Determinants of Participation and Consumption: The Case of Crawfish in South Louisiana

S. T. Yen, L. E. Dellenbarger and A. R. Schupp*

Abstract

This study investigates the determinants of crawfish consumption in South Louisiana using a generalized limited dependent variable model that accounts for both participation and consumption decisions. Income, Catholic, white, and household size increase the likelihood of crawfish consumption but not the conditional level of consumption. Education and employment status are among the other household characteristics that determine the conditional level of consumption.

Key Words: Box-Cox transformation, crawfish consumption, double-hurdle model, South Louisiana

Relatively little empirical evidence on seafood consumption is available in the United States. The early studies tend to be descriptive in nature (Miller and Nash, 1971; Nash, 1971). The more comprehensive studies of U.S. seafood consumption include Capps (March 1982, May 1982), Cheng and Capps (1988), Keithley (1985), Perry (1981), Purcell and Raunikar (1968), and Lin and Milon (1993). Seafood, in its broadest definition, includes aquacultural products as well as harvests from salt, brackish and fresh water sources. Nationally, estimated per capita seafood consumption rose by three pounds from 1970 to 1992, reaching 14.7 pounds in 1992 (U.S. Department of Agriculture, 1993). Nearly two thirds of this consumption was fresh or frozen product.

Louisiana represents one of the major U.S. seafood landing states, following only Alaska. Louisiana also leads the nation in total acreage and production of aquacultural species (LCES, 1994). Exclusive of the wild catch, Louisiana crawfish farmers produced 60 million pounds of crawfish in 1992 (LCES, 1994). Given their access to fresh seafood from the Gulf of Mexico, fresh products from nearly half a million acres of aquacultural production, fresh and brackish water species through sport fishing activities and processed seafood from multiple outlets, Louisiana households have available a large number of sources of seafood on an almost year-round basis.

Seafood consumption patterns likely differ in coastal areas from noncoastal areas, particularly if the coastal area is also a major aquacultural production area. Coastal areas, which are representative of much of the highly populated part of the United States, are expected to consume more seafood than other areas and to have households

*Steven T. Yen is visiting assistant professor in the Center for Agricultural and Rural Development, Iowa State University, and Lynn E. Dellenbarger and Alvin R. Schupp are, respectively, associate professor and professor in the Department of Agricultural Economics and Agribusiness, Louisiana State University Agricultural center. The authors thank Leo Guedry, Steven Henning, Roger Hinson, Helen Jensen, Stanley Johnson, Andrew Jones, Hector Zapata, and two anonymous reviewers for helpful comments and suggestions. Approved for publication by the Director of Louisiana Agricultural Experiment Station as manuscript No. 94-05-8180.

with higher levels of knowledge of seafood products. Of interest, therefore, is the seafood consumption practices of coastal Louisiana residents. To date, however, there has been no empirical study of seafood consumption in this area.

This paper examines the consumption of an aquacultural species, crawfish, that is unique to the Southern part of the United States. Specifically, the paper investigates crawfish consumption among South Louisiana residents, using data from a recent household seafood consumption survey. The use of household-level data allows for the investigation of the effects of detailed household characteristics on crawfish consumption that are not available in aggregate time series. However, data from randomly selected households are characterized by one interesting feature: the significant proportion of households reporting zero consumption in the sample. In this study, these zero observations are modeled explicitly, using a limited dependent variable model.

