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# Estimating U.S. household seafood demand based on longitudinal and cross-sectional data

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# ESTIMATING U.S. HOUSEHOLD SEAFOOD DEMAND BASED ON LONGITUDINAL AND CROSS-SECTIONAL DATA

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# ABSTRACT

This overall goal of this research is to examine and update U.S. at-home household demand estimates for seafood (including species and generic products) that can be used in policy formulation (by both the private and public sector). As such, this study estimated quantity-based household demand functions for seafood in aggregate, by generic product form (fresh, frozen, and prepared), and primary species. Given that the role of quality has been shown to significantly influence expenditures and seafood demand, this paper also seeks to incorporate the household quality choice into the demand model. In order to help to tailor the market strategy, this study also estimates household seafood demand in a complete demand system framework to track the substitution and complementation between seafood product forms and other protein sources. Emphasis is also given to the influence of socioeconomic factors on the demand for quantity.

This study uses 2005-2006 NOAA Fisheries Seafood Consumption Survey data which consisted of 10798 completed interviews. In the complete demand system analyses, comparison of model results with a quality proxy, without a quality proxy, and with a quality adjusted price were examined to determine a ‘preferable’ means for incorporating household quality choice. Results suggest that quality does play an important role in seafood demand. As for the quantity-based demand equations, a bivariate model was applied to simultaneously investigate the quality variation and consumer preference. As an outcome of this model, and based on the hypothesis that demand for quality is proportional to the level of aggregation, the study examines whether the demand for quality diminishes in relation to the level of disaggregation. The bivariate model utilized the maximum likelihood method to successfully deal with a truncation problem as well as difficulties of unobserved unit price values.

# CHAPTER 1 INTRODUCTION

## 1.1 General Background

U.S. consumption of commercial fish and shellfish increased from 12.5 pounds (edible meat weight) per capita in 1980 to 16.6 pounds per capita in 2004 (USDOC, 2012). Since 2004, however, per capita consumption has been trending downwards with 2012 consumption, equal to 14.4 pounds per capita, representing less than 90% of that observed in 2004.[1] Moreover, whereas per capita consumption in 2004 exceeded that reported in 1980 by almost a third, per capita consumption in 2012 exceeded that reported in 1980 by a more 'modest' 15%. While the increase in per capita consumption between 1980 and 2012 might be considered 'modest' in nature, an 87 million increase in U.S. civilian population during the period (from 225.7 million in 1980 to 312.7 million in 2012) resulted in an increase source requirement over the period of about 1.7 billion pounds; or more than 50 million pounds annually.

In general, the vast majority of the increased source requirement has been derived from imports. Domestic production of edible commercial product, for example, advanced from 3.6 billion pounds (round weight) in 1980 to 7.5 billion pounds in 2012 (USDOC, 2012), or by just over 100%. Though this increase is impressive, much of it reflects increased harvest of Pollock; a low-valued species of which a considerable proportion is destined for the export market.[2] That portion not exported is primarily used in the production of surimi. Overall, the domestic Pollock harvest increased from an annual average of about 40 million pounds during the early 1980s to 2.8 billion pounds in 2012 at which point in time this product accounted for more than a third of domestic production of edible commercial product.[3]

While annual domestic production of commercial edible product approximately doubled between 1980 and 2012, imports of edible products, by comparison, increased from 2.1 billion pounds in 1980 to 10.6 billion pounds in 2012; or by more than 400%. While increasing imports of a large number of species/products can be identified, three

[1] The decline was particularly pronounced during the latest two years where per capita consumption fell from 15.8 pounds in 2010 to 15.0 pounds in 2011 and fell again to 14.4 pounds in 2012.

[2] The other product that deserves some discussion is catfish. Catfish primarily represents a farmed product and production of this product increased from 46 million pounds (round weight) in 1980 to more than 600 million pounds by the early 2000s.

[3] The increase in domestic production of edible commercial product between 1980 and 2012 equaled 2.9 billion pounds. With production of Pollock in the early 1980s being negligible compared to 2.8 billion pounds in 2012, one can conclude that the vast majority of the increase in domestic production of edible commercial product is the result of increased Pollock harvest.

species – salmon, shrimp, and tilapia – account for much of the total. Shrimp imports, for example, increased from 220 million pounds (product weight) in 1980 to 1.2 billion pounds in 2012. Exports of salmon to the United States, equaling less than 10 million pounds (product weight) in 1980, increased to more than 600 million pounds (product weight) in 2012. Similarly, exports of tilapia to the United States advanced from less than 10 million pounds in the early 1990s to about 500 million pounds in 2012. These three species, combined, account for a large percentage of the growth in imports, by volume, during the 1980-2010 period. Of relevance, increased imports of all three of these species primarily represent farm-raised product. This finding, in conjunction with relatively constant domestic production (with the exception of Pollock which, as mentioned, is largely destined for the export market or made into surimi) would suggest that much of the increased U.S. per capita consumption since the 1980s reflects a limited number of species and those species are linked to supply increases via farming activities.[5] As suggested by Kinnucan and Nelson (1993), this may reflect a 'propinquity effect' whereby preferences are determined, in part, by source availability.

In general, changing species composition reflected in the increasing U.S. per capita seafood consumption can be determined, to some extent, via careful analysis of historical trade and domestic production data. More difficult to determine, however, is changing product composition. This is the result of several factors. First, with respect to import data, the harmonized tariff code for products associated with a given species is often relatively limited (e.g., fresh versus frozen). Furthermore, the code will provide information only on product as it enters the customs house. Much of the imported product undergoes substantial value added transformation after it passes through customs. Second, information on value added activities for domestic product is often just as limited. While the National Marine Fisheries Service conducts an end-of-the-year survey of seafood processing establishments, these establishments, in general, represent only those conducting the first stage in value-added activities. As with imported product, considerable transformation of the domestic product often occurs beyond the initial processing stage.[4]

As the socioeconomic characteristics of the "average" U.S. household changes, one can expect changes in seafood consumption. In addition to the absolute quantity being consumed, these changes reflect both species consumed and product forms. For example, increasing (decreasing) income is likely result in demand for species considered to be

[4] While NMFS does provide information on annual per capita consumption by product type, these product types are highly aggregated (i.e., canned, fresh and frozen, and dried).

of higher (lower) quality. Similarly, changes in the ethnic composition will result in increasing demand for particular species. Changes in other characteristics, such as household size and age, 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 latter 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 fell by nearly one-half during the decade of the 2000s[5]. This decline is mostly, if not entirely, the result of increasing imports.

Despite the potential benefits that may accrue to the domestic seafood industry (and supporting services) from an analysis of U.S. household seafood demand, empirical studies are few and, for the most part, dated. Furthermore, advances in econometric techniques associated with demand analysis have progressed in recent years which can be used to examine demand in a more complete framework. The paucity of seafood demand studies, the dated nature of many of these studies, and the estimation techniques employed at the time of these studies makes it difficult for those involved in seafood marketing to adequately make long-term, well-informed, marketing decisions. Furthermore, management of those species under U.S. jurisdiction requires information on future seafood demand. This being the case, it is important to reexamine seafood demand in relation to those factors that might result in long-run changes. This study focuses on examining at-home demand for seafood by generic product form (e.g., fresh, frozen) as well as the at-home demand for certain 'key' species (e.g. shrimp and tilapia).

### 1.2 Study Objectives

The overall goal of this research is to empirically analyze U.S. at-home demand for seafood taking into account the influence of socioeconomic factors on quality. To achieve this overall goal, the following specific objectives are proposed:

1. To briefly examine trends in U.S. seafood consumption (supply) in total, by product form, and by key species. Sources for these products (i.e., domestic versus imports) will also be identified and discussed;

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[5] The Gulf of Mexico dockside shrimp price has rebounded since 2010, much of which is likely the result of a significant decline in farm-raised shrimp production as a result disease (referred to as Early Mortality Syndrome).

2. To provide relevant descriptive statistics on at-home seafood consumption (by generic product form and key species) based on a unique seafood consumption survey commissioned by the National Marine Fisheries Service (NOAA Fisheries National Seafood Consumption Survey) conducted from January 2005 through February 2006;

3. Based on the NOAA Fisheries National Seafood Consumption Survey, and with some basic descriptive statistics presented under Objective 2, to estimate at-home seafood demand by generic product form (fresh, frozen, and prepared) considering both animal protein substitutes (beef, chicken, and pork). The estimation procedures employed will attempt to control for quality variation (i.e., the demand for quality) across households and will be compared to results where quality variation is not taken into consideration;

4. Based on the NOAA Fisheries National Consumption Survey, to estimate the demand for seafood in aggregate and for several 'key' species (or aggregation of species) in a framework wherein purchases (quantity) and quality effect are determined simultaneously.

5. Based on results associated with the previous objectives, to summarize findings and present implications with respect to the marketing of seafood for at-home consumption.

**1.3 Contributions of This Study**

Generally speaking, analysis of seafood demand is limited in relation to studies analyzing the demand for alternative animal protein sources (i.e., beef, pork, and poultry). Furthermore, most seafood demand analyses are conducted using dockside and/or import data due the prevalence of data at this level. Analyzing demand at a lower level in the marketing chain often entails the estimation of inverse demand equations given that supply is considered to be 'relatively' fixed in the short run. Finally, those seafood studies that have examined seafood demand at the retail level tend to be outdated and changes in tastes and preferences, in conjunction with a changing demographic structure of the 'typical' U.S. household, has almost certainly altered seafood demand preferences over time.

This study contributes to the limited body of research covering retail seafood demand for at-home seafood consumption in a number of different ways. First, it employees data collected specifically for analysis of at-home seafood demand and thus allows for examination of demand at the species level and by product form. The study also considers the issue of quality in relation to demand in a much more thorough manner than has been considered in previous research. Econometric methods of a more recent vintage (including multiple imputation analysis and Expected Maximization Algorithm) are used to estimate the demand for seafood and other animal protein commodities than what have been utilized in the past. These methods include the use of multiple imputation analysis and the Expected Maximization Algorithm for analysis of seafood demand, by generic product form, and the use of a bivariate selectivity model to estimate demand for individual species which corrects for selectivity bias by distinguishing between those households purchasing (consuming) a commodity from those that do not.

### 1.4 Outline of Study

Insight into the U.S. seafood market is presented in the next chapter via published statistics on the industry. This review, while less than exhaustive, provides background information on trends in the industry that can help identify 'key' areas to examine in the subsequent analysis of at-home seafood consumption. Following this review, analysis of seafood demand by generic product form (fresh, frozen, and prepared) along with other animal protein commodities is presented in a complete demand framework with detail being given to the role of quality. In Chapter 4, attention is given to analysis of seafood and seafood species (or groups) based on the assumption that prices for a commodity vary from one household to the next and that this variation is, at least in part, the result of the demand for quality which is simultaneously determined with quantity. In the last Chapter, conclusions, implications associated with the analysis, and additional areas of research that would be beneficial are presented.

# CHAPTER 2 A REVIEW OF THE SEAFOOD MARKET

## 2.1 Introduction

The overall purpose of this chapter is to provide a brief descriptive analysis of major trends in the seafood industry relevant to accomplishing the overall goal of this project as outlined in the previous chapter. This descriptive analysis is based, primarily, on secondary data collected and published by various federal agencies including the U.S. Department of Commerce, Census Bureau (imports and exports) and the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (commercial landings).

When maximizing utility, the consumer must select among a wide variety of products in the market. Other animal protein products –including beef, pork, and chicken – are, one might assume, the closest substitutes to seafood in the market. Hence, this chapter begins by examining seafood trends in relation to these other products. Then, attention is turned to providing information specific to the U.S. seafood market. Consideration is given to seafood consumption by product form, sources of supply, and consumption by primary species.

This review is not meant to be exhaustive; rather, it is provided to set the stage for more complete analysis of at-home seafood consumption in a complete demand system (i.e., Chapter 3), analysis of at-home consumption of key individual species (i.e., Chapter 4) and Conclusions (Chapter 5).

## 2.2 Seafood in Relation to Other Animal Proteins

Average annual U.S. per capita consumption by alternative animal protein sources and seafood is given in Table 2.1 for the 1980-2012 periods.

Table 2.1 Annual U.S. Per Capita Consumption by Protein Source, 1980-2012

| Year | Beef[a] | Pork | Chicken | Fish |
|---|---|---|---|---|
| 1980 | 76.6 | 57.3 | 48.0 | 12.5 |
| 1981 | 77.3 | 54.7 | 49.4 | 12.7 |
| 1982 | 77.0 | 49.1 | 49.6 | 12.5 |
| 1983 | 78.7 | 51.8 | 49.8 | 13.4 |
| 1984 | 78.4 | 51.5 | 51.6 | 14.2 |
| 1985 | 79.2 | 51.9 | 53.1 | 15.1 |
| 1986 | 78.8 | 49.0 | 54.3 | 15.5 |
| 1987 | 73.9 | 49.1 | 57.4 | 16.2 |

(Table 2.1 continued)

| | | | | |
|---|---|---|---|---|
| 1988 | 72.8 | 52.4 | 57.5 | 15.2 |
| 1989 | 69.0 | 52.0 | 59.3 | 15.6 |
| 1990 | 67.8 | 49.7 | 61.5 | 15.0 |
| 1991 | 66.6 | 50.2 | 63.9 | 14.9 |
| 1992 | 66.2 | 52.8 | 67.5 | 14.8 |
| 1993 | 64.6 | 51.9 | 69.8 | 15.0 |
| 1994 | 66.3 | 52.5 | 70.4 | 15.2 |
| 1995 | 66.2 | 51.8 | 69.5 | 15.0 |
| 1996 | 64.6 | 48.4 | 70.2 | 14.8 |
| 1997 | 66.3 | 47.9 | 71.9 | 14.6 |
| 1998 | 66.7 | 51.5 | 72.5 | 14.9 |
| 1999 | 67.5 | 52.7 | 76.9 | 15.4 |
| 2000 | 67.7 | 51.2 | 78.0 | 15.2 |
| 2001 | 66.2 | 50.2 | 77.9 | 14.8 |
| 2002 | 67.6 | 51.5 | 82.2 | 15.6 |
| 2003 | 64.9 | 51.8 | 83.0 | 16.3 |
| 2004 | 66.1 | 51.4 | 85.5 | 16.6 |
| 2005 | 65.6 | 50.5 | 87.1 | 16.2 |
| 2006 | 65.8 | 49.4 | 87.7 | 16.5 |
| 2007 | 65.3 | 50.8 | 86.4 | 16.3 |
| 2008 | 62.7 | 49.4 | 84.8 | 16.0 |
| 2009 | 61.1 | 50.1 | 81.0 | 16.0 |
| 2010 | 59.6 | 47.8 | 83.7 | 15.8 |
| 2011 | 57.4 | 45.7 | 84.3 | 15.0 |

[a]Includes beef, veal, pork and mutton/lamb.
Note: Livestock and poultry are expressed on a retail weight basis while seafood is expressed on an edible weight basis.
Source: United States Department of Agriculture and available at (http://www.nationalchickencouncil.org/about-the-industry/statistics/per-capita-consumption-of-poultry-and-livestock-1965-to-estimated-2012-in-pounds/

As indicated, per capita consumption of seafood is ‘dwarfed’ when compared to alternative protein sources. Several hypotheses have been advanced over the years to over the years to explain this fact. Culture certainly plays a role in the relatively low U.S. per capita seafood consumption vis-à-vis other animal protein sources. Prior to the large increases in world aquaculture production (and export of much of this product in the trade market), the argument was made that limited.

