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Grouped Data Probability Model for Shrimp Consumption in the Southern United States

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Abstract

Shrimp represents 27% of total U.S. seafood consumption. A shrimp farming industry has been developing in the southern United States in response to shrimp market demand. To provide farmers with market information needed to develop successful marketing strategies, this analysis examines sociodemographic determinants of at-home and away-from-home shrimp consumption behavior. A survey was mailed to 5,000 households in nine southeastern U.S. states. A probability model was developed to estimate the influence of consumer characteristics on the frequency of shrimp consumption. Using the estimated coefficients, the probability distribution for shrimp consumption frequency can be calculated for any combination of explanatory variables.

Keywords: consumer behavior, consumption, grouped data regression, shrimp

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Introduction

Per capita consumption of shrimp—the leading seafood consumed in the United States—increased by more than 185% between 1980 and 2014, from 1.4 pounds to 4.0 pounds per person. Shrimp consumption in 2014 represented 27% of total U.S. seafood consumption. Because demand for shrimp far exceeds the amount supplied by U.S. commercial fishermen and aquaculture producers, about 90% of the total supply is imported into the United States, primarily from Southeast Asia (National Marine Fisheries Service, 2015). A U.S. shrimp farming industry has been developing in the southern states in response to domestic market demand.

Several studies have examined determinants of shrimp consumption in the United States. Coastal residents are significantly more likely to consume seafood than inland residents; experience with fresh seafood and purchase frequency of seafood decline with increasing distance from the sea (Nauman et al., 1995; Dore, 2000). The southeast region, together with the inland border states, consumes approximately 37% of shrimp consumed in U.S. homes (Prochaska and Andrew, 1974).

Dore (2000) reported that the most frequent consumers of shrimp or seafood in general tend to be well-educated, affluent adults between 35 and 55 years of age. Hispanics are more likely to eat shellfish at home than non-Hispanics, and African Americans are more likely to eat shellfish at home than Caucasians (Nayga and Capps, 1995). White households are only about half as likely as non-white households to be frequent at-home consumers of seafood (Nauman et al., 1995), so the growth of immigrant populations and the increasing popularity of ethnic cuisines is probably a positive indicator for shrimp consumption in the United States (Dore, 2000).

Zhang et al. (2004) used a double hurdle model to examine factors influencing at-home consumption of shrimp, oysters, and catfish and found that Caucasian consumers were less likely to frequently consume shrimp than non-Caucasian consumers. Religion was also significant, with Catholic consumers more likely to consume shrimp at home. Groups with higher levels of education were also more likely to consume shrimp at home.

To provide shrimp farmers with the current market information necessary for developing successful production and marketing strategies, this analysis examined sociodemographic determinants of at-home and away-from-home shrimp consumption behavior in the United States. We developed a probability model to estimate the influence of consumer characteristics on the probability distribution for the frequency of shrimp consumption.

Methods and Model

A six-page survey instrument was developed and administered by mail to a randomly selected, stratified sample of 5,000 households in the southeastern United States. Addresses were selected from Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee. The number of addresses selected in each state was proportional to that state's share of the total southeastern U.S. adult population (age 18 and older) as reported in the 2000 U.S. Census (U.S. Department of Commerce, 2001).

The survey instrument consisted of 53 questions. Consumers were asked a range of questions relating to demographic characteristics, general shopping habits, and shrimp preferences and purchasing behavior. The shrimp purchasing behavior questions elicited information about both away-from-home shrimp consumption (i.e., restaurant consumption) and at-home shrimp consumption. Shrimp preference questions identified consumer preferences for various refrigeration states, product forms, and sizes of shrimp.

The frequencies of at-home and away-from-home shrimp consumption were each modeled as a function of consumer sociodemographic characteristics. The explanatory variables included sex, age, race, marital status, household size, education, income, religion, and diet as well as the type of area (urban, suburban, rural, resort) in which the consumer resides.

(1) Purchase Frequency (at-home consumption) = f (sex, age, race, marital status, household size, education, income, area of residence, religion, diet)

(2) Purchase Frequency (away-from-home) = f (sex, age, race, marital status, household size, education, income, area of residence, religion, diet)

As with most survey data, the variables measured in this study are categorical in nature, either nominal or ordinal. This leads to the use of a probability model designed for limited dependent variables, similar to the ordered probit model. This study used the grouped data regression model, a modification of the ordered probit model that differs from probit analysis in that the category thresholds for the observed variable *y* are known and need not be estimated. This model is appropriate because the thresholds limits for each response category were explicitly specified in the questionnaire.