Methods

As noted in the previous section, one complicating feature of household survey data is the significant proportion of zero observations. That is, the dependent variable has a limited (nonnegative) range of realized values. It is well known that in this case standard econometric procedures, such as ordinary least squares, produce biased and inconsistent parameter estimates (Maddala, 1983). Early studies of household demand with limited dependent variables often used the Tobit model (Tobin, 1958). Despite its wide acceptance by empirical analysts, however, the Tobit model is inordinately restrictive in terms of its parameterization and distributional assumptions. First, in the Tobit model, the variables and parameters that determine the probability of consumption also determine the level of consumption (Cragg, 1971; Lin and Schmidt, 1984; Lee and Maddala, 1985). Thus, all zero observations are treated as true non-consumption or corner solutions. This may not be true for crawfish, in which case zero observations may be due to, besides non-consumption, infrequency of consumption (i.e., consumption occurs during nonobservation periods) or "conscientious abstention" (Pudney, 1988, p. 131), which could have other behavioral explanations. In addition, in much of the empirical literature, the Tobit model has been estimated with a truncated normal distribution for the errors. However, for the Tobit model, the parameter estimates are inconsistent when the normality assumption is violated (Arabmazar and Schmidt, 1982).

Recent demand analysts have used models that generalize the Tobit parameterization. Haines, Guilkey, and Popkin (1988) used the double-hurdle model proposed by Cragg (1971) and modeled the food consumption decision as a two-step process. Other applications of the double-hurdle model include Atkinson, Gomulka, and Stern (1984), Popkins, Guilkey, and Haines (1989), and Reynolds (1990). In a related literature, Lin and Milon (1993) used a count-data double-hurdle model to examine the impacts of attribute and food safety perceptions on seafood consumption. Gould (1992) used the purchase-infrequency model, an extension of Cragg's double-hurdle model in which a probit purchase equation was estimated simultaneously with a consumption equation (Blundell and Meghir, 1987).[1] More recently, Yen (1993) relaxed the normality assumption of Cragg's double-hurdle model (Cragg, 1971) using a Box-Cox transformation on the dependent variable in a study of U.S. household consumption of food away from home. In this extensive empirical literature, the Tobit parameterization has consistently been rejected. In addition, Yen (1993) also rejected the normality of errors. These results suggest the use of models with more flexible parameterization and distributional assumptions in empirical demand analysis.

In the present study, we use the Box-Cox double-hurdle model proposed in Yen (1993). Cragg's double-hurdle specification provides a convenient bench mark model:

$$\begin{aligned} y_i &= \boldsymbol{x}_i\beta + u_i \quad \text{if } \boldsymbol{x}_i\alpha + v_i > 0 \\ &= 0 \quad \text{otherwise,} \end{aligned} \tag{1}$$

where y_i is observed level of consumption, $\boldsymbol{x}_i$ is a vector of exogenous variables, α and β are conformable parameter vectors determining participation and level separately, and random errors v_i is distributed as $N(0,1)$ and u_i as $N(0,\sigma^2)$ truncated at $-\boldsymbol{x}_i\beta$. The double-hurdle model includes two equations: the consumption equation $x_t\beta+u_t$ and the participation equation $x_t\alpha+v_t$. Thus, the probability of consumption and level of consumption are determined by separate sets of parameters. Note that the use of the same set of variables (i.e., x_t) in both equations is not as restrictive as it seems because these variables affect consumption and participation differently through the different parameter vectors (α and β).[2]

To allow for more flexible distributional assumptions than Cragg's double-hurdle model, consider the Box-Cox transformation on the dependent variable y_t

$$y_t^T = (y_t^\lambda - 1)/\lambda \quad \text{if } \lambda \neq 0 \qquad = \log(y_t) \quad \text{otherwise,} \tag{2}$$

where λ is the unknown parameter. Incorporating the Box-Cox transformation in (1), the double-hurdle model can be specified as

$$y_t^T = x_t\beta + u_t \quad \text{if } x_t\alpha + v_t > 0 \qquad = 0 \quad \text{otherwise,} \tag{3}$$

where v_t is distributed as $N(0,1)$ and u_t as $N(0,\sigma^2)$, and v_t and u_t are independent. The Box-Cox transformation on y_t in (3) requires that the error term u_t be truncated as follows:

$$\begin{cases} -\infty < u_t < -1/\lambda - x_t\beta & \text{if } \lambda < 0 \\ -\infty < u_t < \infty & \text{if } \lambda = 0. \\ -1/\lambda - x_t\beta < u_t < \infty & \text{if } \lambda > 0 \end{cases} \tag{4}$$