U.S. per capita seafood consumption reflected, at least in part, limited available supply. Other arguments advanced for the observed relatively low per capita consumption of seafood in the United States vis-à-vis other animal proteins include the high price of seafood relative to other protein sources, the fragmentation of the seafood industry (both the large number of products being produced and the geographical sectors) making it difficult to sustain marketing campaigns, consumer fears associated with the consumption of seafood (e.g., mercury), and a lack of knowledge by the 'average' person on how to cook seafood.[6]

As important as the absolute levels of consumption of the different protein sources is the relative changes in consumption levels of these protein sources over time. U.S. per capita consumption of beef, as indicated from the information in Table 2.1, fell from an average of 77.6 pounds annually during the first five-year period of consideration (i.e., 1980-84) to 61.2 pounds during the most recent five-year period (i.e., 2007-11); or by more than 20%. The decline in U.S. per capita pork consumption, by comparison, was much more moderate (about 8%) with consumption averaging 52.9 pounds per capita annually during 1980-84 and 48.8 pounds per capita in 2007-11. The decline in beef consumption and to a lesser extent pork consumption has come at the expense per capita chicken consumption which increased from an average of about 50 pounds during the early 1980s to 84 pounds during the most recent five-year period. While contributing only a small share of the protein budget, consumption of fish increased almost 20% during the period of analysis from 13.1 pounds per capita during 1980-84 to an average of 15.8 pounds per capita during 2007-11.

Several explanations have been advanced in an attempt to explain the relative changes in per capita consumption of the different protein sources. Relative price changes are one explanation. As indicated in Table 2.2, the Consumer Price Index for beef (1982-84 = 100) increased by approximately 125% from 1980-84 average to the 2007-11 average.

Table 2.2 Consumer Price Index for Meat, Poultry, and Seafood (1982-84 = 100), 1980-2011

| Year | Seafood | Beef | Pork | Poultry | Total Meat |
|---|---|---|---|---|---|
| 1980 | 87.50 | 98.36 | 81.88 | 93.64 | 92.66 |
| 1981 | 94.80 | 99.20 | 89.47 | 97.49 | 96.03 |
| 1982 | 98.20 | 100.61 | 101.03 | 95.78 | 100.65 |
| 1983 | 99.30 | 99.12 | 100.12 | 96.94 | 99.51 |
| 1984 | 102.50 | 100.27 | 98.84 | 107.27 | 99.84 |
| 1985 | 107.50 | 98.16 | 99.08 | 106.23 | 98.88 |
| 1986 | 117.40 | 98.76 | 107.17 | 114.27 | 101.99 |
| 1987 | 129.90 | 106.26 | 115.94 | 112.58 | 109.65 |
| 1988 | 137.40 | 112.08 | 112.46 | 120.71 | 112.18 |

[6] A recent Wall Street Journal article (4/15/2014) "Why People are Eating Less Fish" (accessible at: http://online.wsj.com/news/articles/SB10001424052702304688104579465721070784980)provides some additional detail on many of these factors.

(Table 2.2 continued)

| Year | Seafood | Beef | Pork | Poultry | Total Meat |
|---|---|---|---|---|---|
| 1989 | 143.60 | 119.34 | 113.18 | 132.67 | 116.70 |
| 1990 | 146.70 | 128.75 | 129.78 | 132.48 | 128.45 |
| 1991 | 148.30 | 132.44 | 134.12 | 131.47 | 132.54 |
| 1992 | 151.70 | 132.26 | 127.82 | 131.41 | 130.65 |
| 1993 | 156.60 | 137.09 | 131.66 | 136.93 | 134.63 |
| 1994 | 163.70 | 135.95 | 133.88 | 141.54 | 135.35 |
| 1995 | 171.60 | 134.85 | 134.83 | 143.47 | 135.47 |
| 1996 | 168.00 | 134.48 | 148.18 | 152.43 | 140.15 |
| 1997 | 174.00 | 136.76 | 155.89 | 156.63 | 144.36 |
| 1998 | 180.00 | 136.52 | 148.45 | 157.14 | 141.63 |
| 1999 | 185.30 | 139.20 | 145.88 | 157.91 | 142.33 |
| 2000 | 190.40 | 148.11 | 156.51 | 159.82 | 150.73 |
| 2001 | 191.10 | 160.47 | 162.39 | 164.86 | 159.30 |
| 2002 | 188.10 | 160.60 | 161.75 | 167.04 | 160.27 |
| 2003 | 190.00 | 175.08 | 164.86 | 169.08 | 168.91 |
| 2004 | 194.30 | 195.30 | 174.20 | 181.70 | 183.20 |
| 2005 | 200.10 | 200.40 | 177.70 | 186.70 | 187.50 |
| 2006 | 209.50 | 202.10 | 177.30 | 182.00 | 188.80 |
| 2007 | 219.09 | 211.06 | 180.91 | 191.36 | 194.98 |
| 2008 | 232.12 | 220.59 | 185.03 | 200.90 | 201.82 |
| 2009 | 240.56 | 218.27 | 181.37 | 204.22 | 200.55 |
| 2010 | 243.23 | 225.41 | 189.04 | 203.98 | 206.70 |
| 2011 | 260.49 | 248.98 | 205.30 | 209.92 | 225.50 |

Source: USDA ERS Food Consumption Food Availability Spreadsheets Fish and Shellfish

The index for pork, by comparison, approximately doubled while the poultry price index also approximately doubled. The seafood price index which averaged about 97 during 1980-84 finished the period at an average of 239 indicating an increase approximating 150%. Based on a Rotterdam model covering the period from 1976 through 1993 (quarterly data) and including both a health information index and advertising expenditures on the respective products in the model , Kinnucan et al. (1997) suggest that while change in relative prices have influenced consumption patterns of different protein sources (compensated own-price elasticities equal to -0.444 for beef, -0.688 for pork, -0.158 for poultry, and -0.885 for seafood), the dissemination of health-related cholesterol information also significantly influenced consumption patterns. Specifically, the authors found that poultry benefitted from dissemination of cholesterol information largely at the expense of beef. The researchers further found that pork and seafood were largely unaffected by health information. With respect to the influence of advertising, the researchers found parameter estimates to be generally unstable and, as such, caution should be employed when making claims about the efficacy of generic promotion programs.

One factor that distinguishes seafood consumption from other animal protein commodities is that expenditures for seafood occur overwhelming in the away-from-home market. In 2010, for example, U.S. consumers spent an estimated $79.7 billion on edible seafood products. Of this total, an estimated $54.0 billion in expenditures was at food service establishments while $25.8 billion of the total was on retail sales for at-home consumption (NMFS, 2010). This translates to more than two-thirds of U.S. seafood expenditures on edible seafood occurring in the away-from-home market. By comparison, total U.S. food expenditures away from home as a proportion of total food expenditures in 2010 equaled 42.2%.[7] This 42.2% represents a significant increase when compared to the 1980 figure of 32.0%.

### 2.3 Seafood: A Closer Look

#### 2.3.1 Consumption by Product Form

Annual U.S. per capita seafood consumption (edible weight) for 1980 through 2012 is illustrated in Figure 2.1. As indicated, annual per consumption gradually increased from 1980 through 2004, at which point it equaled 16.6

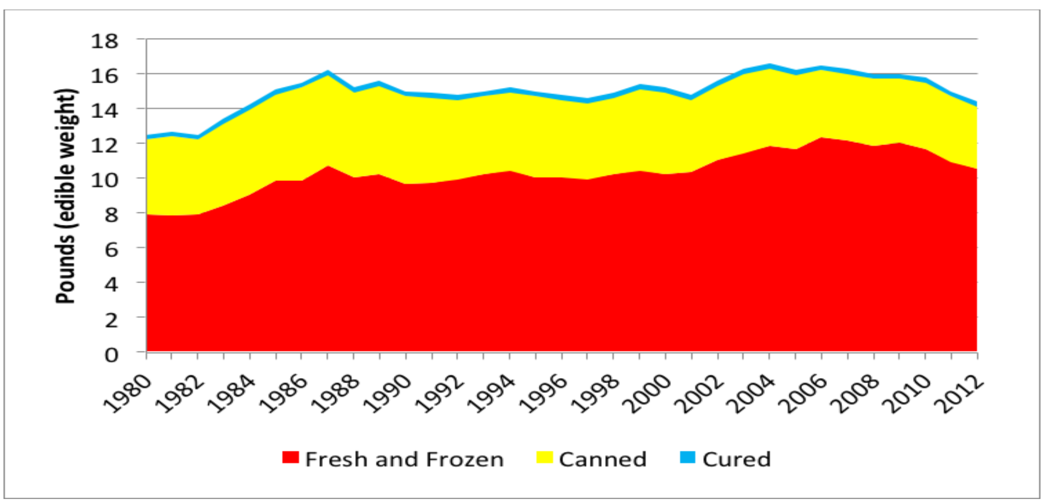


Figure 2.1 U.S. Per Capita Consumption of Edible Seafood.

[7] Source: Economic Research Service; available at: http://www.ers.usda.gov/topics/food-choices-health/food-consumption-demand/food-away-from-home.aspx

pounds. Thereafter, per capita consumption tended to decline with per capita consumption in 2012, equal to 14.4 pounds, being the lowest observed figure since 1984 when per capita consumption equaled 14.2 pounds. While per capita consumption generally trended upward from 1980 through 2004. Consumption, for example, increased by more than two pounds per capita between 1982 and 1985; from 12.5 pounds to 15.1 pounds. It increased by another pound per capita in the next two years (from 15.1 pounds to 16.2 pounds) but this increase was followed by a prolonged decline through 1992 by which time per capita consumption had fallen to 14.8 pounds. A similar rapid increase in per capita consumption was apparent during the four-year period ending in 2004 at which point per capita consumption had reached a record 16.6 pounds. Thereafter, per capita consumption generally declined with the decline between 2010 and 2012 being particularly pronounced (i.e., from 15.8 pounds to 14.4 pounds).

As also indicated by the information in Figure 2.1, the majority of seafood consumption is of the fresh or frozen category and, for all intents and purposes, all growth (reductions) in annual per capita consumption can be explained by changes in consumption of the fresh or frozen category. During the early 1980s, annual consumption of fresh and frozen seafood averaged less than eight pounds per capita. By the 1990s, per capita consumption of this generic product form had consistently exceeded nine pounds and in many years during the 1990s exceeded ten pounds. By the early 2000s, U.S. consumption of fresh and frozen seafood had advanced to more than 11 pounds per capita and reached its maximum, 12.3 pounds, in 2006 after which point consumption then trended downward with the 2012 per capita consumption, 10.5 pounds, equaling only 85% of that observed six years earlier.

Whereas U.S. per capita consumption of fresh and frozen seafood gradually trended upward through the mid-2000s, a different picture emerges when one looks at canned seafood. Specifically, per capita consumption of canned seafood shows some moderate growth during the 1980s but thereafter shows a relatively steady decline. Per capita consumption of canned seafood during the five-year period ending in 2012 averaged only 3.8 pounds annually, or less than 85% of that observed during the first five years of the 1980s and less than three-quarters of that reported during the mid-to-late 1980s. Finally, consumption of cured seafood has remained unchanged, at 0.3 pounds per capita, since 1980.

### 2.3.2 Sources of Edible Seafood Supply

In the broadest sense, the U.S supply of edible seafood is derived from two sources; domestic commercial harvest and imports. Supply from these two sources, as indicated in Figure 2.2 increased from about eight billion pounds (round weight) annually during the early 1980s to a figure approaching 20 billion pounds annually in recent years.

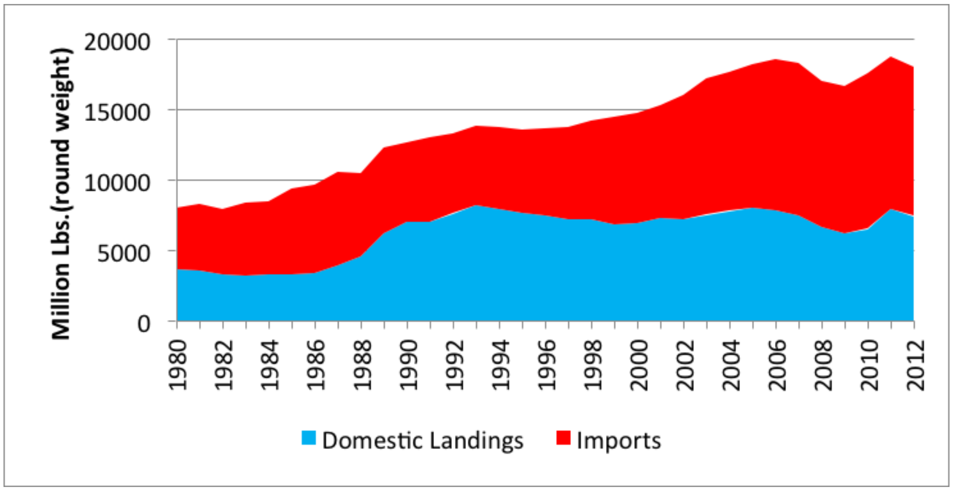


Figure 2.2 Sources of U.S. Edible Seafood Supply, 1980-2012

Domestic production, as indicated, increased sharply during the 1980s but has since remained stable in the seven to eight billion pound range annually. Edible seafood imports, on the other hand, have increased from four to five billion pounds annually during the early 1980s to 10 billion to 11 billion pounds annually in more recent years. Supply, of course, does not necessarily represent domestic consumption because product can be exported. U.S. exports of edible seafood are sizeable, averaging about 5.6 billion pounds (round weight) since 2008. Most of the exported product is derived from domestically harvested product vis-à-vis imports that are subsequently exported.