The response categories and response frequencies for the dependent variables (at-home consumption and away-from-home consumption) are shown in Table 1. There were six ordered categories of response frequency, ranging from "never purchase" to "purchase once or more per week." Consumption behavior is often modeled as a double hurdle to explain the primary decision to consume and the secondary decision of consumption frequency. However, the number of respondents reporting no consumption of shrimp at home (1%) or away from home (2%) is so small that there appears to be no need to analyze the decision not to consume shrimp.

Table 1. Dependent Variables: Frequency of At-Home and Away-From Home Shrimp Consumption.

Response Categories	**Response Frequency**	
Frequency of Shrimp Purchase	**For At-Home Consumption**	**For Away-From-Home Consumption**
Never	1.0%	2.0%
Once per six months	15.6%	15.1%
Once per three months	26.8%	24.9%
Once per month	25.8%	28.2%
Twice per month	25.3%	21.1%
Once or more per week	5.6%	8.7%

Table 2 describes the explanatory variables, which were modeled as dummy variables (i.e., set to 1 if the patron reports the indicated characteristic, 0 otherwise). To avoid perfect collinearity, one category for each of the explanatory variables was dropped from the model. The base element for this analysis was a white female between the ages of 36 and 50, married with a household size of two. She had some college or a bachelor's degree, an annual household income of $20,001–$40,000, and lived in a suburban area. She was not Catholic, was not on a diet, and had no special health concerns.

Table 2. Explanatory Variables for Shrimp Purchase Frequency Model.

Variable	Definition
male	1 if male; 0 otherwise
younger	1 if age ≤ 35; 0 otherwise
older1	1 if age > 50 and ≤ 65; 0 otherwise
older2	1 if age > 65; 0 otherwise
nonwhite	1 if not white; 0 otherwise
single	1 if not married; 0 otherwise
hhone	1 if household size = 1; 0 otherwise
hhthree	1 if household size = 3; 0 otherwise
hhfour	1 if household size = 4; 0 otherwise
hhmore	1 if household size > 4; 0 otherwise
lowed	1 if high school education or lower; 0 otherwise
highed	1 if higher than bachelors degree; 0 otherwise
lowinc	1 if income ≤ $20,000; 0 otherwise
medinc	1 if income > $40,000 and ≤ $60,000; 0 otherwise
highinc1	1 if income > $60,000 and ≤ $80,000; 0 otherwise
highinc2	1 if income > $80,000 and ≤ $100,000; 0 otherwise
wealthy	1 if income > $100,000; 0 otherwise
rural	1 if area of residence is rural; 0 otherwise
urban	1 if area of residence is urban; 0 otherwise
resort	1 if area of residence is resort; 0 otherwise
catholic	1 if Catholic; 0 otherwise
diet	1 if on a special diet; 0 otherwise

Results and Discussion

Of the 5,000 surveys mailed, 778 were undeliverable and 532 were returned completed, for an overall response rate of 12.6%. Almost 55% of respondents were female; 85% were white, 8% were black, and 2.4% were Hispanic. Two-thirds of survey respondents were married, with almost half from two-person households. Respondents represented a wide distribution of age, income, and education.

The data were analyzed in LIMDEP, using the grouped data regression model and maximum likelihood estimation. The estimated coefficients are shown in Table 3. Although there is no general measure of fit for non-linear models, several values provide some insight. The log likelihood ratio, λ, compares the maximized model to a restricted (constant only) model. The ratio λ has a chi-squared distribution with the degrees of freedom equal to the number of

estimated coefficients (df=22). For the at-home consumption model, λ = 1212 with p=0.0000, and λ = 1512 with p=0.0000 for the away-from home consumption model. Thus, both models have significant explanatory power. Another commonly reported measure for nonlinear models is McFadden's pseudo-R^2 (MF), which offers some indication of model fit, with MF = 1 for a perfectly predictive model. For this analysis, MF = 0.83 for the at-home consumption model and MF = 0.81 for the away-from-home model.

Table 3. Coefficients for Dependent Variables Purchase Frequency for At-Home and Away-From-Home Shrimp Consumption.