Therefore, the conditional density of y_t^T is (Johnson and Kotz, 1970, p. 81)

$$g(y_t^T|x_t) = \frac{1}{\sigma}\phi\left(\frac{y_t^T - x_t\beta}{\sigma}\right)\left[\Phi\left(\frac{1/\lambda + x_t\beta}{\kappa\sigma}\right)\right]^{-1}, \tag{5}$$

where $\phi(\,)$ and $\Phi(\,)$ are the density and distribution functions of the standard normal, respectively, and κ is a dichotomous indicator such that $\kappa = 1$ if $\lambda > 0$ and $\kappa = -1$ if $\lambda < 0$. By transformation of variables from y_t^T to y_t, the conditional density of y_t is

$$f(y_t|x_t) = y_t^{\lambda-1}\frac{1}{\sigma}\phi\left(\frac{y_t^T - x_t\beta}{\sigma}\right)\left[\Phi\left(\frac{1/\lambda + x_t\beta}{\kappa\sigma}\right)\right]^{-1}, \quad y_t > 0. \tag{6}$$

Note that, because of the bounds on u_t suggested in (4), the distribution of y_t^T cannot strictly be normal unless the Box-Cox parameter equals zero (Amemiya and Powell, 1981; Poirier, 1978). However, Draper and Cox (1969) have shown that the Box-Cox parameter λ is fairly robust against nonnormality as long as y_t^T is reasonably symmetric.

The probability, conditional mean, and unconditional mean of consumption are, respectively,

$$P(y_t > 0 \,|\, x_t) = \Phi(x_t\alpha), \tag{7}$$

$$E(y_t|y_t>0) = \frac{1}{\sigma}\left[\Phi\left(\frac{1/\lambda + x_t\beta}{\kappa\sigma}\right)\right]^{-1}\int_0^\infty y_t^\lambda\,\phi\left(\frac{y_t^T - x_t\beta}{\sigma}\right)dy_t, \tag{8}$$

$$E(y_t) = \Phi(x_t\alpha)E(y_t|y_t>0). \tag{9}$$

Based on (3), (6) and (7), the likelihood function for the Box-Cox double-hurdle model can be written as

$$L = \prod_0 [1 - \Phi(x_t\alpha)] \prod_+ \left\{\Phi(x_t\alpha)y_t^{\lambda-1} \times \frac{1}{\sigma}\phi\left(\frac{y_t^T - x_t\beta}{\sigma}\right)\left[\Phi\left(\frac{1/\lambda + x_t\beta}{\kappa\sigma}\right)\right]^{-1}\right\}, \tag{10}$$

where the "0" and "+" under the product signs indicate multiplications over zero and positive observations, respectively.[3] Estimation of the Box-Cox double-hurdle model can be done by the maximum-likelihood (ML) method.

The likelihood function (10) nests the truncated normal ($\lambda = 1$) and lognormal ($\lambda = 0$) specifications of the double-hurdle model (Cragg, 1971). It obviously also includes the standard Tobit (Tobin, 1958) and log-normal Tobit (Amemiya and Boskin, 1974) models as special cases. Therefore, tests of the Box-Cox double-hurdle model against these nested models can be done by regular means.

Data and Procedures

This study was part of a project partially funded by the U.S. Environmental Protection Agency to study seafood consumption patterns in Houma, Louisiana during the first quarter of 1993. The project aimed at estimating the household's source of product, how and where it was obtained (purchase, fish, or gift), and how much was consumed. The current study concerns only the latter.

A total of 1,100 households, stratified by racial characteristics, were surveyed (approximately 10 percent of the households in the city). Miller Research Group of Little Rock, Arkansas was subcontracted to collect information on the quantities consumed of various seafood species as well as information on household income and other socioeconomic characteristics; no price or expenditure data were collected.

