobit and Generalized Heckman Models

| Explanatory Variable | Tobit Model | Generalized Heckman Model | |
|---|---|---|---|
| | | Probability of Purchase | Selection Model of Purchases |
| CONSTANT | −10.826* | −4.534* | −9.612 |
| | (−6.219) | (−5.842) | (−1.439) |
| GRINCOME | 0.322* | 0.142* | 0.300 |
| | (2.362)[a] | (2.258) | (1.374) |
| AMTSPT | 0.157* | 0.063* | 0.138* |
| | (3.976) | (2.887) | (1.787) |
| AMTSPT-SQ | −0.001* | −0.0005 | −0.001* |
| | (−2.797) | (−1.117) | (−1.692) |
| NUTGFTS | −0.024 | 0.013 | −0.072 |
| | (−0.155) | (0.179) | (−0.401) |
| VARUSE | 0.337* | 0.099* | 0.351* |
| | (2.679) | (1.734) | (1.923) |
| BADEXP | 0.268 | −0.098 | 0.515 |
| | (0.961) | (−0.704) | (1.571) |
| MKTOUTLT | 1.394* | 0.848* | 1.000 |
| | (4.413) | (4.751) | (1.226) |
| GROCST | 2.245* | 0.689* | 2.513* |
| | (4.256) | (3.070) | (2.255) |
| POSQUAL | 0.073 | 0.001 | 0.140 |
| | (0.879) | (0.035) | (1.362) |
| RACE | 1.498 | 0.923* | 0.697 |
| | (1.356) | (1.916) | (0.357) |
| LAMBDA | | | 2.588 |
| | | | (1.261) |
| N | | 224 | 100 |

[a] Numbers in parentheses are asymptotic t-values.
* Denotes the estimated coefficient is statistically different from zero at the 0.05 significance level.

with more than two marketing outlets compared with 62% of those purchasing pecans during the survey period. Both purchasers and non-purchasers rely on grocery stores and mail-order outlets. Specialty stores and fundraisers are important outlets for purchasers but are underutilized in attracting non-purchasers.

*Empirical Results for the Generalized Model*

The generalized purchase model for pecans is estimated following Heckman's two-step limited information maximum likelihood 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. Important differences in the implications of the models are discussed 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. This result in-

dicates that low quality is not a primary impediment in consumer purchases of pecans and reinforces industry emphasis on the positive nutritional and quality characteristics of nuts in marketing.

The survey results showed that pecan purchasers experience more problems on average with nut quality than those who did not purchase pecans. However, multiple experiences with poor quality deter repeat purchases, suggesting that producers must maintain high quality standards. Only 4% 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 taste 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 have significant effects on pecan purchases in the Tobit model, but do not appear to exert any important influence on purchases in the selection 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, suggesting that marketing efforts to increase pecan purchases can focus on consumers with relatively lower levels of current expenditures on nut products.

The Tobit estimates indicate 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 uses for edible nuts reported by consumers 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 demonstrate 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 developed 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% level for the F-distribution with 11 and 88 degrees of freedom. The restrictions imposed by the Tobit model are rejected.

The Tobit and Heckman models are also evaluated by comparing the predictive ability of the two models. The two models are used to predict the probability that an individual purchases pecans. A correct prediction is defined under two conditions. The predicted probability exceeds 0.50 and the individual purchased pecans or the predicted probability is less than one-half and the individual did not purchase pecans. The Heckman model correctly predicted purchases 76.3% of the time while the Tobit model generated correct predictions 74.6% of the time.

The accuracy of the models in predicting purchases was evaluated by computing the mean squared error as actual purchases minus predicted purchases. The predictions from the Heckman model generated more accurate predictions with a mean squared error of 3.26. In comparison, the mean squared error for the Tobit model is 4.40.

The set of statistical tests confirms the validity of the generalized purchase model. Thus, we suggest that for effective marketing of pecans, the industry should target its marketing efforts to identify key factors that influence the decision to purchase pecans separately from efforts to influence the number of purchasers.

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. We include variables which are important to the pecan industry in assessing consumer concerns about quality attributes. 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 show that the marginal effects from the Tobit model can be decomposed into two elements: changes in the effects conditional on positive observations of the dependent variable and effects on the probability of being above zero. The Tobit model implies that 36% of the adjustment in pecan purchases in response to changes in the independent variables is due to marginal changes in positive purchases. This effect measures adjustments in demand by those who currently purchase pecans. The remaining 64% 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. The impact of any explanatory variable on expected pecan purchases is:

$$(3) \quad \frac{\partial E(N)}{\partial X_i} = Pr(N^* > 0)\left[\frac{\partial E(N^* | N^* > 0)}{\partial X_i}\right]$$
$$+ E[N^* | N^* > 0]\left[\frac{\partial Pr(N^* > 0)}{\partial X_i}\right].$$

These elements are computed for both the Tobit and Heckman models using the estimated parameters for each model (Table 3). The marginal effect for the grocery store variable is evaluated by comparing the change evaluated at the two values of the binary variable. The first component on the right-hand side of equation (3) measures the change in expected pecan purchases for consumers who currently purchase pecans and is defined as conditional effect of purchases in Table 3. The second component on the right-hand side of equation (3) measures the change in the probability of pecan purchases and is defined as unconditional effect in Table 3.