Variable	At-Home Consumption	Away-From-Home Consumption
Male	-4.10*	3.95
younger	-1.91	-4.43
older1	-1.51	0.77
older2	5.72	0.55
nonwhite	19.10**	9.69**
Single	3.10	-1.49
Hhone	10.83**	5.08
Hhthree	4.46	1.79
Hhfour	-2.58	-3.61
Hhmore	-3.40	1.16
Lowed	3.83	-1.38
Highed	3.42	-1.23
Lowinc	-3.90	-9.39**
Medinc	5.14	1.23
highinc1	3.98	-1.62
highinc2	6.75	1.95
Wealthy	7.05	-2.89
Rural	1.11	-0.92
Urban	-4.73	-7.49*
Resort	-0.86	0.07
Catholic	7.07**	3.98
Diet	4.09*	6.08**

Notes: Single and double asterisks (*, **) indicate significance at the 10% and 5% level.

Because the model is probabilistic, the βs are the coefficients of the explanatory variables in the linear function that generates the latent variable. In that context, the sign and significance of the coefficients, as well as their relative magnitude, are easily understood. For at-home consumption, the explanatory variables non-white, Catholic, diet, and household size of one each exert a statistically significant positive influence on the latent variable, with the variable male exerting a statistically significant negative influence. Non-white is the most influential characteristic for at-home consumption. For away-from-home consumption, variables non-white and diet again exert a significant positive influence, with urban residence and low income exerting a negative influence. The magnitude of the influence of non-white is comparable to that of low income.

The effect on the observed variable is subtler. The probability distribution for the observed variable can be calculated for any vector of explanatory variables. Tables 4 and 5 give the

probability distribution for at-home and away-from-home shrimp consumption for the typical respondent (the base element, $x_k = 0$ for all k) and for respondents that differ from the base element in exactly one of the significant explanatory variables.

Table 4. Probability Distribution for At-Home Shrimp Consumption Frequency.

	Base	Base & Non-white	Base & Catholic	Base & Diet	Base & hhsize One	Base & Male
prob (never)	0.30	0.00	0.09	0.16	0.04	0.48
prob (once/six months)	0.13	0.01	0.07	0.10	0.04	0.14
prob (once/three months)	0.22	0.03	0.18	0.21	0.12	0.19
prob (once/month)	0.28	0.22	0.43	0.39	0.42	0.17
prob (twice/month)	0.06	0.69	0.23	0.14	0.38	0.02
prob (once/week or more)	0.00	0.05	0.00	0.00	0.00	0.00
prob (once/month or more)	0.34	0.96	0.66	0.53	0.80	0.19

Table 5. Probability Distribution for Away-From-Home Shrimp Consumption Frequency.

	Base	Base & Non-white	Base & Diet	Base & Urban	Base & Lowinc
prob (never)	0.18	0.04	0.07	0.41	0.48
prob (once/six months)	0.08	0.03	0.05	0.11	0.11
prob (once/three months)	0.17	0.08	0.11	0.17	0.16
prob (once/month)	0.34	0.29	0.34	0.23	0.19
prob (twice/month)	0.23	0.51	0.41	0.08	0.06
prob (once/week or more)	0.01	0.05	0.02	0.00	0.00
prob (once/month or more)	0.58	0.85	0.77	0.31	0.25

The typical respondent is most likely to purchase shrimp for at-home consumption or away-from home consumption once per month. The probability of purchasing shrimp twice per month rises from 0.06 to 0.69 for at-home consumption and 0.23 to 0.51 for away-from-home consumption for a similar respondent who is non-white. A similar respondent who is male is most likely to never purchase shrimp for at-home consumption. The final row in each table illustrates the change in the probability that shrimp is purchased at least one per month by respondents who differ in the significant explanatory variables. The probability that shrimp is purchased at least once per month for at-home consumption rises dramatically, from 0.34 for the typical respondent to 0.80 for a household size of one and to 0.96 for non-white. Similarly, the probability that shrimp is purchased at least once per month for away-from-home consumption increases from 0.58 for the typical respondent to 0.77 for dieting and 0.85 for non-white.

From a marketing and promotional strategy development perspective, the ideal target customer for at-home shrimp consumption appears to be a non-white Catholic female with small household size who is currently dieting. The ideal target customer for away-from-home shrimp consumption appears to be a dieting non-white with higher income living in a suburban area.

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