In general, the U.S tends to import higher valued seafood products and export lower valued products. In 2012, for example, U.S. imports of edible products were valued at \$16.7 billion based on 5.4 billion pounds (product weight). This translates to an import price equal to \$3.10 per pound. U.S. exports of edible seafood, on the other hand, were valued at \$5.5 billion based on exports of 3.3 billion pounds (product weight); or \$1.68 per pound. Asia, in recent years, has accounted for about 60% of U.S. imports of edible seafood by volume, followed by North America (15%-20%), South America (10%), and Europe (5%-7%). While Asia is the primary exporter of edible seafood to the United States, it is also the largest buyer of U.S. exports of edible seafood accounting for about 60% of the total in recent years. However, whereas U.S. imports from Asia were valued at \$2.45 per pound in 2010, its exports to Asia in the same year were valued at only $1.26 per pound. Similarly, whereas U.S. exports of edible seafood products to North American countries (largely Canada) in 2010 were valued at $2.62 per pound, its imports from North American countries (largely Canada and Mexico) entered the United States at an average price of $3.45 per pound.

A closer examination of primary products being imported to the United States and exported from the United States helps to explain the large differential between import price and export price. Shrimp in recent years, for example, has consistently accounted for more than 25% of the total value of U.S. imports of edible seafood and imports of shrimp in 2010, equal to 1.6 billion pounds (heads-off weight) accounted for over 90% of U.S. supply of that product. Other imported products of significance include salmon ($1.7 billion or about 12% of the total value of edible seafood imports), and lobster (approximately $800 million or about 6% of the total value of edible U.S. imports). U.S. exports of edible seafood was dominated by fresh and frozen salmon ($592 million), lobsters ($440 million) and surimi ($287 million). Interestingly, U.S. exports of fresh and frozen salmon sold for an average price of $1.66 per pound while imports of the same product were valued at almost $3.50 per pound. Similarly, while U.S. exports of lobsters were sold for a price equal to about $5.60 per pound, the import price was $8.70 per pound.

### 2.3.3 Consumption of Primary Species

U.S. per capita consumption by species (top ten) for selected years is given in Table 2.3.

Table 2.3 U.S. Per Capita Consumption of Top Ten Species for Selected Years (Source: National Fishing Institute)

| 1994 | | 2001 | | 2006 | | 2012 | |
|---|---|---|---|---|---|---|---|
| | Lbs. | | Lbs. | | Lbs. | | Lbs. |
| Canned tuna | 3.3 | Shrimp | 3.40 | Shrimp | 4.40 | Shrimp | 3.80 |
| Shrimp | 2.5 | Canned tuna | 2.90 | C. tuna | 2.90 | Canned tuna | 2.40 |
| Pollock | 1.5 | Salmon | 2.02 | Salmon | 2.03 | Salmon | 2.02 |
| Salmon | 1.1 | Pollock | 1.21 | Pollock | 1.64 | Tilapia | 1.48 |
| Cod | 0.9 | Catfish | 1.15 | Tilapia | 1.00 | Pollock | 1.17 |
| Catfish | 0.9 | Cod | 0.56 | Catfish | 0.97 | Pangasius | 0.73 |
| Clams | 0.5 | Clams | 0.47 | Crabs | 0.66 | Crabs | 0.52 |
| Flatfish | 0.4 | Crabs | 0.44 | Cod | 0.51 | Cod | 0.52 |
| Crabs | 0.3 | Flatfish | 0.39 | Clams | 0.44 | Catfish | 0.50 |
| Scallops | 0.3 | Scallops | 0.35 | Scallops | 0.31 | Clams | 0.35 |
| Total (all) | 15.2 | Total (all) | 14.8 | Total | 16.2 | Total (all) | 14.4 |

In 1994, as indicated, total U.S. per capita consumption of seafood equaled 15.2 pounds. More than one-fifth of this total was canned tuna while shrimp accounted for an additional 16%. Pollock, used to produce surimi, accounted for an additional 10% of total per capita consumption while salmon, with a per capita consumption of 1.1 pounds, accounted for about seven percent. Overall, the top ten species represented about three-quarters of the total per capita consumption of 15.2 pounds.

By 2001, per capita consumption of shrimp had increased by more than a third (i.e., from 2.5 pounds to 3.4 pounds) and it replaced canned tuna as the most popular seafood species. Per capita consumption of salmon nearly doubled from 1.1 pounds to 2.02 pounds while per capita consumption of catfish increased from 0.9 pounds to 1.15 pounds (approximately 25%). Canned tuna consumption fell by about 15% to 2.9 pounds per capita.

Per capita shrimp consumption in 2006 equaled 4.4 pounds which exceeded the value for 2001 (i.e., 3.4 pounds by 30% and the 1994 value (2.5 pounds) by 75%. Tilapia, which was not even among the top ten most popular species in 2001 was the fifth most popular species (in terms of per capita consumption) by 2006 with per capita consumption equaling one pound. Per capita consumption of canned tuna and salmon, on the other hand, remained virtually unchanged between 2001 and 2006. Combined, the ten most popular species in 2006 represented more than 90% of all seafood consumed (i.e., 16.2 pounds) in that year.

In a reversal of the trend from previous periods, per capita shrimp consumption in 2012, equal to 3.8 pounds, was about 15% below that reported in 2006 while per capita consumption of canned tuna fell by a similar proportion. Per capita consumption of salmon, on the other hand, remained constant between 2006 and 2012 at 2.0 pounds. Pangasius, not even recognized in 2006, achieved a sixth place ranking in 2012 while the ranking associated with catfish slipped from sixth place in 2006 to eighth place in 2012 due to a reduction in per capita consumption from 0.97 pounds to 0.50 pounds.[8]

Comparing per capita consumption of the most popular species over selected years leads to the undeniable fact that, in general, changes (growth) in per capita consumption of many of the most popular species is related to those species where aquaculture production of these species have advanced. For example, significant proportion of the

[8] Catfish and Pagasius are of the same family of fish and much of the decrease in catfish consumption between 2006 and 2012 is the result of a Congressional mandate that only catfish produced in the United States could be labeled as catfish. Thus, imports, once labeled as catfish, now enter the market as Pagasius. Thus, for all intents and purposes, per capita consumption of catfish in 2012 equals the summation of catfish and Pagasius (i.e., 1.23 pounds).

world production of shrimp, salmon, tilapia, catfish, and Pagasius is all produced in an aquaculture-based setting and there has been a significant increase in production of these species in recent decades. With respect to shrimp, for example, aquaculture production increased form less than 100 million pounds (live weight) in 1980 to 8.3 billion pounds in 2012 (Food and Agriculture Organization). Similarly, production of salmon in an aquacultural setting increased from 17 million pounds in 1980 to 4.6 billion pounds in 2012. Finally, production of tilapia in an aquacultural setting was only about 160 million pounds (live weight) in 1980 but had advanced to 7.8 billion pounds by 2012 (FAO).

Exports of these species to the United States have increased in relation to the aquaculture-based production of these species. U.S. imports of shrimp, for example, increased from about 260 million pounds (heads-off weight) in 1980 to 1.5 billion pounds in 2012 (NMFS, 2012). Imports of fresh and frozen salmon, which were less than 100 million pounds in 1980, equaled 1.6 billion pounds in 2012 (NMFS, 2012). Finally, U.S. imports of tilapia advanced from less than 10 million pounds in 1991 to more than 500 million pounds in 2012.

In summary, much of the growth in absolute U.S. edible seafood supply and changing composition of species being consumed in recent decades appears to be related to advances in aquaculture production of selected species. As further advances are made in the raising of other species, one might expect to see further changes in the seafood products considered to be most ‘popular’ by the U.S. consumers.

# CHAPTER 3 SEAFOOD IN A COMPLETE DEMAND FRAMEWORK

### 3.1 Introduction

Analysis of those factors influencing U.S. seafood demand at both the aggregate and disaggregate levels (e.g., individual species) has been the focus of several studies over the past several decades. These studies have utilized both time-series and cross-sectional data with those using time-series data generally analyzing the demand for individual species/groups of species.[1] One inherent weakness associated with time-series studies is their general inability to be used in examining the influence of household characteristics on demand with their primary strength vis-à-vis cross-sectional studies historically being their ability to provide estimates of own-and-cross price elasticities and test for structural changes in demand over time.[1] Marketing efforts, however, are often less concerned with price elasticities than how programs can be tailored to partitioned groups of households where the groups possess different characteristics (e.g., household size, race, income).

The overall goal of this chapter is to model the demand for generic seafood products (i.e., seafood product forms) and other animal protein commodities in a complete demand system framework. The analysis, based on cross-sectional data, examines influence of demographic demand shifters on expenditure shares for generic seafood products (i.e., fresh seafood, frozen seafood, and prepared seafood) as well as other animal protein commodities (beef, pork, and chicken). In addition, the impact of prices on expenditure shares is examined via own-and-cross price elasticities. Finally, theoretical literature examining the role of quality on price and demand dates back to the 1950's (Theil, 1951; Houthakker, 1951). Yet, quality is only infrequently considered in cross-sectional analysis despite the fact that Cramer (1973) asserted that demand analysis is usually based on composite commodities rather than elementary goods.[9] As one moves from the elementary good level to the composite commodity level, one can expect increased heterogeneity in the good/commodity being examined and an increase in price variation associated with that good/commodity. The influence of quality on expenditure shares of generic seafood products and other animal protein commodities is examined in this chapter based on the premise that there is a positive relationship

[9] A composite commodity can be defined as a collection of elementary goods.

between income (or other household characteristics) and price.[10] To do so, two techniques are employed. The first technique, proposed by Cox and Wohlgenant (1986), entails adjusting prices to account for variations in quality across households. The second technique involves developing quality proxies for the generic seafood products and other animal protein commodities and using these proxies as instruments in the expenditure share equations. These two techniques are compared amongst themselves and also compared to results that do not take quality adjustment into account.

### 3.2 Literature Review

Early cross-sectional demand studies focused primarily on assessing the relationship between income and consumption (i.e., the Engel curve) and the influence of household characteristics on consumption. Variation in prices associated with any good/commodity would, it was believed, reflect differences in quality in which case the demand for quality (as measured by the quality elasticity) could be derived by subtracting the quantity elasticity with respect to income from the expenditure elasticity with respect to income (see George and King, 1971). Keithly (1985) employed this technique to examine at-home seafood demand in aggregate and for generic products (i.e., fresh, frozen, and canned) using the 1977/78 United States Department of Agriculture (USDA) Nationwide Food Consumption Survey. The author found positive income elasticities for at-home consumption of seafood in aggregate and for all generic products. Furthermore, expenditure elasticities with respect to income consistently exceeded the corresponding quantity elasticities implying a positive demand for quality with respect to a change in income for at-home seafood consumption in aggregate and by generic product. He also found a large proportion of demographic variables statistically significant in explaining expenditures and/or quantity by generic product form including region, race, and urbanization.[11]

Cox et al. (1984) argued that variation in price for a given commodity/good across households results from more than simply variation in quality (i.e., the aggregation across heterogenous commodities). Specifically, prices may also vary across households as a result of seasonal variation in the supply of a product or as a result of, say, transportation costs that result in prices increasing in association with distance from where the commodity is

[10] Due to estimation limitations, analysis of quality in this chapter assumes that quality and quantity demanded are not simultaneously determined. Consideration to quality and quantity demanded being simultaneously determined is given in the next chapter.
[11] In the literature, the term 'demographic factors (or variables)' is used to denote demand shifters related to the individual household, such as region, race, or urbanization.

produced.[12] This being the case, the authors noted that failure to include price(s) in cross-sectional demand analysis may result in biased estimates of relevant parameters, including the income parameter and that Engel analysis may be inappropriate.[13] To investigate the role of prices in disaggregated cross-sectional analysis of food consumption, Cox et al. (1984) analyze household demand for fresh potatoes (with substitute products being frozen/canned and dehydrated potatoes) based on the 1977/78 USDA Nationwide Food Consumption Survey. As is the case with disaggregated cross-sectional data, not all households consume (purchase) all products and collected information on purchases generally includes expenditures and quantities from which price can be 'retrieved' for those households consuming the considered good/commodity. However, no price can be retrieved among the non-consuming households.[14] As noted by Cox et al (1984), elimination of the non-consuming households might result in selection bias. As proxies for missing prices, therefore, the authors used the mean price stratified by area (Mountain or Pacific) and season (i.e., quarter) and the analysis was conducted using a maximum likelihood Tobit procedure to account for truncation of the dependent variable (quantity of fresh potatoes). The results, including statistically significant own-price elasticity of the expected sign, suggested that including prices in cross-sectional demand analysis warrants consideration.

Based on the hypothesis that observed price variations across households for a specific commodity/good reflect not only supply-related variability but also variability resulting from demand for quality, Cox and Wohlgenant (1986) proposed that deviations from regional/quarterly mean prices reflect quality effects related to household characteristics and/or other non-supply related factors. These deviations, they argued, can be expressed as:

$\mathrm{RDMP} = p_i - \alpha_i = \sum_j \Upsilon_{ij} b_{ij} + e_{ij}$

where RDMP represents the deviations from regional/quarterly mean prices among consuming households, $\alpha_i$ represents the mean regional/quarterly price, $e_{ij}$ represents the regression residual, and $b_{ij}$ represent household characteristics serving as proxies for household preferences for the unobserved quality characteristics. Quality adjusted prices ($p_i^*$) can then be represented as:

$p_i^* = \alpha_i + e_i$

where $e_i$ represents the residual term from the deviations (RDMP) equation.