This portion of the study focuses entirely on crawfish consumption. Crawfish is a seasonal product and the sample period is within the harvest period for both wild and farm-raised crawfish. The responding households reported the quantities of crawfish consumed (in pounds) over the most recent five-day period prior to the survey.

Quantity of crawfish consumed during the five-day period is used as the dependent variable. It is worth mentioning that, crawfish is typically purchased/obtained in the form of tail meat (peeled), boiled, or live, the latter being heavily associated with crawfish boils–a social event in the study area. On average, the yield from live or boiled crawfish is approximately 20 per cent. Thus, much of this crawfish is not consumed. Only 7 percent of the crawfish were reported to have been obtained in the form of tail meat, typical of consumption pattern during the harvest period. All reported quantities were converted to live-product equivalent.

The neoclassical demand theory suggests income, prices and socio-demographic variables as the determinants of demand. However, the current survey covered a single area during a relatively short time period. Therefore, prices are not expected to vary. Drawing on earlier studies of seafood demand (e.g., Capps, May 1982; Cheng and Capps, 1988), the independent variables include income, household size, and dummy variables indicating professional types (professional, skilled labor), employment status (unemployed, retired), education (high school, some college, college, graduate school), religion (Catholic) and race (white). Households with missing information for important variables are dropped. This results in a final sample of 915 households, among which only 200 households (or 21.9%) report consumption of crawfish during the period. The high proportion of zero observations is very typical of surveys with a short sampling period and may also reflect infrequency of purchase.[4] Pereira (1990) reported, based on a nationwide household survey in 1988, that 55 percent of households in the West South Central and East South Central Census regions did not consume crawfish. This high proportion of zeros suggests that any estimation procedure not accounting for this data feature is unlikely to produce reliable results. The average five-day household consumption of crawfish is 4.0 pounds for the full sample and 18.3 pounds for the consuming households (or about 7.5 pounds per person). With the exception of sex, sample socioeconomic characteristics are comparable to census data.[5] The sample statistics for the full sample and the consuming households are presented in table 1.

Parameter Estimates and Elasticities

Estimation of the Box-Cox double-hurdle model was accomplished by maximizing the logarithm of the likelihood function (10). The parameter estimates are presented in table 2. To assess the goodness-of-fit of the participation equation, a pseudo R^2 was computed (0.37), which suggests that the participation equation is a moderate fit.[6] The Box-Cox parameter (λ) is significantly different from both zero and one.

Table 1. Sample Statistics: Household Crawfish Consumption, Houma, Louisiana, 1993.

Variable	Full sample Mean	Full sample St. dev.	Consuming households Mean	Consuming households St. dev.
Quantity consumed (lbs.)	4.006	12.294	18.328	20.747
Annual household income ($000)	31.369	22.261	35.850	21.202
Household size	2.731	1.344	2.930	1.395
Dummy variables (household head)[a]				
Professional	0.245		0.255	
Skilled labor	0.174		0.250	
Unemployed	0.036		0.040	
Retired	0.139		0.090	
High school	0.391		0.395	
Some college	0.232		0.220	
College	0.207		0.240	
Graduate work	0.066		0.080	
Catholic	0.578		0.695	
White	0.817		0.900	
Sample size	915		200	

Source: Compiled from the 1993 South Louisiana Seafood Consumption Survey.
[a] For all dummy variables, yes = 1; 0 otherwise.

Table 2. ML Estimates of the Box-Cox Double-Hurdle Model

Variable	Participation Parameter	Participation St. err.	Consumption Parameter	Consumption St. err.
Constant	−1.778[a]	0.229	−67.463[a]	29.820
Income	0.005[a]	0.002	−0.125	0.233
Household size	0.066[a]	0.036	0.508	3.056
Professional	0.009	0.129	9.336	12.586
Skilled labor	0.345[a]	0.128	28.200[a]	15.577
Unemployed	0.184	0.249	28.639[a]	13.406
Retired	−0.104	0.163	−43.069[a]	10.307
High school	0.202	0.182	−0.369	6.761
Some college	0.122	0.196	22.950[a]	13.137
College	0.180	0.207	13.131	15.200
Graduate work	0.267	0.251	29.063	20.035
Catholic	0.282[a]	0.103	9.379	8.423
White	0.306[a]	0.144	2.111	9.258
λ	0.795[a]	0.049		
σ	26.368[a]	6.218		
Log-likelihood	−1227.498			

