Quality versus Quantity for Aggregate Household Seafood Consumption and Relevant Southeast U.S. Species

Calidad versus Cantidad en el Consumo Doméstico Agregado de Mariscos y Especies Importantes del Sureste de los Estados Unidos

La Qualité contre la Quantité dans la Consommation des Fruits de Mer et Autres Espèces Pertinentes par les Ménages du Sud-Est des Etats-Unis d'Amerique

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ABSTRACT

From February 2005 through January 2006, a NOAA Fisheries Seafood Consumption Survey was conducted to gather information regarding household seafood consumption patterns. Based on the 10,798 completed interviews, this study estimates expenditure-based household demand functions for seafood in aggregate as well as for shellfish and shrimp. Emphasis is given to the influence of socioeconomic factors influencing the demand for quality. As an outcome of this objective, and based on the hypothesis that demand for quality is proportional to the level of aggregation (i.e., as one moves from seafood to shrimp), the study examines whether the demand for quality diminishes in relation to the level of disaggregation.

KEY WORDS: Quality, quantity, seafood

INTRODUCTION

U.S. consumption of commercial fish and shellfish increased from 12.5 pounds (edible meat weight) per capita in 1980 to 16.6 pounds in 2004 and thereafter declined in successive years to 15.8 pounds in 2010. While seemingly moderate in nature, the increase from 1980 to 2004, when adjusted for population change, represents an additional source requirement of 2.1 billion pounds annually. Though per capita consumption has fallen since 2004, the increase in population since 2004 has resulted in virtually no change in source requirements.

As the socioeconomic characteristics of the "average" U.S. household changes, one can expect changes in seafood consumption and the composition of that consumption. These changes reflect both species consumed and product forms. Economic theory, for example, suggests that increasing income is likely to result in demand for species considered to be of higher quality. Similarly, changes in the ethnic composition will result in increasing demand for particular species. Changes in other characteristics, such as household size, age, and the opportunity cost of the homemaker will culminate in changes in demand for product composition (including optimal packaging etc.).

An analysis of household seafood demand can be used to (a) forecast changes in product species and composition that will likely be forthcoming over time and (b) develop appropriate marketing programs. The later one is particularly relevant in light of increased imports and the impact of the increasing import base on domestic product. Nowhere is this more evident than in the Gulf shrimp fishery where dockside price has fallen by nearly one-half during the decade of the 2000s. This decline is mostly, if not entirely, the result of increasing imports.

Cheng and Capps's analysis examined household seafood expenditure behavior based a 1981 cross-sectional survey of 9,422 households (the Seafood Consumption Survey conducted by the Market Research Corporation of America for the National Marine Fisheries Service). Using retail data, the authors estimated household expenditure functions for shellfish, finfish, and individual shellfish and finfish species. The authors did not attempt to examine the role of quality though quality has been shown to significantly influence expenditures and seafood demand (Keithly, 1985). Arguing that prices are likely to vary by season and/or region, Cheng and Capps (1988) included prices as arguments in the various expenditure functions. This allowed for the examination of the influence of price on demand for the various seafood products.

Dong et al. (1998) argued that the quantity and price are determined simultaneously and the bivariate model estimated by Dong et al. (1998) utilized the maximum likelihood method to successfully deal with a truncation problem as well as difficulties associated with unobserved unit price values. This paper builds upon the analysis proposed by Dong et al. (1998). As such, the quality variation and consumer preference can be simultaneously investigated by this bivariate analysis. A bivariate normal density function is noted as a joint probability density function for both purchasing and non-purchasing. In addition, the log-likelihood function is largely based on the joint probability distribution function. Taking the partial derivative of the log-likelihood function allows one to derive values for parameters which maximize this equation.

The objective of the study is to estimate expenditure-based household demand functions for seafood consumed at home at three levels: seafood in aggregate, total shellfish, and shrimp (the most valuable species harvested in the Southeast U.S.). Emphasis will be given to the influence of socioeconomic factors on the demand for quality. As an outcome of this objective, and based on the hypothesis that demand for quality is proportional to the level of aggregation (i.e., as one moves from grouped commodity to elementary goods), the study examines whether the demand for quality diminishes in relation to the level of disaggregation.