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[12] Note that there should be no price variation due to seasonality in a 'pure' cross-sectional data set. However, many consumption studies are based on datasets that are stratified by season.
[13] This is elaborated upon by Cox and Wohlgenant (1986).
[14] The degree of truncation can be large when one considers highly disaggregated commodities/goods with the level of truncation among the three products ranging from about 30% to more than 90%.

Using this quality-adjusted price procedure, the researchers estimated RDMP price/quality functions demand functions) for vegetable commodities (fresh, canned, and frozen) based on the USDA's 1977-78 Nationwide Food Consumption Survey (western region). Estimated parameters associated with the price/quality function were used to generate prices for non-consuming households.

Results, in general, agreed with *a priori* expectations with all own-price effects being negative and statistically significant. However, the RDMP equations exhibited low R-squared values indicating that adjustment for quality effects did not fully capture price variation. As noted by the authors furthermore "…assuming a correct model specification, the bias on income and family size elasticities because of a failure to model nonconstant price effects was found to be small (p. 918)." They go on to state "…while the conceptual structure clearly indicates the potential difficulties of not correctly modeling cross-sectional price effects, these difficulties appear to be minor for the disaggregated and relatively homogeneous commodities considered. Whether these results will hold for more aggregated and/or less homogeneous commodities is an empirical issue worthy of further research."

While not related to seafood consumption, these two studies (i.e., Cox et al., 1984 and Cox and Wohlgenant, 1986) are of relevance to the current study. Cox et al. (1984) provides one of the earlier attempts to incorporate prices in cross-sectional demand analysis; thus allowing one to derive own-and-cross price elasticities when working with cross-sectional data. This study generated interest in the use of cross-sectional data in demand analysis and is included here for that purpose. The second study (Cox and Wohlgenant, 1986) further considered the potential bias that may result from not including prices in cross-sectional demand analyses and also provided a 'structured' methodology to adjust unit costs for quality variation.

Cheng and Capps (1988), noting a paucity of information on demand parameters for disaggregated finfish and shellfish species, particularly at the retail level, utilized a 1981 Seafood Consumption Survey conducted by the Research Corporation of America for the National Marine Fisheries Service to examine at-home demand for a number of seafood species including both shellfish (crabs, oysters, and shrimp) and finfish (cod, flounder/sole, haddock, perch, and snapper) species. To circumvent the statistical problems associated with deleting non-consuming households for which no price is observed (i.e., inconsistency and selectivity bias), Cheng and Capps (1988) employ a Heckman two-stage procedure. This then allows for Ordinary Least Squares or Generalized Least Squares with estimation only involving non-zero observations (see Cheng and Capps for additional details on procedure). Estimated own-price elasticities for all species (and finfish in aggregate and shellfish in aggregate) were all negative and statistically significant at the 10% level. Substitute products considered by Cheng and Capps (1988) included poultry and red meat and, in general, these substitute products were not found to statistically influence expenditures on disaggregated fishery species. Other significant findings by Cheng and Capps (1988) include: (a) households in the South tended to spend more on seafood than households in other regions, (b) nonwhite households, in general, tended to spend more on fresh and frozen products than did white households, and education level was, in general, not found to be a contributing factor in explaining seafood purchases for at-home consumption.

Yen and Huang (1996) examined the at-home demand for finfish based on the1987-88 U.S. Nationwide Food Consumption Survey (conducted by Human Nutrition Information Service of the USDA) based on a final sample of 4,066 households. As noted by the authors, unit values (prices) are not defined for non-consuming households which can present a challenge when conducting demand analysis based on cross-sectional data. Noting difficulties associated with the use of multiple predicted prices (via regression analysis as proposed by Cox and Wohlgenant, 1986), the authors opt for use of a more 'practical' approach for imputing missing prices; that being averages of unit values based on geographic region and season.[15] For estimation purposes, the authors employ a limited dependent variable model that accounts for both participation and consumption decisions (i.e., a double-hurdle model).[16] The authors found that own-price was negative and statistically significant with a 1% increase in the finfish price resulting in a 0.47% decrease in probability of consumption and the conditional level of consumption by 0.62%. The probability of participation was found to be positively related to an increase in household income but the conditional level of consumption was not found to be influenced by a change in income. The income elasticity, equal to 0.1%, suggests, as noted by the authors, that finfish consumption is not likely to increase significantly as household income increases. Additional findings of relevance include: (a) the probability of consumption is higher among urban households than among non-urban households, (b) black and other non-white households have a higher probability of consumption as well as the conditional level of consumption than do white households and, conditional on consumption, can be expected to consume about 2.3 pounds more per week than white households,

[15] The authors note that use of multiple predicted prices introduces heteroskedasticty in the error terms and that it is impossible to derive consistent estimates for the unit values independent of the quantity equation.

[16] As noted by the authors, use of the simple Tobit model which had been employed in cross-sectional seafood demand analyses (e.g. Keithly, 1985) tends to be very restrictive with respect to estimation of relevant parameters because those parameters that determine the probability of consumption are also assumed to determine the level of consumption.

and (c) there was no evidence that higher educational attainment resulted in increases in the level of participation or consumption.

Based on information on 3,600 households generated from a telephone survey conducted from April through June 1988, Kinnucan et al. (1993) attempted to determine what factors shape U.S. consumer preferences for fish and shellfish. In general, three sets of variables – (1) psychological variables consisting of those factors that may influence beliefs about seafood product attributes, (2) experience variables consisting of those factors that indicate a consumer's general knowledge of fish and shellfish, and (3) socioeconomic variables – were used to examine the their respective roles in determining seafood product (i.e. individual species) choice. Results indicate that preferences tend to be influenced by source availability (e.g., scallops are harvested in the eastern U.S. and thus most frequently enter the evoked sets among households residing in the east). Preferences, with the exception of catfish and lobster, tended to be invariant to income (higher income households tended to shy away from catfish and preferred lobster). Occupational categories and educational levels were also found to influence preferences for a number of species.

Arguably, the most complete and detailed analysis of U.S. seafood demand to date (certainly based on cross-sectional data) is that conducted by Wellman. Specifically, analysis by Wellman (1992) represents the first attempt to analyze the demand for seafood, by product form, in a complete demand system framework; thus preserving the conditions making the demand equations theoretically consistent.[17] In addition, based on work by Cramer (1973), she included a proxy for quality choice in each of the share equations using a price/income interaction term. As with Keithly (1985), she utilized the 1977/78 USDA Nationwide Food Consumption Survey as the primary data source in the study. Her analysis, based on a variant of the Almost Ideal Demand Systems model, included disaggregated fishery products (fresh fish, frozen fish, prepared fish, miscellaneous fish products, and shellfish) in addition to disaggregated meat products (beef, pork, and other red meats), and poultry (for a total of nine expenditure equations).

[17] An earlier study by Capps and Havlicek (1984) estimated seafood demand in a complete demand framework but no attempt was made to disaggregate seafood into different products. Furthermore, numerous studies have examined the demand for individual seafood species (e.g., salmon, oysters) or groups of species. With few notable exceptions, most of these studies were not based on retail data but instead dockside level data.

As with other researchers utilizing cross-sectional data in demand analyses, Wellman (1992) was confronted with the issue of how to handle those observations with zero expenditures and, hence, missing prices.[18] Under the premise that simply deleting these observations would result in both a loss in efficiency and selection bias, the researcher "recovered" the missing prices by using the average value within clusters (season, division, and urbanization). She justified using this method (referred to as the zero-order method) as opposed to the first-order method (estimating prices in an hedonic framework) based on (a) analysis by Cox (1986) who found insignificant differences in results between the two methods and (b) that the hedonic approach lacks objectivity and theoretical justification.[19] Based on the assumption that zero budget shares for a particular good by any household are censored by an unobservable latent variable (which culminates in the decision whether or not to purchase that good), Wellman estimated the model in a simultaneous equation framework as suggested by Lee (1978). The first stage is modeled as a dichotomous choice problem; i.e., whether or not to consume and is estimated using a probit binary choice technique for each of the nine items households have to select from given their animal protein expenditures. After computing the inverse Mills Ratio for each commodity for each household that consumes (purchases) that commodity, it is then used as an instrument (incorporating the latent variables) in the second stage of the AIDS model.

In general, the results presented by Wellman are supported by economic theory with all but one of the fish products (miscellaneous fish) exhibiting negative (Marshallian) own-price elasticities. With respect to the fishery products exhibiting the theoretically expected negative sign, the lowest own-price elasticity was associated with fresh finfish (-0.06) while the highest one was reported for shellfish (-1.37). Reported own-price elasticities for frozen fish and prepared fish were -0.44 and -0.52, respectively. Own-price elasticities for other animal protein commodities ranged from -0.73 for pork to -0.39 for poultry.[20]

With respect to cross-price elasticities, Wellman (1992) found several of the fish products to be complements to one another (e.g., fresh fish is a complement to frozen fish) which is difficult to reconcile with demand theory. Similarly,

[18] The occurrence of zero expenditures (and missing prices) in cross-sectional analysis is expected to increase in relation to the level of disaggregation and given the level of disaggregation in the analysis by Wellman (1991), the occurrence of missing prices was large ranging from about 5% for beef to about 95% for prepared seafood products.

[19] Cox and Wohlgenant (1986) further suggest that the zero-order method becomes a more attractive method if regional/season price differences reflect, primarily, commodity supply conditions rather than factors that would influence the unit cost via demand for quality.

[20] This excludes 'Other' red meat for which a positive own-price elasticity was reported.

fresh fish was found to be a complement to all of the other animal protein commodities and frozen fish was also found to be a complement to many of the other animal protein commodities.[21]

Estimated expenditure elasticities indicate that fresh fish and shellfish are luxuries (i.e. expenditure elasticities exceeding one) while other fish products are necessities.[22] Other animal protein commodity expenditure elasticites ranged from 0.77 (poultry) to 1.26 (other red meats) with beef and pork expenditure elasticities both approximately equal to one.

Finally, though the model presented by Wellman (1992) was developed in a highly disaggregated manner to begin with (i.e., five fish products), the price/income interaction term was found to significantly improve model results (i.e., expected substitutability effects). As stated by the author "[i]t was found that the addition of a quality proxy led to a change in indirect price elasticities. That is, fish products found to be complementary in the model without a price/income interaction term became substitutes in the model including a quality term. Thus failing to incorporate the consumer's quality choice may result in misrepresentation of the relative status of certain goods and the household's willingness to switch between various fishery products." This, on the surface, would suggest that modeling seafood demand without consideration of the influence of quality may lead to results of dubious nature.
Other results of relevance in the analysis by Wellman (1992) include the following. First, education attainment, in general, was found to have little influence in explaining the variation in household expenditure shares associated with the various seafood products. However, the occupation of the household head was, in general, found to have a statistically significant impact on explaining the variation in household budget shares associated with the various seafood products. The influence of household size (expressed in 21-meal equivalents) exhibited mixed outcomes with it having a significant positive influence on the budget shares for prepared seafood and miscellaneous seafood products. Black households exhibited higher budget shares for fresh seafood than did non-black households but the converse was found for prepared and miscellaneous fish products. Finally season, region, and urbanization were found to be important factors in explaining variation in budget shares for fish products. With respect to season, for example, the budget shares associated with fresh fish were found to be higher in the spring and summer seasons than

[21] Wellman (1992) only provided the Marshallian elasticities and it is likely that some relationships that were found to be complementary would have been substitutes if Hicksian (compensated) elasticities were estimated.
[22] Standard errors (and significance levels) were not presented by Wellman (1992) and hence caution should be exercised when consideration is given to whether fresh fish and shellfish are luxuries and other generic seafood products are necessities. The expenditure elasticity for fresh fish equaled 1.33 while that of shellfish equaled 1.62. The expenditure elasticity for frozen fish (0.95) was very close to 1.

in the winter season while the budget share for prepared fish is higher in the winter season than in the summer or fall seasons. Households in central cities exhibited higher budget shares for fresh and frozen fish, shellfish, and miscellaneous seafood products than did households in rural areas. Relative to households in the Mountain Region, the highest budget share for fresh fish was observed in the Mid-Atlantic Region while the West South Central Region exhibited the highest budget share for shellfish and the New England Region exhibited the highest budget share for miscellaneous fish products.

Coffey et al. (2011) used national panel diary data covering the October 1992 to September 2000 period (collected by the National Purchase Diary Group, Inc.) to examine demand for animal protein commodity sources. Selection of households for the survey was based on stratification both geographically and demographically with each household having the option to continue in the survey for as many months as it chose to do so. The study is unique because it evaluated household meat (and other animal protein) demand at a very disaggregated level. Meat products considered in the analysis included ground beef, beef roast, beef steak, other beef, pork chops, pork roast and ham, and other pork products. Poultry products included in the analysis included miscellaneous poultry, poultry breast, and other poultry products. Finally, two fishery products – finfish and shellfish – were also included in the analysis.

In general, the cross-sectional as well as time-series nature of the data employed by Coffey et al. (2011) provided the framework to analyze both price and non-price demand determinants and the influence of health and food safety information on individual meat product demand. To accommodate issues that arise with missing prices, the researchers regressed observed prices for the different products as a function of the Bureau of Labor Statistics (1992-2000) national average retail prices for similar products in similar months, regional dummy shifters, and consumer income.[23] Indices for meat food safety and health information to which the household may have been exposed were developed based upon the number of articles present in the print media. To accommodate zero expenditures, Coffey et al. (2011) employed an expectations maximization algorithm, originally proposed by Dempster et al. (1977). To make use of this approach, the system is first specified as if it were a complete data set (i.e. non zero expenditures) and estimated based on this specification. Expenditure shares that are zero are then predicted based on parameter estimates predicted within the initial framework (i.e., a complete data set). This

[23] As noted by the authors, retail prices for finfish and shellfish are not available. In lieu of secondary retail price data, average monthly prices were approximated based on the observed survey data.

process yields the predicted (expected) values of the latent shares. Finally, the system is reestimated with expected share values being substituted for the latent shares.[24]

Results presented by the authors are of a mixed nature. Specifically, as noted by the authors, few of the demographic demand shifters were found to statistically influence expenditure shares. Neither the finfish share nor the shellfish shares were found to be statistically influenced by seasonality, regional effects, or household shifters (including number of persons).[25] While not significant, Coffey found that the elasticity with respect to household size was negative for finfish (-0.538) as well as for shellfish (-0.789).While demographic variables were, in general, not found to be statistically relevant in determining expenditure shares, all twelve expenditure elasticities were found to statistically impact expenditure shares. For finfish, the expenditure share equaled 1.16 with the corresponding expenditure share for shellfish equaling 2.08. The majority (nine of twelve) of own-price elasticities (Marshallian) were also found to be statistically significant with the own-price elasticity for shellfish (-4.60) having by far the largest impact. The own-price elasticity for finfish, -2.62, also exceeded all other estimates with the exception of roast and 'other' beef products.[26] Finally, there appears to be relatively limited substitution of other animal protein products for the two fish products (finfish and shellfish) resulting from relative price changes.