[a] Significant at the 0.10 level

Thus, both the truncated normal (λ = 1) and lognormal (λ = 0) specifications (not estimated) are rejected, which justifies the Box-Cox transformation. According to the estimated participation equation, households that are more likely to consume crawfish than others are characterized by the following attributes: higher income, larger household, skilled labor, Catholic, and white.

Interpretation of parameter estimates for the consumption equation are complicated by the Box-Cox transformation. However, with the homoscedastic error specification considered in this study, the effects of explanatory variables on the conditional mean have the same signs as and are proportional to the associated parameter estimates (Poirier and Melino, 1978). Thus, judging from parameter estimates of the consumption equation, given that a decision is made to consume crawfish, households with skilled laborers or unemployed heads consume more crawfish than others, as do households with college educated heads. Retirement status reduces crawfish consumption. Employment status was important in explaining fishing habits and whether crawfish boils would be held. The positive role of "unemployment" and negative role of "retirement" on crawfish consumption were expected as they relate to fishing habits. Crawfish can be caught live in many areas of the state and does not need to be purchased. The unemployed "fish" for crawfish when in season as they are a "free" good, and therefore are more likely to report consumption of crawfish. Retirees, on the other hand, don't have the need or desire to fish and probably consume less because of a mistaken belief that crawfish are fatty. Income and household size increase the likelihood of crawfish consumption but not the level of consumption. The positive effects of income, household size, and skilled labor on the probability of consumption are consistent with findings reported by Pereira (1990) and Schupp and Dellenbarger (1993).

In limited dependent variable models, it is often useful to examine separately the effects of explanatory variables on the probability, conditional level, and unconditional level of consumption (McDonald and Moffitt, 1980). The effects on probability explain the binary decision on consumption, *viz.*, to consume or not to consume. The effects on conditional level explains what make those consuming consume either more or less. The effects on unconditional level provide an overall assessment of what contributes to consumption level by increasing (or decreasing) either the probability or conditional level. Such decomposition of effects is particularly insightful for the model considered in this study, because participation and consumption are parameterized separately and because the Box-Cox transformation further complicates the effects of explanatory variables. The elasticities of probability can be derived by differentiating (7), and the elasticities of the conditional level by differentiating (8); see Poirier and Melino (1978) and Yen (1993) for the derivatives. Then, the elasticities of the unconditional level of consumption follow from the adding-up property (9). All elasticities with respect to exogenous variables were evaluated using the parameter estimates and the sample means of explanatory variables. In addition, the standard errors for these elasticities were computed using the *delta method* (Fuller, 1987, pp. 85-88). The results are presented in table 3. The elasticities of probability and conditional levels suggest the same effects as the parameter estimates. The elasticities of the unconditional level with respect to income and household size are not significant, perhaps because the (insignificant) effects on the conditional level dominate the effects on probability of consumption. Overall, judging from these elasticities of unconditional level, factors that increase the unconditional level of consumption are skilled labor, graduate education, Catholic and white. Retirement status has negative elasticities throughout.

Although the study area is limited to the coastal region of the state, a number of states bordering the Gulf of Mexico or other large bodies of water have similar access to seafood and, therefore, consumers in these states are likely to exhibit similar behavior in seafood consumption. For instance, our results suggest that crawfish is income inelastic and this is likely to be true in these other areas of the country.

Concluding Remarks

Zero observations are common features of survey data. The Box-Cox double-hurdle model used in this study allows the investigation of crawfish consumption, which is not possible using traditional regression models. The results attest to earlier findings that the truncated normal and lognormal specifications of the double-hurdle model are not suitable for empirical studies.