THE DATA

The data used for the analysis, as noted, is the 2005/2006 NOAA Fisheries Seafood Consumption Survey which consists of 10,632 completed interviews, 5,311 of which were fresh cross-sectional interviews. The structure of the dataset makes analysis in a panel structure infeasible but does allow for pooling of all observations. Variables used in the study, as well as a description of these variables, are presented in Table 1. As indicated, monthly at-home expenditures averaged $15.48 per household for seafood in aggregate with shrimp accounting for almost one-third of the total.

The data used for this analysis contains 27 finfish species and 13 shellfish species. These various species also had information on product forms. Aggregation across all shellfish and finfish species and product forms provided an estimate for total seafood expenditures. Similarly, aggregation across the shellfish species and product forms provided an estimate of shellfish expenditures. Finally, aggregation across the shrimp product forms provided an estimate of shrimp expenditures. The fact that many households did not purchase seafood (or shellfish or shrimp) during the one month survey period results in a censoring problem that needs to be taken into account in the estimation procedure. The reason why many households did not purchase seafood might stem from that the cost of the seafood goes beyond the budget of some consumers; the lack of the cooking skill or the opportunity cost of time to prepare seafood is high. Relevant information pertaining to purchasing and non-purchasing household for seafood in aggregate, shellfish, and shrimp are provided in Table 2.

Theoretical and Econometric Model

Historically, prices were assumed constant in cross-sectional demand analyses. However, the assumption that the commodity/good price was the same for all households has increasingly been called into question; initially under the premise that transportation costs would result in price variations across regions and seasonality factors (i.e., supply variations). Extending the explanation as to why prices may vary across households, Cramer (1973) asserted that the aggregate demand analysis is usually based on composite commodities rather than elementary goods. A direct consequence of this assertion is the absence of the assumption of constant price in cross-sectional demand analysis. A more bothersome consequence is that the demand analyses must be adapted to cope with the quality variation caused by the heterogenous commodity aggregates.

Nelson (1991) argued that the simple sum of physical quantities cannot be used as the measure of demand when the goods are heterogeneous. Therefore, an alternative measure of demand derived from the Hicksian composite commodity theorem was used by Nelson (1991):

$$(1) Max U(Q_1, ..., Q_n)$$
$$s.t. \sum_{G=1}^{n} P_G Q_G = y$$

Table 1. Variable names and description

Variable name	Description	Mean	Standard Deviation
Exp	Household expenditures on finfish and shellfish	$15.48	28.84
Sfexp	Household expenditures on shellfish	$7.66	18.78
Sripexp	Household expenditures on shrimp	$5.13	11.98
College	Household manager has at least some college education	0.62	0.49
Northeast(omitted category)	Region variable	0.20	0.40
Midwest		0.24	0.24
South		0.34	0.34
West		0.22	0.22
Spring(omitted category)	Season variable	0.24	0.43
Summer		0.25	0.42
Autumn		0.25	0.42
Winter		0.26	0.39
Income	Annul household income	$51909	$37252
Pphhsize	Household size	2.53	1.38
Ppt018	Number of household members younger than 18 years	0.53	0.0093
White (omitted category)	Race variable	0.79	0.41
Black		0.10	0.30
Other		0.04	0.21
Hispanic		0.06	0.25
Ppage	Age of household manager	48.74	15.27
Ownhouse	Equal to 1 if household owns house and zero if renting	0.82	0.38
Urban	Equal to 1 if household lives in urban area and zero in rural area	0.73	0.44
Work	Employment status of household manager	0.56	0.50

Table 2. Descriptive statistics of household expenditure on total seafood, shellfish, and shrimp.