### 3.3 Economic and Estimation Considerations

As noted in the Introduction to this chapter, the overall goal of this chapter is to estimate a complete demand system for seafood (by product form) and related animal protein commodities. Specific objectives include: (1) estimation of income and price elasticities associated with the various seafood products and substitute/complement animal protein commodities (2) examine the role of quality in seafood purchases/consumption, and (3) examine the role of other socioeconomic factors on budget shares for seafood products and other animal proteins. To complete these objectives attention must first be given to a number of economic and estimation issues that arise when estimating complete demand systems. These issues are briefly addressed in this section with additional treatment being given when the empirical model employed for the current analysis is presented.

[24] This process is discussed in more detail in a subsequent section of this chapter.
[25] This finding also applies to poultry products and, with very few exceptions, meat and pork products.
[26] Though insufficient information is given by Coffey et al. (2011) to test whether the estimated own-price elasticity for finfish is significantly different than that given for roast (-2.43) or 'other' beef (-2.43), the small differences in estimates would suggest that they are not statistically different.

### 3.3.1 Economic Considerations

**3.3.1.1 Demand Theory and the AIDS Model**[27] Given the assumption of utility maximization subject to a budget constraint and a cost function expressed as *C (p, u),* utility maximization implies an individual (household) minimizes cost *C* or expenditure *E* to attain a utility level *u*:

(1) $$Min.C(p,u) = Min.E(p,u) = \sum_i p_i q_i$$

$$S.T.v(q) = u$$

Where *p* represents a vector of prices faced by the representative consumer, $p_i$ represents the price of the i-th good in the commodity set (i=1,2,..n) and $q_i$ represents the quantity of the i-th good in the same commodity set. A complete demand system consists of n expenditure equations plus one budget constraint. Given the large number of potential goods (and the need to estimate parameter estimates) that could be included in a complete demand system is large, a set of *a priori* restrictions, based on the assumption that consumers preferences are weakly separable between certain groups of goods, are imposed on the system to make it tractable. Specifically, the assumption is made that the preference ordering on the goods in subset G , conditional on the consumption of all other goods not in set G, is independent of the consumption levels of those other goods, then that subset of goods meat (G) is weakly separable.

The Almost Ideal Demand System (AIDS) model, originally proposed by Deaton and Muellbauer (1980), has become the 'model of choice' for analyzing demand in a systems framework due to its simplicity and ability to handle a number of issues (e.g., impacts of advertising, health scares). The model is based on the expenditure share and provides a first order approximation to any demand system. Specifying $w_i$ as the budget share of the i-th good which can be derived by $w_i = \dfrac{p_i q_i}{c(p,u)}$, the AIDS model can be specified as:

(2) $$w_i = \alpha_i + \sum_j \gamma_{ij} \ln P_j + \beta_i \ln(X / P^*)$$

Where $P^*$ is a price index denoted by a translog form:

(3) $$\log p^* = \alpha_0 + \sum_k \alpha_k \log p_k + \frac{1}{2} \sum_j \sum_k \gamma_{kj} \log p_k \log p_j$$

[27] A more complete mathematical treatment of consumer theory and the AIDS model is given in Appendix A.

Due to the translog form of the price index, the AIDS model is nonlinear in nature which can lead to problems in computation. To circumvent this problem, Deaton and Muellbauer suggest that the translog price index be replaced by the Stone Price Index which can be given as:

(4) $\ln p^* = \sum_k w_k \ln p_k$

This modified version is referred to as the Linear Approximation to the Almost Ideal Demand System (LA/AIDS). While often performing well when compared to the AIDS model, Pashardes (1993) and Moschini (1998) illustrated that use of the Stone Price Index can result in estimated parameters being inconsistent. Asche and Wessels (1997), however, note that linear approximation of Almost Ideal Demand System (LA/AIDS) will provide as consistent parameter estimates as the nonlinear AIDS model when both of them are evaluated at the mean price value.

The AIDS model provides an attractive framework for demand-based research since it not only satisfies the basic restrictions upon which demand theory is based —adding-up, homogeneity and symmetry, but also permits convenient quantification of elasticities.[28] The adding-up requirement imposes the restriction that the estimated expenditure shares add up to total expenditures:

(5) $\sum_i \alpha_i = 1, \sum_i \gamma_{ij} = 0, \sum_i \beta_i = 0$

Homogeneity of degree zero implies that in response to the proportional change in price and income, the expenditure share for each commodity/good remains unchanged.

(6) $\sum_j \gamma_{ij} = 0$

The Slustky symmetry stems from the fact that the Hessian of the expenditure function is symmetric. In the process of demand analysis, Slutsky symmetry will ensure the consumers' consistency which was realized by the Jacobian of the Hicksian demand function. The Slustky symmetry can be expressed by:

(7) $\gamma_{ij} = \gamma_{ji} \; \forall i \neq j$

As noted, the LA/AIDS and AIDS models are locally identical at the point of normalization. Moreover, LA/AIDS also provide consistent elasticities when the price is normalized to unity. The normalized price is used in the following formulas to calculate the elasticities as proposed by Chafant (1987). The Marshallian price elasticity for good i with respect to good j can be expressed as:

[28] The added attractiveness of the AIDS model for this study is that other "popular" complete demand systems, such as the Rotterdam Model, require time-series data for estimation.

$$(8)\ \varepsilon_{ij}^{M} = -\delta + (\frac{\gamma_{ij}}{w_i}) - (\frac{\beta_i}{w_i}) w_j$$

As noted by Asche and Wessels (1997), at the point of price nomalization, the Marshallian price elasticity is identical between AIDS model and Linear Approximation Almost Ideal Demand System.

The expenditure elasticity can be expressed as:

$$(9)\ \eta_i = 1 + \frac{\beta_i}{w_i}$$

The Hicksan or compensated elasticities can transformed from Marshallian elasticites by the Slutsky equation.

$$(10)\ \varepsilon_{ij}^{H} = \varepsilon_{ij}^{M} + w_j \cdot \eta_i$$

**3.3.1.2 Demographic Translating**

As noted by Pollak and Wales (1992), demographic variables, such as family size and composition, play an important role in household demand and purchasing behavior. The restrictions imposed on any demand system, however, raises the issue of how one can introduce these demographic factors into a system of demand equations while still maintaining the established demand properties (e.g., homogeneity). The two common approaches for introduction of demographic variables into the demand system are 'demographic translating' and 'demographic scaling'. Let *S* represent demographic variables such as family size, urbanization, employment status and let *d* represent a linear function or an exponential function of these demographic variables:

$$(11)\ d_i = f(S_{1,} S_2, ......, S_k) = \sum_k R_{ki} S_k$$

$$(12)\ d_i = \Pi_k S_k^{Rk_i}$$

The original demand function can be modified by:

$$(13)\ q_i(p, x) = d_i + f_i(p, x - \sum p_k d_k)$$

Where *d*'s are translating parameters. Pollak and Wales (1992) show that the modified demand system can be derived from its utility function $u(q) = u(q_1 - d_1, ......, q_n - d_n)$ and the indirect utility function is equal to $v(p, x) = v(p, x - \sum_k p_k d_k)$ if the original demand function is confirmed to be theoretically plausible. Heien and Pompelli (1989) extended the demographic translating to share equations such as Almost Ideal Demand System:

(14) $w_i = \alpha_i^* + \sum_j \gamma_{ij} \ln p_j + \beta_i \ln(\frac{x}{p^*})$

where $\alpha_i^* = \alpha_{i0} + \sum_k \alpha_{ik} s_k$

The specification of the adding up restriction for this share equation is given:

(15) $\sum_i \alpha_{i0} = 1; \sum_i \alpha_{ik} = 0 \ (k = 1....s)$

### 3.3.1.3 Accounting for Quality

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. As noted by Okrent and Alston (2011), demographic, regional, and seasonal variables have been used by some researchers (e.g., Gao et al. (1995), Huang and Lin (2000) to proxy quality and quality-adjusted prices and these studies generally employ a method proposed by Cox and Wohlgenant (1986). Referring to research by Wales and Woodland, however, Yen and Huang (1996) argue against the method suggested by Cox and Wohlgenant due to the fact that use of the approach would inevitably introduce heteroskedasticity in the error terms (which, in turn, would greatly complicate estimation in a system framework). Based on the premise that the demand for quality is positively related to income, Cramer (1973) suggests adding a price/income interaction term in the estimated demand equation. Wellman (1992) employed this approach in her system of equations developed to analyze seafood and other animal protein commodity demand.

### 3.3.2 Estimation Considerations

The analysis of complete demand systems in a cross-sectional framework generally raises issues with respect to two primary factors. The first is the treatment of missing prices. The second is the treatment of zero expenditures. These two issues are briefly considered below.

#### 3.3.2.1 Missing Prices

As noted, use of cross sectional data in demand system analysis often results in a large percentage of observations for which expenditures on goods in the system are equal to zero and, hence, missing prices. The percentage of observations exhibiting zero expenditures increases, furthermore, as the level of disaggregation in the analysis increases. Several methods have been proposed to 'treat' missing prices; some of which were briefly discussed in previous sections of this chapter. The simplest method for handling missing prices is, of course, to merely delete those observations where non-consumption occurs. This approach, however, is recommended only when the percentage of missing values is not 'excessive' since doing so may result in selectivity bias.

Another approach for handling missing prices is to impute prices for those observations where they are missing (i.e., zero expenditures on the good). Within the large family of imputation methods, mean imputation (referred to as the zero-order method) and regression imputation (referred to as the first-order method) are considered as two possible solutions to the incomplete data problem. The zero-order method is commonly used as it provides an appropriate average value for the missing values. Based on this method, each missing price of a household is estimated as the average price for the households in a similar setting (e.g., region and season). The justification for using this average price is that observed differences in prices for a given good among households is the result of, say, different geographical locations that results in different transportation costs being added to the 'base' price. Similarly, prices may be expected to vary by season due to supply variations associated with the commodity being considered.[33] This may be particularly the situation when considering fresh items such as fruits or vegetables.

In theory, the missing prices can be imputed based on a combination of a large number of factors (e.g., clusters defined by region and season and level of urbanization) though doing so would, of course, reduce the number of observations for which prices are observed. Cox et al. (1984) utilized this method to analyze household demand for fresh potatoes. Similarly, the values used by Wellman (1992) in her analysis constituted average values within clusters defined by season, geographical region, and level of urbanization.

The first-order method for imputing missing prices is a regression-based technique. Specifically, based on the assumption of that there is a relationship between the missing price and other variables, hedonic price technique is applied to estimate missing price values. This procedure, originally proposed by Cox and Wohlgenant (1986), allows for examination of price variation across households resulting from supply-based influences (e.g., regional price differences resulting from differences in transportation costs and seasonal variations in price resulting from changes in supply) as well as those factors that may induce quality effects (e.g., income and household size).[29] In general, Cox and Wohlgenant (1986) found the influence of regional and seasonal supply factors to be relatively limited in explaining price variations across households and that considerable variation remained after controlling for these factors. The authors conclude their analysis, however, by stating that failure to include those factors that influence quality effects when estimating missing prices does not appear to significantly bias elasticity estimates associated with those variables that induce a quality effect (e.g., household size and income) when the level of product disaggregation is sufficient. Based upon the findings by Cox and Wohlgenant (1986), Wellman (1991) notes that the use of the first order method presents no significant differences in parameter estimates when compared to the zero order approach and that there is little theoretical justification for accepting the first order approach (i.e., that proposed by Cox and Wohlgenant, 1986). Therefore, she concludes that the zero order approach may have advantages when imputing missing price values associated with nonconsuming households.

Yet another approach for handling missing values is that of Multiple Imputation. This procedure, as outlined by Rubin (1987), replaces the missing values with a set of possible values rather than just a single value. Uncertainty of the imputation is reflected in this approach. Furthermore, it provides valid statistical inferences, such as unbiased estimated variance and confidence intervals, for the parameter estimates. Rather than replacing missing values with values assumed to be known with certainty (such as zero order approach), the multiple imputation method uses a simulation-based approach to ‘catch’ more of the variance(s) and estimate the confidence interval(s) of the missing values. It includes two models: the imputation model and the analysis model. M sets of plausible values are first derived (i.e., the imputation model). Then, the econometric or statistical model is estimated using each set of the plausible values (total M sets). In the end, the results from M models are used to derive the valid statistical inference. The parameter estimate is calculated as the mean of M sets of parameter estimates and the variance contains both the within-imputation variability (average of the variance estimate for each model) and the between-imputation variability (variance estimate of overall M models).

[29] The authors also suggest that some price variation may be the result of non-systematic supply-related factors, such as retail merchandising behavior.

#### 3.3.2.2 Zero Expenditure

As noted by Okrent and Alston (2011), a major econometric issue associated with using survey data in empirical demand analysis relates to the significant proportion of households reporting zero expenditures (consumption) for any particular commodity with the proportion increasing with the level of disaggregation. Specifically, a significant proportion of zero expenditures likely represents a truncated dependent variable with a set of underlying unobservable latent variables being the cause for this truncation. [30] Making accomodation for these zero observations must be made, therefore, in order to ensure consistent parameter estimates. Earlier studies, such as Keithly (1985) and Cox et al. (1984) accommodated the issue of zero expenditures (consumption) via a truncated dependent variable or Tobit model. As suggested by Yen and Huang (1996), however, use of the Tobit model infers that those factors that determine the probability of purchase (consumption) also determine the level of purchase (consumption); an assumption that is likely to be overly restrictive. As such, Yen and Huang (1996) employ an extension of the double-hurdle model originally proposed by Cragg (1971) in their estimation of at-home finfish consumption. In this framework, the decision to consume and the level of consumption are determined by two separate stochastic processes.[31]

Use of a Tobit or double hurdle method is complicated when estimating a complete demand system. As such, Wellman (1992), based upon a technique attributable to Lee (1978) accommodates the censoring problem in a two step process in estimation of her AIDS model examining seafood consumption. In the first step, the expenditure share is converted to a binary variable based on the decision whether or not to purchase. This decision, indicated by a binary variable is estimated as a probit model based on a subset of unobserved latent variables. The Inverse Mills Ratio for each product (her the analysis by Wellman this was nine products) for each household is then be estimated from this dichotomous choice problem and is incorporated and this instrumental variable is then used the second stage of analysis which is the estimation of the Almost Ideal Demand System.Hence, the complete demand system reflects the information of censored latent expenditure share.