The highest probability of crawfish consumption in Houma, Louisiana, is found in households with skilled workers and Catholic heads. This particular group, who reside in a predominantly Catholic area and are likely employed in the petroleum or seafood processing industry, can be

Table 3. Elasticities With Respect to Exogenous Variables

Variable	Probability Elas.	Probability Std. err.	Conditional level Elas.	Conditional level Std. err.	Unconditional level Elas.	Unconditional level Std. err.
Income	0.203[a]	0.102	−0.069	0.122	0.146	0.144
Household size	0.251[a]	0.135	0.023	0.140	0.271	0.183
Professional	0.003	0.044	0.037	0.046	0.037	0.061
Skilled labor	0.083[a]	0.031	0.108[a]	0.042	0.155[a]	0.042
Unemployed	0.009	0.012	0.018[a]	0.007	0.024[a]	0.014
Retired	−0.020	0.031	−0.060[a]	0.028	−0.108[a]	0.052
High school	0.110	0.098	−0.002	0.041	0.107	0.106
Some college	0.039	0.063	0.078[a]	0.044	0.117	0.077
College	0.052	0.059	0.048	0.055	0.091	0.075
Graduate	0.024	0.023	0.036	0.022	0.052[a]	0.029
Catholic	0.226[a]	0.083	0.100	0.080	0.305[a]	0.105
White	0.346[a]	0.164	0.029	0.127	0.371[a]	0.198

[a] Significant at the 0.10 level

targeted with educational and promotional programs stressing additional crawfish purchase and consumption.

One of the maintained assumptions of the model used is independence of the participation and consumption decisions. In some applications, interactions between the two decisions may exist. Thus, further research might consider such interactions. Though the size of the total sample was statistically determined, missing data limited the current study to 915 usable observations and 200 households reporting consumption of crawfish during the sample period. The lack of significance of income and household size effects on consumption level may be due to the relatively small number of consuming households. Further studies should consider more comprehensive surveys, which would cover more areas and a larger sample, in which case regional price variations might allow the estimation of price effects.

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Endnotes

1. The use of the purchase infrequency models represents progress over the more traditional models (e.g., Tobit) in dealing with zero observations resulting from infrequency of purchases. Unfortunately, Blundell and Meghir's (1987) model is plagued by the restrictive purchase probability (independent of the level of true consumption) and an inadequate accounting for the relationship between purchase and consumption (Pudney 1989, pp. 179-80).

2. Empirical analysts have struggled with the choice of explanatory variables in the consumption and participation equations because theory provides no guidance for such specification issues.

3. We also attempted the heteroscedastic specification, using income and household size to explain variation of the standard deviation (σ) across observations. We found no evidence of such heteroscedasticity.

4. Yen (1993, p. 887) suggested that the Box-Cox double-hurdle model also accounts for zeros from infrequency of purchase.

5. Contact authors for details.

6. The pseudo R^2, adapted from the expression developed by McKelvey and Zavoina (1975) for their ordinal probit model, is calculated as $R^2=\Sigma_i[\boldsymbol{x}_i\hat{\alpha}+\lambda(\boldsymbol{x}_i\hat{\alpha})]^2/\Sigma_i\{[\boldsymbol{x}_i\hat{\alpha}+\lambda(\boldsymbol{x}_i\hat{\alpha})]^2+1\}$, where $\hat{\alpha}$ is the ML estimator of α, $\lambda(\boldsymbol{x}_i\hat{\alpha})$ is the inverse Miller's ratio, defined as $\lambda(\boldsymbol{x}_i\hat{\alpha})=\phi(\boldsymbol{x}_i\hat{\alpha})/\Phi(\boldsymbol{x}_i\hat{\alpha})$ for the nonlimit observations and $\lambda(\boldsymbol{x}_i\hat{\alpha})=-\phi(\boldsymbol{x}_i\hat{\alpha})/\Phi(-\boldsymbol{x}_i\hat{\alpha})$ for the limit (zero) observations.