Categories	Number of Nonzero Values	Average Expenditures Among all Households	Average Expenditures Among Consuming Households
Shrimp	2568	$5.13	$19.87
Total Shellfish	2698	$7.66	$23.17
Total Seafood	4635	$15.48	$29.84

Where Q_G is defined as the quantity of composite commodity G which is not directly observable from survey data, P_G represents the corresponding composite commodity price which is also not directly observable, and y is defined as the consumer's income. Hicks' composite commodity theorem assumes that the prices of goods within the group G move proportionally:

$$(2) i \in G \Rightarrow p_i = P_G p_i^*$$

Where $P_i{*}$ is the 'base' price for each elementary goods i and Q_G can be defined as:

$$(3) Q_G = \sum_{i \in G} P_i^* x_i$$

Combining Equations (2) and (3) implies an expenditure equation which can be expressed as:

$$(4) E_G = \sum_{i \in G} p_i x_i = \sum_{i \in G} P_G p_i^* x_i = P_G \sum_{i \in G} p_i^* x_i = P_G Q_G$$

While P_G and Q_G are unobservable in cross-sectional household surveys, the expenditures E_G and the sum of physical quantities q_G is observable and the unit value equation holds by the ratio of expenditure and the physical quantity:

$$(5) V_G = E_G / q_G = P_G Q_G / q_G = P_G v_G$$

Following Theil (1952) and Cramer (1973), the indicator of quality v_G in Group G is represented by the summation of the quantity-weighted base price:

$$(6) v_G = \sum_{i = G} \left(\frac{x_i}{q_G} \right) p_i^* = \frac{\sum_{i \in G} p_i^* x_i}{q_G}$$

The unit value equation is based on the relationship

$$(7) \ln V_G = \ln p_G + \ln v_G$$

(Taking the natural logarithm on both sides of equation 9) Therefore the unit value can be calculated by two terms. The first term is the constant price within group G and the second term is considered as the measure of quality. Adding socioeconomic (SE) and demographic variables (DE), the expenditure function of a composite good can be expressed by Equation 8:

$$(8) E_G = f(\ln V_G, y, SE, DE)$$

Empirical Model of Seafood Demand and Quality

As mentioned, Nelson (1991) introduced a theoretical method to investigate quality variation and consumer preference. Since then, her analysis has been extended by Dong et al. (1998) who applied her theoretical work to the estimation of household expenditures for beef (beef steaks and roasts) using the cross-sectional USDA 1987/88 Nationwide Food Consumption Survey. The bivariate model estimated by Dong et al (1998) utilized the maximum likelihood method to successfully deal with truncation problem as well as difficulties of the unobserved unit price value. Given the left-hand truncated data, the econometric model of the expenditure function equation 8 was given by:

$$(9) E_i^* = \beta_0 + \beta_1 * \ln V_i + \beta_2 * y_i + \beta_3 * SE_i + \beta_4 * DE_i + \mu_{1i}$$

Such that $E = E^*$ if $E^* > 0$ and

$E = 0$, otherwise

Because V is left truncated on 0, LnV rather than V is included as an argument in the expenditure equation. Empirically, equation 7 can be expressed as:

$$(10) LnV_i = \alpha_i + \sum \beta_i x_i + \mu_{2i}$$

$$If \ \beta_0 + \beta_1 * \ln V_i + \beta_2 * y_i + \beta_3 * SE_i + \beta_4 * DE_i > -\mu_{1i}$$

α represents $\ln P_G$ in equation 7 which is the base price for group G. It was considered to be constant. X is subset of SE and DE which is a proxy for household preference for goods quality v_G (equation 7).

The Log likelihood function is largely based on the joint probability distribution function. When simultaneously considering both quantity and quality effects for the analysis of seafood consumption behavior, μ_1 and μ_2 are assumed jointly and normally distributed with mean 0 and covariance matrix:

$$\sum = \begin{bmatrix} \sigma_1^2 & \sigma_{12} \\ \sigma_{12} & \sigma_2^2 \end{bmatrix}$$

The simultaneous equations also affect the calculation of the price elasticity. For example, the higher household income will increase the purchase on the seafood. Furthermore, it also indirectly affects the purchase through the unit price, which means consumers prefer to buy high quality seafood. Therefore the elasticity should include both the expenditure effect and unit value effect. The Equation (11) and (12) show the expected value of expenditure and unit value. And,

$$\omega_1 = (\sigma_1^2 + 2\sigma_1\sigma_2 + \sigma_2^2)^{1/2}$$

which can be derived from the covariance matrix.Φ (.) Represents the standard normal Cumulative distribution function and φ (.) indicates the standard normal probability density function.