Coffey et al. (2011) proposed an alternative method ---Expectation and Maximization (EM) Algorithm – as a means ensuring consistent parameter estimates when confronted with the issue of a significant number of zero expenditure

[30] For example, income may be below some threshold amount required to 'entice' an individual to make a purchase.
[31] As noted by Yen and Huang (1996), the double-hurdle model procedure is similar to the Heckman procedure in that two separate sets of parameters can be generated.

shares. The ‘Expectation’ step of this algorithm entails estimating the demand system using the censored sample data and then predicting the missing latent expenditure shares. With respect to the ‘Maximization’ step, the missing expenditure shares are replaced by the predicted shares which are used to maximize the likelihood function of the demand system.

### 3.4 Empirical Models and Data

The model used to examine seafood demand by product form (fresh, frozen, and prepared) as well as other animal protein commodities is first outlined in this section of the chapter. After attention is given to discussion of the specific model, attention is turned to the data used in the analysis.

#### 3.4.1 Empirical Models

As noted, three alternative model specifications are given for estimation of the complete demand system that includes seafood (by generic product form) and alternative animal protein commodities. The first model, in general, follows that procedure employed by Wellman (1992). The second model follows that initially developed by Cox and Wohlgenant (1986). These two models attempt to control for quality with the second model directly controlling for quality variations across households in the consumption of animal protein commodities (due to say the relationship between quality and income) while the first model only indirectly controlling for quality differences across households. The final model makes no attempt to control for quality.

##### 3.4.1.1 Wellman-Type Quality Adjusted Model

The first empirical model used to analyze seafood and other animal protein commodity demand closely parallels that developed by Wellman (1992) with some notable differences. Like Wellman (1992), the functional form assumed for the complete demand system is that of the LA/AIDS model. As with Wellman, the model includes a number of demographic demand shifters (e.g., region, season, employment status) discussed below. Also like Wellman (1992), seafood products are disaggregated but in a more parsimonious manner. Specifically, Wellman included five generic seafood products in her analysis (fresh finfish, frozen finfish, prepared finfish, miscellaneous fish, and shellfish) with some products accounting for a very small proportion of the budget share (e.g., prepared fish represented 0.5% of the budget share with the percentage of non-zero observations for the product being less than

5%). For the current analysis, as noted, aggregate seafood expenditures are disaggregated into only three generic categories (fresh, frozen, and prepared).[32][33] Similar to Wellman (1992), the traditional LA/AIDS model (equation (14)) was appropriately modified to incorporate socioeconomic factors and proxies to examine the influence of quality on demand.[34] Such modification is given in equation 16 where $S_k$ represents a vector socio-demographic variables and Z represents a vector of quality shifters.

$$(16)\quad w_i = \alpha_i + \sum_j \gamma_{ij} \ln P_j + \beta_i \ln(X / P^*) + \sum_k \phi_{ik} \ln(s_k) + \rho_i Z_i$$

Cramer (1973) suggests that price/income be a proxy for quality and, like Wellman (1992), quality proxies are incorporated via appropriate price/income interaction terms as proposed by Cramer (1973) for a single equation model. Thus, each budget share equation includes five price/income interaction terms: one for associated with each budget share's own price and four associated with the other prices competing for the animal protein budget.[35] However, whereas Wellman only included one price/income interaction term in each equation (i.e., that associated with the budget share being considered) this study includes interaction terms for all products competing for the animal protein budget.

While the first model employed in the current analysis parallels that conducted by Wellman in many ways, there are two major differences. First, Wellman (1992) accommodated missing prices via the zero-order method; replacing missing prices by observed prices by region/season cluster. For purposes of the first model, missing prices were estimated via the multiple imputation method discussed in Section 3.3.2(a). Rubin (1987) argued that for missing value rate as high as 50%, five sets of imputation are sufficient since the asymptotic relative efficiency (RE) is 90% for the Multiple Imputation with finite M compared with infinite M. Based on this finding, a Markov Chain Monte Carlo (MCMC, assumes multivariate normality) method was used in the current analysis for the imputation step to obtain M=5 sets of imputations. The mean of the five imputation sets was then used to replace missing prices for the three generic seafood products (fresh, frozen, and prepared) and the three other animal protein commodities (beef,

[32] Following Salvanes and DeVoretz (1997), a formal separability test was conducted to determine an appropriate aggregation level. Discussion of this test and results are presented in Appendix A2.
[33] Wellman also included an 'other red meat' category in her analysis. Data limitations precluded such a specification in this study.
[34] If quality could be measured directly (say, nutritional content), this variable could be directly incorporated into the AIDS model.
[35] This specification, unfortunately, violates the complete demand system restrictions (i.e., the quality proxy uses price in its construction).

pork, and chicken) which then permitted estimation of the AIDS model with the complete data sets. The analysis model component of multiple imputation is not used here because bootstrapping will be performed for the EM approach which is also a simulated-based approach.

The first model also differs from that by Wellman (1992) in that whereas she employed a binary choice approach to accommodate zero expenditures (i.e., the decision whether to purchase any given commodity is indicated by a binary indicator variable which is a function of a subset of unobserved latent variables and estimated via a probit procedure), the expectatations algorithm, first introduced by Coffey et al. (2011) for use in the Almost Ideal Demand System, is employed in this study. To do so, if the original share is equal to zero the incomplete data is initially estimated to obtain the expected expenditure shares (i.e., the Expectation step of EM algorithm). The complete data is then re-estimated to maximize the likelihood after the imputation of the latent shares. For the Maximization step, the log-likelihood is guaranteed to be improved. Once the objective value approximates that for the next iteration, the stopping condition is met and Maximization is achieved.

The Model procedure in SAS was used to compute the expected shares and SUR option to estimate the LA/AIDS model. However, when the latent shares are replaced by the expected shares, the adding-up restriction associated with the AIDS model no longer holds. Therefore, a mapping procedure proposed by Wales and Woodland (1983) is utilized to ensure the adding up restriction. During the expectation procedure of EM algorithm, the predicted share Wp is estimated. After that, the zero expenditure share is replaced by the predicted share (if the predicted expenditure share is negative, the expenditure shares remain at 0). At this stage, the adding up restriction will be violated because some summation of all six animal protein expenditure shares for the household is greater than unit. Therefore, the new expenditure share Wn is calculated from the ratio of Wp (predicted shares) and the summation of Wp which is Wn =Wp/sum (Wp) to ensure the adding up restriction holds.

As Coffey et al. (2011) note, one criticism leveled against the use of the EM is the inability to obtain variance covariance matrix and parameter estimates from the algorithm. Hence a bootstrap approach is used to randomly resample 1000 observation from current sample 100 times and repeated the AIDS model 100 times. An empirical distribution of 100 observations for estimates of each parameter was generated. Within-variability and between-variability was used to calculate the standard error. The mean of 100 observations for each parameter estimate was considered as the final parameter estimates.

Finally, as with most micro-level cross-sectional demand models, variables in the analysis include a mixture of continuous variables (e.g., income and household size) and discrete variables (e.g. region, urbanization). Continuous variables, with the exception of prices, are transformed to log values to allow for curvature. Since the log of zero is undefined, zero values for the continuous variables are replaced by an arbitrarily small number (.0001) approaching zero.

#### 3.4.1.2 Cox and Wohlgenant Quality Adjusted Model

The second model conducted to examine the demand for seafood (by generic product form) and other animal protein commodities in a complete demand system framework is that proposed by Cox and Wohlgenant (1986). Thus, the same variables as those employed in the first model are also employed in the second model with the exception of the price/income interaction terms (i.e., five variables in each equation). Rather than controlling for quality indirectly, the second model 'adjusts' prices in an attempt to remove the influence of quality (see Section 3.2). The second model, like the first model, also uses the EM algorithm to handle the zero shares. The Cox and Wohlgenant (1986) procedure, however, does not lend itself to the multiple imputation procedure to estimate missing prices and thus it is not used in this model. In accordance with the first model, all continuous variables, with the exception of prices, are transformed to a log form.

#### 3.4.1.3 Non-Quality Adjusted Model

The third model employed to examine the demand for seafood (by generic product form) and other animal protein commodities in a complete demand system does not attempt to control for quality. It utilizes the EM algorithm to handle zero shares and also employees the multiple imputation procedure to estimate the missing prices. The same variables as are included in the first two models (with the exception of the interaction terms included in the first model) are used in the third model and like the other two models, continuous variables are expressed in log form.

### 3.4.2 Survey Data and Variable Description

The data used in this study is from the 2005-2006 National Seafood Consumption Survey[36] which was conducted on behalf of the National Oceanic and Atmospheric Administration by Knowledge Network Methodology. This survey was designed to collect information pertaining to household consumption behavior during a one-month period with at least 800 interviews per month over a 12 month period. A total 10,798 interviews were conducted from February 2005 through January 2006 with the data collection method consisting of three waves of interviews. The first wave included twelve cohorts with each cohort (number of households) being asked to maintain a record of household seafood and other animal purchases (quantities and prices (and other animal proteins) during the last thirty days. Eight of the 12 cohorts in wave 1 were designed as second wave, but they were collected four months later than wave 1. The third wave contained four cohorts who were already included in wave1 and wave 2 but 4 months after the wave 2. Overall, this suggests a sampling stratification representing three groups of respondents; one group was repeated three times to complete the survey, one group was repeated twice and the last group was only interviewed once.[37] The survey stratification is presented in Table 3.1.

Table 3.1 Stratification for the 2005-06 National Seafood Consumption Survey

| COHORT | Seafood Consumption Month | | |
|---|---|---|---|
| | Wave 1 | Wave 2 | Wave 3 |
| 1 | February | June | October |
| 2 | March | July | November |
| 3 | April | August | December |
| 4 | May | September | January |
| 5 | June | October | |
| 6 | July | November | |
| 7 | August | December | |
| 8 | September | January | |
| 9 | October | | |
| 10 | November | | |
| 11 | December | | |
| 12 | January | | |

Source: NOAA 2005-2006 National Seafood Consumption Survey Data Description

In general, potential panel members (households) were selected by a random digit dialing (RDD) methodology

[36] The survey questionaire is presented in Appendix A5.

[37] Note that this actually represents an unbalanced panel dataset. The unbalanced nature of the panel data, however, made use of panel (or time-series cross-sectional) analysis unfeasible.

based on the listed and unlisted telephone numbers. Eligibility for participation in the survey was determined via an online screening process. One primary requirement for participating in the full survey was that the panel numbers (households) have purchased shellfish or finfish from a retail outlet[38] or restaurant[39] in the past 12 months.

As noted, 10,798 interviews were conducted from February 2005 to January 2006. Detailed information on seafood purchases during the past 30 days (by species and product form) was collected as well as less detailed information on other animal proteins. In addition to the expenditure and quantity data collected during the survey process, demographic and socioeconomic characteristics associated with each household (discussed in more detail below) was also compiled.

Though information on monthly purchases was collected for 10,798 households, the actual number of observations included in the analysis was substantially less. First, some respondents did not provide relevant information on expenditures or quantities for one or more commodities (coded as -1) during the one-month survey period and these observations were first deleted. Second, some observations were recorded with positive pounds (or expenditures) but with a corresponding zero value being given for expenditures (pounds) and these observations were deleted.[40] Finally, in accordance with the method used by Cox and Wohlgenant (1986), observations where the calculated unit value (i.e., expenditures divided by quantity) deviated from the mean for that commodity by more than five standard deviations (about 5%) were excluded.[41] . Deletion of these invalid/questionable observations, along with those for which other relevant information was missing, left 9,310 usable observations for analysis.

Some summary statistics associated with the six expenditure share equations used in the analysis are presented in Table 3.2. As indicated, beef expenditures account for more than one-third of at-home expenditures on fish and animal protein commodities with chicken also accounting for more than 30%. Combined seafood expenditures

[38] Such as a convenience store, a grocery store, fish market, super market or a general store.
[39] Includes the school cafeterias, hospital, military, fast service restaurant and casual dining restaurant
[40] While home production may account for some observations where quantity is greater than zero while expenditures are equal to zero, insufficient information was available to ascertain the extent of this practice and which of the observations would be valid under such a practice.
[41] Cox and Wohlgenant deleted about 2% of the observations based on this five standard deviation criteria. However, their analysis was based on three products (fresh vegetables, canned vegetables, and frozen vegetables) compared to the six products included in this analysis.

Table 3.2 Summary statistics associated with the six expenditure share equations

| Commodity Group | Budget Share | Non-zeroobs | Proportion non-zero observation | Average Expenditure for total sample ($) | Average Expenditure for consuming sample ($) | Average Price ($/lb.) |
|---|---|---|---|---|---|---|
| beef | 0.3556 | 7933 | 0.8521 | 24.1403 | 28.4157 | 3.2472 |
| chicken | 0.2988 | 8147 | 0.8751 | 17.0572 | 19.5714 | 2.5282 |
| pork | 0.1757 | 6409 | 0.6884 | 11.7215 | 17.0783 | 2.9277 |
| fresh seafood | 0.0435 | 1411 | 0.1516 | 4.0227 | 26.6221 | 4.8912 |
| frozen seafood | 0.0848 | 2738 | 0.2941 | 6.9356 | 23.634 | 4.7916 |
| prepared seafood | 0.0416 | 1884 | 0.2024 | 2.7926 | 13.8415 | 4.3964 |

represented 17% of total monthly at-home fish and animal protein commodity expenditures with frozen seafood representing about one-half of seafood expenditures.