As shown in Table 3, the total effects from the Tobit and Heckman models 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, total marketing outlets, and grocery stores on pecan purchases. A variable, TOTSPT, is added in Table 3 to account

**Table 3.** Decomposition of Effects on Expected Pecan Purchases

| Variable | Conditional Effect | | Unconditional Effect | | Total Effect | |
|---|---|---|---|---|---|---|
| | Tobit | Heckman | Tobit | Heckman | Tobit | Heckman |
| GRINCOME[a] | 0.067 | 0.288 | 0.074 | 0.025 | 0.141 | 0.313 |
| NUTGFTS | −0.005 | −0.037 | −0.006 | 0.002 | −0.011 | −0.035 |
| VARUSE | 0.071 | 0.131 | 0.078 | 0.179 | 0.149 | 0.310 |
| BADEXP | 0.056 | 0.267 | 0.062 | −0.017 | 0.118 | 0.250 |
| MKTOUTLT | 0.292 | 1.209 | 0.323 | 0.149 | 0.615 | 1.358 |
| GROCST | 0.294 | 0.519 | 0.193 | 0.347 | 0.487 | 0.866 |
| POSQUAL | 0.018 | 0.108 | 0.020 | 0.00009 | 0.038 | 0.108 |
| TOTSPT (AMTSPT & AMTSPT-SQ) | 0.025 | 0.102 | 0.030 | 0.008 | 0.055 | 0.110 |

[a] Variable definitions from Table 1: GRINCOME = gross household income, AMTSPT = amount spent (in dollars) on nuts & nut products, AMTSPT-SQ = amount spent squared, NUTGFTS = kinds of nuts received as gifts, VARUSE = uses for nuts, BADEXP = unpleasant experiences with purchased nuts, MKTOUTLT = outlets where pecans are purchased, GROCST = dummy variable for grocery store purchases, POSQUAL = positive qualities associated with pecans, RACE = dummy variable for Caucasians.

for the impact of total spending on nuts and nut products (the linear and quadratic terms). The result suggests that the Tobit model overlooks the impact of total spending on pecan purchases. In addition, the role of variety of uses for nuts in stimulating pecan purchases would be overlooked in a marketing campaign based on the Tobit model.

Both the Tobit and the Heckman models suggest that expanded marketing outlets and grocery stores have the biggest influences on pecan purchases. These results strengthen the importance of grocery-store-based promotions as a vehicle to increase both the number purchases and the probability that consumers will purchase pecans. These promotions should be extended to other marketing outlets. Furthermore, the number of nuts received as gifts and unpleasant experiences with pecan quality has different effects on the probability of purchase versus the number of purchases.

## Conclusions

The generalized Heckman model for purchase decisions of pecans offers an alternative to the single-equation approach based on the Tobit model. The model incorporates the role of perceived consumer quality attributes, ease of purchase, familiarity with marketing outlets, and positive consumer product images that influence the fixed costs of pecan purchases.

These factors may have different impacts on the probability of purchase and the number of purchases. The Tobit model lacks this flexibility.

Fixed search costs associated with locating and purchasing a specialty item are not consistent with the Tobit model. Application of the Tobit model and the failure to apply self-selectivity corrections based on the Heckman model produces misleading assessments of the key variables which influence pecan purchases.

While the Tobit and the generalized purchase models for pecan purchases are influenced by the same set of significant variables, there are important differences in the implications of the results. Gross household income and total marketing outlets used by pecan purchasers influence the probability of pecan purchases but are not significant in the selection model for number of purchases. Marketing programs that target consumers based on these variables will attract new purchasers of pecans but may not expand demand from current purchasers.

Marketing efforts that encourage consumers to increase expenditures on nut products as a group increase both the probability of purchases and the number of pecan purchases. Consumers who use nuts in a greater variety of foods tend to purchase pecans more fre-

quently. Information on how to use nuts in alternative recipes and foods apparently has a spillover effect on expanding demand for pecans along with other nuts. Both models highlight the importance of marketing outlets in providing consumers with a convenient source for purchasing pecans. The total number of marketing outlets previously used by consumers has a significant influence on the frequency of pecan purchases, with grocery stores serving as the primary outlet influencing pecan purchases.

The pecan industry has expressed concern about the influence of perceived quality attributes on consumer purchasing and the model provides information on the role of these factors. The study suggests that unpleasant experiences were not significant factors affecting purchase decisions and do not constrain purchases. Industry programs to emphasize the positive nutritional and quality characteristics of pecans show no significant impact on inducing purchases by new consumers or in expanding purchases from current consumers.

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