(11) $$E(E) = \Phi(\theta)[(X\beta)\alpha_1 + Z\alpha_2] + \omega_1\varphi(\theta)$$

(12) $$E(\ln V) = X\beta,$$

Given the unit value, the expected purchase effect can be derived from Equation (13).

(13) $$E(E/V) = \Phi(\delta)(\ln V\alpha_1 + Z\alpha_2] + \omega_2\varphi(\delta)$$

In Equation 13, the probability of a household who purchases seafood given unit value V during the survey period is represented by φ (σ).

(14) $$\delta = [\ln V\alpha_1 + Z\alpha_2 + \frac{\sigma_{12}}{\sigma_2^2}(\ln V - X\beta)]/\omega_2,\ and\ \omega_2 = (\varsigma - \frac{\sigma_{12}^2}{\sigma_2^2})^{1/2}$$

Using this estimation approach, Dong et al. (1998) were able to compare the two-equation simultaneous model to the Cox and Wohlgenant (1986) modeling approach (i.e., the zero order and first order imputation approach). In general, significant differences were found between the two approaches including the influence of (log) price (unit value) on expenditures. Specifically, the Cox and Wohlgenant procedure resulted in a positive coefficient associated with unit value whereas the two-equation simultaneous model approach resulted in a negative coefficient associated with unit value (implying, of course, an inverse relationship between quality and expenditures). Furthermore, Dong et al. (1998) found σ_{12} (i.e., the covariance between the error terms in the two equations) to be statistically significant, suggesting simultaneity between quality and expenditures. Based on a comparison of findings between the two approaches, Dong et al. (1998) suggest that the Cox and Wohlgenant approach is likely to be inferior to the two-equation simultaneous model approach and, based on their findings, is likely to be inappropriate in analyzing cross-sectional demand functions. The model as originally proposed by Dong et al. (1998) and more recently adapted by Myrland et al (2007) will be employed to estimate at-home seafood expenditure-based household demand functions. Initially, the focus of the analysis will be on aggregate at-home seafood demand. Then, attention will be given to analysis of total shellfish and primary fishery species in the U.S. Southeast —shrimp.

Estimation Results

Given the expenditure and unit value equation, maximum-likelihood parameter estimate of the simultaneous equations were achieved by using the GAUSS software system. Differentiate the likelihood function with respect to parameter vector α,β and the variance and covariance of the error term to derive the gradient vector. Parameter estimates of the bivariate model systems are found in Table 3 by setting the gradient vector to zero.

As indicated by the information in Table 3, the logarithm of unit value for aggregate seafood, total shellfish, and shrimp are all negative and statistically significant in the expenditure equations. The negative sign implies the inverse relationship of quantity and quality and that consumers sacrifice quantity for higher quality. Some of this tradeoff may represent a higher price paid per unit of weight for more processed seafood (e.g., fillet vs. a whole fish). The own price elasticity of the bivariate model is needed to answer the question as to whether the disaggregation will yield higher own-price elasticities. The own-price elasticities will be reduced by the substitution among the sub-groups and sub-species for the aggregated seafood. We expect that the own-price elasticities of shrimp will be higher than that of total seafood.

As noted, the results were consistent with the expectation about income. All coefficients of income are positive and statistically significant for both unit value and expenditure equation among all these seafood categories. It supports the hypothesis of positive influence of income on the demand for both quantity and quality which follows the Engel's law If we move from the shellfish commodity to a product species such as shrimp, the parameter estimates of income in the unit value equation diminishes proportionally to the level of disaggregation. With respect to the expenditure equation, the positive sign of income associated with each seafood category (i.e., aggregate seafood, shellfish, and shrimp) indicate that expenditures increase in relation to increasing income.

There is also a significantly negative relationship between the household size and the unit-value. This negative relationship reflects economies of scale in purchasing. Specifically, larger households can buy in 'bulk' at a lower price per unit than when making smaller purchases. A similar finding is apparent when considering the expenditure equation in which all the coefficient of ppt018 are negative and statistically significant.