Approximately 85% of the sample population indicated purchasing chicken and beef for at-home consumption during the previous one-month interview period compared to less than 70% who reported purchasing pork. Almost thirty percent of the sample population reported purchasing frozen seafood for at-home consumption during the previous one-month interview period while 20% reported purchasing prepared seafood and 15% reported the purchase of fresh seafood.

Average beef expenditures during the past month for at home consumption averaged $24.1 among households in the sample and about $28.4 among consuming households. While fresh seafood expenditures during the previous month for at-home consumption averaged only $4.02 among households in the sample, expenditures among purchasers averaged $26.6, or almost as much that beef expenditures among that portion of the sample that purchased beef.[42]

Overall, the average prices for the three seafood products (fresh, frozen, and prepared) exceeded the reported prices for the animal protein commodities by a significant amount with fresh seafood commanding the highest price at $4.89 per pound. Unsurprisingly, the price differential between fresh and frozen seafood was small (about $0.10 per

[42] Though not provided in Table 3, total seafood expenditures for at-home consumption averaged $13.79 for the sample population.

pound) while the price differential between fresh seafood and prepared seafood approximated $0.50 per pound. The average per pound price of chicken, $2.53 per pound, was approximately 75% of the reported average beef price ($2.93) and just over one-half of the average reported fresh seafood price.

Summary statistics related to the exogenous variables used in the analysis of household demand for seafood and animal protein products are presented in Table 3.3.

Table 3.3 Descriptive Statistics for Variables Included in Demand System

| Variate | Variable name | Description | Mean | Standard Deviation |
|---|---|---|---|---|
| Expenditure | Exp | Household expenditure on finfish and shellfish | $13.75 | $26.87 |
| Beef expenditure | Beefexp | Household expenditure on beef | $24.14 | $26.68 |
| Chicken expenditure Expenditure | Chickenexp | Household expenditure on chicken | $17.06 | $17.50 |
| Pork expenditure | Porkexp | Household expenditure on pork | $11.72 | $15.05 |
| Fresh seafood expenditure | Freshsexp | Household expenditure on fresh seafood | $4.02 | $14.21 |
| Frozen seafood expenditure | Frozensexp | Household expenditure on frozen seafood | $6.94 | $16.76 |
| Prepared seafood Expenditure | Preparedexp | Household expenditure on Prepared Seafood | $2.79 | $9.21 |
| Education | College | Equal to 1 household manager has at least some college education; zero otherwise | 0.62 | 0.49 |
| Season | Spring<br>Summer<br>Autumn<br>Winter | Omitted Category | 0.24<br>0.25<br>0.25<br>0.26 | 0.42<br>0.42<br>0.43<br>0.39 |
| Household Income | Income | | $52,164 | $36,538 |
| Household size | Pphhsize | Household Size | 2.56 | 1.38 |
| Race | White<br>Black<br>Other<br>Hispanic | Omitted Category | 0.79<br>0.10<br>0.04<br>0.06 | 0.41<br>0.30<br>0.21<br>0.25 |
| Age of household manager | ppage | Age of household manager | 48.74 | 15.27 |
| Gender | male | Equal to 1 if household manager is male; zero otherwise | 0.31 | 0.46 |

(Table 3.3 continued)

| Variate | Variable name | Description | Mean | Standard Deviation |
|---|---|---|---|---|
| Household head | pphhhead | ‘1’= household head,’0’=not household head | 0.88 | 0.33 |
| Employment status | work | Equal to 1 if household manager is employed; zero otherwise | 0.56 | 0.50 |
| Ownership status of the living quarters | ownhouse | Equal to 1 if household owns house and zero otherwise | 0.74 | 0.44 |
| Marital status | married | Equal to 1 if married; zero otherwise | 0.63 | 0.48 |
| Urbanization | ppmsacat | Equal to 1 if live in urban area; zero otherwise | 0.82 | 0.38 |
| Number of children | Ppt06 | Number of children under age six in household | 0.15 | 0.46 |

Average household income, as indicated, averaged about $52 thousand[43] with members per household averaging 2.53.[44] Seventy-nine percent of the survey participants classified themselves as white, while 10% classified themselves as black and 6% as Hispanic. According to 2005 Census data, 12.2% of U.S. householders were classified as black, 10.7% as Hispanic origin (any race), and 72% as white (not Hispanic). For purposes of analysis, the race/ethnicity variables were treated as discrete variables (White households being the omitted category).

Married couple households accounted for 63% of the sample used for purposes of analysis which is about 12 percentage points higher than that reported for the 2005 Census. The average age of household manager was 48.7 years and more than 60% indicated having, at a minimum, some college education. About 56% of the household managers in the sample indicated that he/she worked while close to three-quarters of the survey respondents

[43] The questionnaire asked participants to list the household income level by category. In total, 19 categories (excluding missing etc. ranging from <$5,000 to >$175,000 were provided to the participants from which to select. For purposes of analysis, the mean value for the category in association with that category selected by the participant was used to change income from a categorical ‘type’ variable to a discrete variable.

[44] The median 2005 household income, according to U.S. Census data was $46.3 thousand with an average of 2.57 members per household (source: http://www.census.gov/prod/2006pubs/p60-231.pdf).

reported that they owned a house.[45] With respect to region, the highest proportion of survey participants resided in the South (34%) while 20% to 24% of the participants resided in the other three regions (i.e., Northeast, Midwest, and West). This matches well with the 2005 Census data which shows 36.5% of households residing in the South, 18.4% residing in the Northeast, 23% residing in the Midwest, and 22% residing in the West. Finally, 82% of the survey respondents resided in a rural setting (U.S. 2000 Census gives an estimate of 79%) while the number of children per household under the age of six equaled 0.15. As can be ascertained in the Literature Review of this chapter, there appears to be little agreement regarding the expected influence of many of the demographic factors on expenditures or expenditure shares. While Keithly (1985), Wellman (1992) and Cheng and Capps (1988) generally found household size to be a significant factor influencing seafood expenditures for at-home consumption, Wellman (1992) found household size to have a positive impact only on the expenditure shares for prepared fish and miscellaneous fish products. Similarly, Cheng and Capps found household size to statistically influence expenditures on only six of the ten species (groups of species considered in their analysis. Yen and Huang (1996) and Coffey et al. (2011), by comparison, found little evidence that household size significantly influences expenditures/shares related to seafood (or products, such as finfish). Expenditure shares must add to one in the current analysis so whether individual expenditure shares for the considered generic seafood products are significantly influenced by household size (and the direction of influence) is an empirical question for which evidence, based on previous studies, is somewhat lacking.

Similarly, previous researchers have found little evidence that the educational attainment level influences at-home seafood consumption. Wellman (1992), for example, found no evidence that educational attainment level influenced the expenditure shares for the five seafood products (fresh fish, frozen fish, prepared fish, miscellaneous fish, and shellfish) considered in her analysis. Similarly, Cheng and Capps (1988) found educational attainment level to impact expenditures on only one of the ten species/groups (haddock and the relationship was negative) considerd in their analysis. Finally, as stated by Yen and Huang (1996) "[c]ontrary to the common belief that the educated may be better informed about healthy diets and tend to consume more fish than red meats, we find no evidence that higher educational attainment significantly increases the level of participation of consumption of finfish in the

[45] 'Working' consists of the following categories. (a) a paid employee, (b) self-employed, (c) an owner/partner in small business, prof practice, (d) farm, and (e) work at least 15hours per week without pay in family business or farm. Non-working includes unemployed, temporarily laid off, retired, and disabled,

United States." Based on these findings, the expected influence of having a college education (bachelor's degree or higher) on expenditure shares for the generic fishery products considered in this study (i.e., fresh, frozen, and prepared) is uncertain.

While the influence of household size and education on seafood expenditures appears to be uncertain, much of the previous research shows a clearer relationship between race/ethnicity and seafood expenditures for at-home consumption. For example, Cheng and Capps found Blacks and others to exhibit higher expenditures than Whites on seven of the ten seafood products (groups) examined. This finding was also, in general, observed by Keithly (1985). Wellman (1992), however, found no such relationship. Thus, like other factors, the influence of race/ethnicity remains an unresolved issue for which this study may 'shed' some additional light.

While Coffey et al. (2011) found no regional (i.e., the region where the household resides) influence on finfish and shellfish expenditure shares, most other research shows a clearer relationship. While generalizations are difficult to make due to different aggregation levels associated with geographical regions and different products being considered, households in the South, Northeast, and Mid-Atlantic regions appear to exhibit a preference for fish relative to those in the Mountain and inland regions and a similar finding is expected in this study.

### 3.5 Results

As noted, three models were considered for purposes of analyzing at-home seafood demand (by generic product form) and other animal protein commodities. Results associated with these three models are first presented and attention is then turned to comparing/contrasting the results among the three models.

#### 3.5.1 Results: Wellman-Type Quality Adjusted Model

Parameter estimates associated with the first model (Wellman-type quality adjusted model) are presented in Table 3.4.

Table 3.4 Estimated parameters associated with seafood product forms and other animal protein commodities (Wellman-type quality adjusted model)

| | Beef | Chicken | Pork | Fresh Seafood | Frozen Seafood | Prepared Seafood |
|---|---|---|---|---|---|---|
| Intercept | 0.454024[a] (0.0226) | 0.64967[a] (0.0210) | 0.070269[a] (0.0168) | -0.08537[a] (0.0131) | -0.09978[a] (0.0165) | 0.011196 (0.0117) |

(Table 3.4 continued)

| | Beef | Chicken | Pork | Fresh Seafood | Frozen Seafood | Prepared Seafood |
|---|---|---|---|---|---|---|
| pbeef | 0.071411[a] (0.00607) | -0.05373[a] (0.00489) | -0.0309[a] (0.00377) | 0.019434[a] (0.00310) | 0.00248 (0.00349) | -0.00696[a] (0.00259) |
| pchicken | -0.05544[a] (0.00459) | 0.080535[a] (0.00596) | -0.01223[a] (0.00383) | -0.01323[a] (0.00316) | 0.000975 (0.00348) | -0.00064 (0.00261) |
| ppork | -0.0309[a] (0.00377) | -0.01223[a] (0.00383) | 0.002662[a] (0.00465) | 0.005825[a] (0.00286) | 0.015916[a] (0.00309) | 0.018732[a] (0.00235) |
| pfresh | 0.019434[a] (0.00310) | -0.01323[a] (0.00316) | 0.005825[a] (0.00286) | -0.03252[a] (0.0036) | 0.004252 (0.00273) | 0.016236[a] (0.00208) |
| pfrozen | 0.00248 (0.00349) | 0.000975 (0.00348) | 0.015916[a] (0.00309) | 0.004252 (0.00273) | -0.0075[b] (0.00395) | -0.01613[a] (0.00220) |
| pprepared | -0.00696[a] (0.00259) | -0.00064 (0.00261) | 0.018732[a] (0.00235) | 0.016236[a] (0.00208) | -0.01457[a] (0.00218) | -0.01123[a] (0.00234) |
| beta | -0.004[b] (0.00182) | -0.05074[a] (0.00169) | 0.003043[a] (0.00135) | 0.025221[a] (0.00106) | 0.027676[a] (0.00133) | -0.0012 (0.000938) |
| Work | 0.012056[a] (0.00330) | 0.01014[a] (0.00306) | 0.000814 (0.00245) | -0.00946[a] (0.00191) | -0.01054[a] (0.00241) | -0.00301 (0.00170) |
| Ownhouse | 0.00238 (0.00392) | -0.00903[b] (0.00364) | 0.009771[a] (0.00291) | -0.00722[a] (0.00227) | 0.011353[a] (0.00286) | -0.00726[a] (0.00202) |
| Midwest | 0.042678[a] (0.00461) | -0.01377[a] (0.00428) | 0.026394[a] (0.00342) | -0.05805[a] (0.00267) | 0.000347 (0.00337) | 0.002396 (0.00238) |
| South | 0.026113[a] (0.00432) | -0.00282 (0.00401) | 0.016334[a] (0.00321) | -0.03973[a] (0.00250) | -0.00304 (0.00316) | 0.003153 (0.00222) |
| West | 0.033078[a] (0.00476) | -0.00163 (0.00442) | -0.00669[b] (0.00353) | -0.03709[a] (0.00276) | 0.011213[a] (0.00348) | 0.001114 (0.00245) |
| Married | 0.00013 (0.00378) | 0.029059[a] (0.00351) | 0.003543 (0.00280) | -0.00652[a] (0.00219) | -0.01084[a] (0.00276) | -0.01537[a] (0.00194) |
| College | -0.0296[a] (0.00331) | 0.019477[a] (0.00308) | -0.01397[a] (0.00246) | 0.01541[a] (0.00192) | 0.004989[a] (0.00242) | 0.003695[b] (0.00171) |
| Male | 0.007857[a] (0.00336) | -0.0075[a] (0.00312) | 0.002735 (0.00249) | 0.003817 (0.00195) | -0.01317[a] (0.00246) | 0.006258[a] (0.00173) |
| Spring | 0.021154[a] (0.00433) | -0.00263 (0.00402) | -0.00632[c] (0.00321) | 0.008433[a] (0.00251) | -0.01172[a] (0.00316) | -0.00891[a] (0.00223) |
| Summer | 0.025701[a] (0.00427) | -0.00233 (0.00397) | -0.00996[a] (0.00317) | 0.003716 (0.00248) | -0.00983[a] (0.00312) | -0.00729[a] (0.00220) |