As indicated by the information in Table 3, race/ethnicity also influences the demand for quality. This may be the result, at least in part, to differences in preferences associated with the level of processing prior to the final purchase. For example, white households may purchase products that have undergone more value-added processing (e.g., fillets or peeled shrimp) than households of other races/ethnicities. White households may also be purchasing higher valued species (say salmon as opposed to catfish) due to inherent cultural differences .Whatever the exact reasons may be, they are not the result of differences in

Table 3. Parameter estimates for the shrimp, shellfish, and total seafood.

Variables	Shrimp	Total Shellfish	Total seafood
Unite Value Equation			
Constant	0.2400[c]	-0.2050	0.2631[b]
	(0.1468)	(0.1393)	(1.0698)
Work	-0.0039	0.0151[c]	0.0532[a]
	(0.0040)	(0.0085)	(0.0156)
Lincome	0.1080[a]	0.1210[a]	0.1188[a]
	(0.0132)	(0.0128)	(0.0133)
Lpphhsiz	-0.0494[a]	-0.0734[a]	-0.1185[a]
	(0.0131)	(0.0143)	(0.0171)
Black	-0.1229[a]	-0.1731[a]	-0.2684[a]
	(0.0255)	(0.0252)	(0.0278)
Other	-0.1183[a]	-0.1773[a]	-0.1868[a]
	(0.0285)	(0.0308)	(0.0368)
Hispanic	-0.0912[a]	-0.1004[a]	-0.2014[a]
	(0.0239)	(0.0250)	(0.0317)
College	0.0164[c]	0.0238[b]	0.0304[b]
	(0.0097)	(0.0119)	(0.0157)
Urban	-0.0357[a]	-0.0163	-0.0036
	(0.0057)	(0.0103)	(0.0196)
Expenditure Equation			
Constant	-4.1082[a]	-5.0662[a]	-6.0644[a]
	(1.3752)	(1.1441)	(1.0698)
Lincome	1.2104[a]	1.2021[a]	1.1505[a]
	(0.2662)	(0.2120)	(7.8412)
PPT018	-0.0880[c]	-0.0887[b]	-0.2169[a]
	(0.0561)	(0.0572)	(0.0711)
Married	0.0856[a]	0.0694	0.0090
	(0.0365)	(0.1352)	(0.1328)
Ownhouse	0.0214	-0.0608	0.1563
	(0.0369)	(0.1400)	(0.1397)
Spring	-0.6042[a]	-0.3205[a]	-0.1855
	(0.1130)	(0.1309)	(0.1580)
Summer	-0.5058[a]	-0.2270[c]	0.1620
	(0.1113)	(0.1294)	(0.1727)
Autumn	-0.4609[a]	-0.3946[a]	0.0660
	(0.1283)	(0.1299)	(0.0660)
Log unit value	-8.0228[a]	-6.0296[a]	-4.9562[a]
	(1.9884)	(1.4128)	(0.7448)
Convariance	-0.5997[a]	-0.5774[a]	0.0570[a]
	(0.0240)	(0.0275)	(0.0305)

A significance level of .01,.05 and .10 are indicated by a, b and c respectively
The value in parentheses are standard errors

income since the influence of this factor is included in the model.

Information associated with the expenditure equation also suggests that households headed by a food manager with at least some college education significantly purchased more seafood then those with no college education. This may reflect increased awareness of the positive health benefits associated with seafood consumption among households with more formal education.

The own price elasticity of the bivariate model in Table 4 gives the answer whether the disaggregation will yield higher own-price elasticities. Elasticities in columns 5 and 6 are evaluated at the sample means with respect to Equation 11 and 13. Overall, as indicated, the absolute values of own-price elasticities are reduced from seafood species such as shrimp (-3.178) to shellfish (-2.147) to the aggregated seafood (-1.39) because the substitution among the sub-groups and sub-species for the aggregated seafood.

The estimated unit value elasticity of shrimp is -3.178, indicating that as the unit value of shrimp increases by 1%, household expenditures on the shrimp is expected to decrease by 3.178%. Hence, shrimp is an elastic seafood species and it shows the luxury image. All the income elasticities of expenditure are positive and 10 out of 12 income elasticities are statistically significant. For PPt018, the number of household whose age is under 18 is found to have a negative and significant effect on shellfish and shrimp.

Not surprisingly, for all the categories we see that the covariance of the two error terms of the bivariate model system is statistically significant which is the evidence of that quantity and quality decisions are simultaneously related. This finding lends support to the superiority of the bivariate model as proposed by Dong et al. (1998) as opposed to the model proposed by Cox (1986) when analyzing seafood demand.

Table 4. Estimated elasticities for total seafood, shellfish, and shrimp.

Disaggregation level	Variables	Prob(E|E>0,lnV)[1]	Prob (E|E>0)[2]	E(E>0)[3]	E(E/lnv)[4]
Seafood	**Income**	0.27[a]	0.21[a]	0.30[a]	0.32[a]
	Ppt018	0.0001	0.001	0.003	0.002
	Unit value	-1.16[a]	---	---	-1.39[a]
Shellfish	**Income**	0.326[a]	0.286[a]	0.396[a]	0.375
	Ppt018	-0.004	-0.028[a]	-0.087[a]	-0.041[a]
	Unit Value	-1.868[a]	----	----	-2.147[a]
Shrimp	**Income**	0.442	0.429[a]	0.581[a]	0.489
	Ppt018	-0.001	-0.021[a]	-0.055[a]	-0.021[a]
	Unit Value	-2.868	----	---	-3.178[a]

1.Conditional elasticity of probability of expenditures given the log unit values and that expenditure are nonzero
2. Conditional elasticity of probability of expenditures given the expenditure is nonzero
3.Unconditional elasticity of expenditures
4.Conditional elasticity of expenditure given the log unit value
Significance levels of .01, .05 and .10 are indicated by a, b and c respectively.

CONCLUSIONS

This study developed a bivariate simultaneous modeling framework for both at-home seafood demands in the aggregate and for individual product species. The bivariate model captured the joint relationship of the quality and quantity decisions and the finding of this study indicate that the socioeconomic variable did affect the demand on quality. One advantage of this model was it accounts for both the selection bias and simultaneity. And the most important finding of this paper is that the demand of quality diminishes in relation to the level of disaggregation. Therefore, controlling the quality of aggregated seafood to adjust the quantity of seafood purchased will be an interesting marketing strategy. This research showed how income and unit price affect the quality of seafood as well as how to measure the quality directly from the income and unit price equation.

The future study will focus on the derivation of the quality elasticity. As expected, the disaggregation will yield higher own-price elasticities due to the fact of that the own-price elasticities will be reduced by the substitution among the sub-groups and sub-species for the aggregated seafood. The quality elasticity can be derived by the difference between the expenditure elasticity and quantity elasticity. We also expected that the quality elasticity will be decreased as the disaggregation level is low.

LITERATURE CITED

Capps, O. Jr. and J. Havlicek, Jr. 1984. National and Regional Household Demand for Meat, Poultry and Seafood: A Complete Systems Approach, *Canadian Journal of Agricultural Economics* **32**:93-108.

Cheng, H. and O. Capps, Jr. 1988. Demand analysis of fresh and frozen finfish and shellfish in the United States. *American Journal of Agricultural Economics* **70**:533-542.

Cox T.L. et al. 1984. Household demand for fresh potatoes: a disaggregated cross-Sectional analysis. *Western Journal of Agricultural Economics* **9**(1):41-57.

Cramer, J.S.1973. Interaction of income and price in consumer demand. *International Economic Review* **14**: 351-363.

Dong, D., J.S. Shonkwiler, and O. Capps, Jr. 1998. Estimation of demand functions using cross-sectional household data: the problem revisited. *American Journal of Agriculture Economics* **80**:466-473.

Keithly, W.R. 1985. *Socioeconomic Determinants of At-home Seafood Consumption: A Limited Dependent Variable Analysis of Existing and Latent Consumers.* Ph.D. dissertation, University of Florida, Gainesville, Florida USA.

Myrland, Ø, D. Dong, and H.M. Kaiser. 2007. Quantity versus quality effects of generic advertising: the case of Norwegian salmon. *Agribusiness* **23**:85-100.

Nelson, J. 1991. Quality variation and quantity aggregation in consumer demand for food, *American Journal of Agricultural Economics* **73**:1204-1212.

Theil, H. 1951. Qualities, prices, and budget enquiries. *the Review of Economic Studies* **19**:129-147.