(Table 3.4 continued)

| | Beef | Chicken | Pork | Fresh Seafood | Frozen Seafood | Prepared Seafood |
|---|---|---|---|---|---|---|
| Autumn | 0.013661[a] (0.00426) | 0.019503[a] (0.00396) | -0.0073[b] (0.00316) | -0.00482[c] (0.00247) | -0.01228[a] (0.00311) | -0.00877[a] (0.00219) |
| Black | -0.09124[a] (0.00543) | 0.025691[a] (0.00504) | 0.004739 (0.00403) | 0.027145[a] (0.00315) | 0.021387[a] (0.00397) | 0.012277[a] (0.00280) |
| Other | -0.06127[a] (0.00748) | -0.02055[a] (0.00695) | 0.000478 (0.00555) | 0.027984[a] (0.00434) | 0.048322[a] (0.00547) | 0.005033 (0.00386) |
| Hispanic | -0.01853[a] (0.00652) | 0.014369[b] (0.00605) | -0.01219[b] (0.00484) | 0.006257[c] (0.00378) | 0.007863[c] (0.00476) | 0.00223 (0.00336) |
| Lppage | -0.04041 (0.00558) | -0.07386[a] (0.00519) | 0.026765[a] (0.00414) | 0.031204[a] (0.00324) | 0.037147[a] (0.00408) | 0.019151[a] (0.00288) |
| Lpphhsize | 0.02387[a] (0.00356) | 0.008706[a] (0.00331) | 0.008636[a] (0.00264) | -0.01939[a] (0.00207) | -0.01456[a] (0.00260) | -0.00726[a] (0.00183) |
| ppmsacat | -0.02053[a] (0.00405) | 0.011302[a] (0.00376) | -0.01019 (0.00300) | 0.010914[a] (0.00235) | 0.016134 (0.00296) | -0.00763[a] (0.00208) |
| Lppt06 | -0.00127[a] (0.000330) | -0.0001 (0.000307) | 0.000074 (0.003) | 0.000906 (0.000191) | 0.000602[b] (0.000241) | -0.0002 (0.00017) |
| Quality proxy: beef | 0.000187[a] (0.000024) | -0.000019[a] (0.000031) | -0.00003 (0.000025) | -0.00004[a] (0.000016) | -0.00010 (0.000015) | -0.00001[a] (0.000014) |
| Quality proxy: Chicken | -0.00011[a] (0.000021) | 0.00017[a] (0.000033) | -0.00001 (0.000024) | -0.00004[a] (0.000015) | -2.31E-6 (0.000015) | -0.00001[c] (0.000013) |
| Quality proxy: Pork | -1.66E-7 (0.000017) | -0.00006a (0.000024) | 0.000173a (0.000023) | -0.00004a (0.000012) | -0.00002 (0.000012) | -0.000004a (0.000011) |
| Quality proxy: Fresh seafood | -0.00005 (0.000013) | -0.00005[a] (0.000019) | -0.00003[a] (0.000016) | 0.000189[a] (0.000011) | -0.00005[a] (9.741E-6) | -0.00002[a] (8.898E-6) |
| Quality proxy: Frozen seafood | -0.00001 (0.000016) | -0.00007[a] (0.000023) | -0.00002 (0.000019) | -0.00005[a] (0.000012) | 0.000177[a] (0.000013) | -8.03E-6 (0.000011) |
| Quality proxy: prepared seafood | -0.00002 (0.000012) | -4.44E-6 (0.000017) | -0.00004[a] (0.0000115) | -0.00003[a] (8.773E-6) | -5.56E-6 (8.379E-6) | -4.44E-6 (0.000017) |

a represents 0.01 significant level, b represents 0.05 significant level and c represents 0.10 significant level
the value in parentheses are standard errors
1.Beta represents the parameters of price index

The model fit diagnosis---coefficients of determination ($R^2$s) show the value range from 0.06 for prepared seafood to 0.21 for chicken. More than 80% of the estimated coefficients were statistically significant in the beef equation and more than 70% of the coefficients were found to be significant in both the chicken and pork equations. The model fit diagnosis---coefficients of determination ($R^2$s) show the value range from 0.06 for prepared seafood to 0.21 for chicken. More than 80% of the estimated coefficients were statistically significant in the beef equation and more than 70% of the coefficients were found to be significant in both the chicken and pork equations. By seafood product form, the proportion of significant coefficients ranged from about 60% (prepared seafood) to more than 85% (fresh seafood).

All of the own-price coefficients, as indicated, are statistically significant as are a high percentage of the cross-price coefficients. The household size coefficients are significant in all six equations though negative in all seafood product form equations (fresh, frozen, and prepared0 and positive in the other animal protein equations (beef, pork, and chicken).

**3.5.1.1 Influence of Demographic Demand Shifters**

Results suggest that the included demographic demand shifters significantly contribute to observed variations in expenditure shares across households for the various seafood products and other animal proteins. Examined by geographical region, after controlling for other factors that might influence relative budget shares, households residing in the Northeast were found to have a statistically higher fresh fish expenditure share than households residing in any of the three other designated regions with the lowest budget share being that among households in the Midwest. By comparison, with respect to frozen fish, only households residing in West Region exhibited an expenditure share significantly different (higher) than that among households in Northeast Region while for prepared seafood no significant differences were found when compared to the based Region (i.e., the Northeast).

Urbanization also apparently influences at-home seafood consumption with households residing in an urban setting exhibiting a higher expenditure share for fresh seafood than their rural counterparts but a lower expenditure share for prepared seafood. Urbanization, however, does not appear to significantly influence at-home consumption of frozen seafood.

With respect to season, expenditure shares for all other seasons (spring, summer, and fall) were statistically less than that of the base (winter) for both frozen and prepared seafood products. With respect to fresh seafood, however, results were somewhat inconsistent. Specifically, household expenditure share for fresh seafood in the spring was found to be statistically higher than that of the base season (winter) though the expenditure share for the autumn season was found to be significantly less than that associated with the base season (i.e., winter).

The results indicate that ethnicity also plays an important role in determining household expenditure shares for seafood products and other animal proteins. Specifically, after controlling for other factors that may influence household expenditure shares, black households were found to exhibit higher expenditure shares for all seafood products (fresh, frozen, and prepared) then their base counterpart (white households) though their expenditure share associated with beef was less than that of white households. Similarly, 'other' ethnic groups exhibited higher household expenditure shares for both fresh and frozen fish products than did their base counterpart but, like black households, their expenditure share for beef was less than their white counterpart.

Household size was found to significantly influence expenditure shares for all seafood products (fresh, frozen, and prepared seafood) as well as for all other animal protein products (beef, chicken, and pork). However, increases in household size had a positive influence on expenditure shares of all other animal proteins but a negative influence on all fish products[46]. By comparison Wellman (1992) found household size to have a positive impact on the expenditure shares for prepared fish and miscellaneous fish products but found it not to significantly influence expenditure shares associated with either fresh fish or frozen fish.

Household expenditure shares for all seafood products (fresh, frozen, and prepared) were found to be positively impacted by the age of the household head as was the expenditure share for pork. Conversely, however, expenditure shares for both beef and chicken were found to be negatively impacted in relation to the age of the household head. It is likely that health concerns play an important role in determining relative expenditures on fish and other animal protein sources and health concerns are likely to be positively related to age. Consumption of fish products is generally perceived to be 'healthier' than consumption of red meats.

Other demographic factors that impact relative expenditure shares include education level, marriage status, and employment status. Specifically, households with a higher education level (defined as the household head having at least some college education) were found to have higher expenditure shares for all three generic seafood products (i.e., fresh, frozen, and prepared) relative to their counterparts with corresponding lower expenditure shares for beef

[46] The elasticity with respect to household size for fresh seafood, frozen seafood and prepared seafood are -0.019,-0.015 and -0.007.

and pork. This finding, with the exception of prepared seafood products, is similar to that of the age of the household manager and explanations for the impacts associated with education probably closely mirror those hypothesized with respect to the age of the household manager. Expenditure shares on seafood products among households where there is a married couple, however, tended to be lower than among non-married households. Finally, the employment status of the household manager was found to negatively impact household expenditure shares for fresh and frozen seafood while increasing the expenditure shares for beef and chicken. This finding may reflect the opportunity cost of time associated with preparing fresh and frozen fish relative to that of either beef or chicken.

**3.5.1.2 Influence of Price Variables**

As noted, all estimated own-price coefficients and a large proportion of the cross-price coefficients associated with the complete demand system for fish products and other animal protein sources were found to be statistically significant. Based on equations 8 and 10 estimated Marshallian and Hicksian own-and-cross price elasticites and the expenditure elasticities associated with the six products (beef, chicken, pork, fresh seafood, frozen seafood, and prepared seafood) were derived and are presented in Tables 3.5 and 3.6, respectively.

Table 3.5 Estimates of Marshallian Own-Price, Cross-Price and Expenditure Elasticities (Wellman-type Model)

| | Beef | Chicken | Pork | Freshs | Frozens | Prepareds | Expenditure elasticity |
|---|---|---|---|---|---|---|---|
| Beef | -0.77409[a]<br>(0.0190) | -0.16898[a]<br>(0.0143) | -0.0938[a]<br>(0.0117) | 0.061177[a]<br>(0.00965) | 0.009112<br>(0.0109) | -0.02093[a]<br>(0.00807) | 0.987561[a]<br>(0.00566) |
| Chicken | -0.14797[a]<br>(0.0175) | -0.64455[a]<br>(0.0225) | 0.01169<br>(0.0145) | -0.03791[a]<br>(0.0120) | 0.25361[c]<br>(0.0132) | 0.008648<br>(0.00988) | 0.808035[a]<br>(0.00750) |
| Pork | -0.17694[a]<br>(0.0211) | -0.07234[a]<br>(0.0213) | -0.98814[a]<br>(0.0258) | 0.031241[b]<br>(0.0159) | 0.086536[a]<br>(0.0172) | 0.102951[a]<br>(0.0131) | 1.016893[a]<br>(0.00859) |
| Freshs | 0.179075[a]<br>(0.0494) | -0.31473[a]<br>(0.0500) | 0.20203<br>(0.0453) | -1.53981[a]<br>(0.0571) | 0.02222<br>(0.0432) | 0.233909[a]<br>(0.0329) | 1.399071[a]<br>(0.0167) |
| Frozens | -0.05692[c]<br>(0.0312) | -0.05616[c]<br>(0.0309) | 0.096988<br>(0.0274) | 0.022191<br>(0.0242) | -1.09407[a]<br>(0.0350) | -0.15697[a]<br>(0.0195) | 1.245139[a]<br>(0.0118) |
| Prepareds | -0.1142[b]<br>(0.0454) | -0.00555<br>(0.0453) | 0.328877[a]<br>(0.0409) | 0.283187[a]<br>(0.0362) | -0.27764[a]<br>(0.0382) | -1.19379<br>(0.0407) | 0.979148[a]<br>(0.0163) |

Table 3.6 Estimates of Hicksian Own-Price, Cross Price, and Expenditure Elasticities (Wellman-type Model)

| | Beef | Chicken | Pork | Freshs | Frozens | Prepareds | Expenditure elasticity |
|---|---|---|---|---|---|---|---|
| Beef | -0.45629[a] (0.0189) | 0.092034[a] (0.0143) | 0.08416[a] (0.0117) | 0.123591[a] (0.00963) | 0.120608[a] (0.0109) | 0.035958[a] (0.00806) | 0.98911[a] (0.00564) |
| Chicken | 0.112057[a] (0.0174) | -0.43099[a] (0.0225) | 0.133922[a] (0.0145) | 0.013161 (0.0119) | 0.116588[a] (0.0132) | 0.05519[a] (0.00987) | 0.806514[a] (0.00638) |
| Pork | 0.16288[a] (0.0213) | 0.117506[a] (0.0215) | -0.79046[a] (0.0260) | 0.087641[a] (0.0159) | 0.185909[a] (0.0172) | 0.16288[a] (0.0131) | 1.019865[a] (0.00859) |
| Freshs | 0.629296[a] (0.0490) | 0.05504[b] (0.0500) | 0.272315[a] (0.0453) | -1.45139[a] (0.0570) | 0.180175[a] (0.0432) | 0.314495[a] (0.0329) | 1.401376[a] (0.0167) |
| Frozens | 0.34377[a] (0.0309) | 0.272935[a] (0.0308) | 0.321362 (0.0274) | 0.10076[a] (0.0242) | -0.95349[a] (0.0350) | -0.08525[a] (0.0195) | 1.243432[a] (0.0118) |
| Prepareds | 0.200892[a] (0.0450) | 0.253243[a] (0.0453) | 0.505321[a] (0.0409) | 0.344971[a] (0.0361) | -0.1671[a] (0.0382) | -1.13739[a] (0.0406) | 0.970674[a] (0.0162) |

Given the fact that the Hicksian elasticities are more informative [47], discussion is limited to this set of elasticities (i.e., those in Table 3.6).

As indicated by the information in Table 3.6, all Hicksian own price elasticities, as measured along the main diagonal, are negative and statistically significant. This finding, which implies that an increase in price for the commodity results in a reduction in quantity demanded, is consistent with economic theory. With respect to the three seafood products, the Hicksian own-price elasticites range from -1.451 (fresh fish) to -0.953 (frozen fish). These own-price elasticities are all higher than those estimated for other animal proteins (which range from -0.431 for chicken to -0.790 for pork). Overall, the own-price elasticities associated with the three fish products (fresh, frozen, and miscellaneous) tend to be larger than those found by Wellman (1992). [48] On the other hand, Coffey et al. (2011) report significantly higher own-price elasticities (-2.58 for finfish and -4.65 for shellfish).

In general, most cross-price elasticities were found to be positive and statistically significant. Fresh seafood was found to be a substitute for all other seafood products (frozen and prepared) and all animal protein commodities (beef, chicken, and pork). Similarly, frozen seafood was found to be a substitute for all products other than prepared

[47] Marshallian demand function is assumed income and price of other commodities are constant. Only own price elasticity can be derived from it. In Hicksian demand function, consumer is operating on the same indifference curve. The pure substitution effect can be derived and income elasticity could be estimated.

[48] Direct comparison of elasticites from this analysis with those found by Wellman (1992) tends to be complicated by the fact that she disaggregated seafood into six products (fresh fish, frozen fish, prepared fish, miscellaneous fish, and shellfish) whereas this study employees a lower level of disaggregation. She estimated an own-price elasticity for shellfish equal to -1.32 (which was the largest) to +0.75 for miscellaneous fish. The reported own-price elasticity for fresh fish was -0.06.

seafood for which is was found to be a complement. Prepared fish show the same pattern as that observed for frozen fish.

Expenditure elasticities associated with the generic seafood products (fresh, frozen, and prepared) were all positive and ranged from 0.971 (prepared) to 1.401 (fresh). With respect to the other animal protein sources, expenditure elasticities ranged from 0.807 (chicken) to 1.02 (pork).

### 3.5.1.3 Influence of Quality Proxies

To examine the role of quality, it is first useful to visualize the possible influence of quality. This possible influence is can be seen in Figures 3.1 through 3.3.

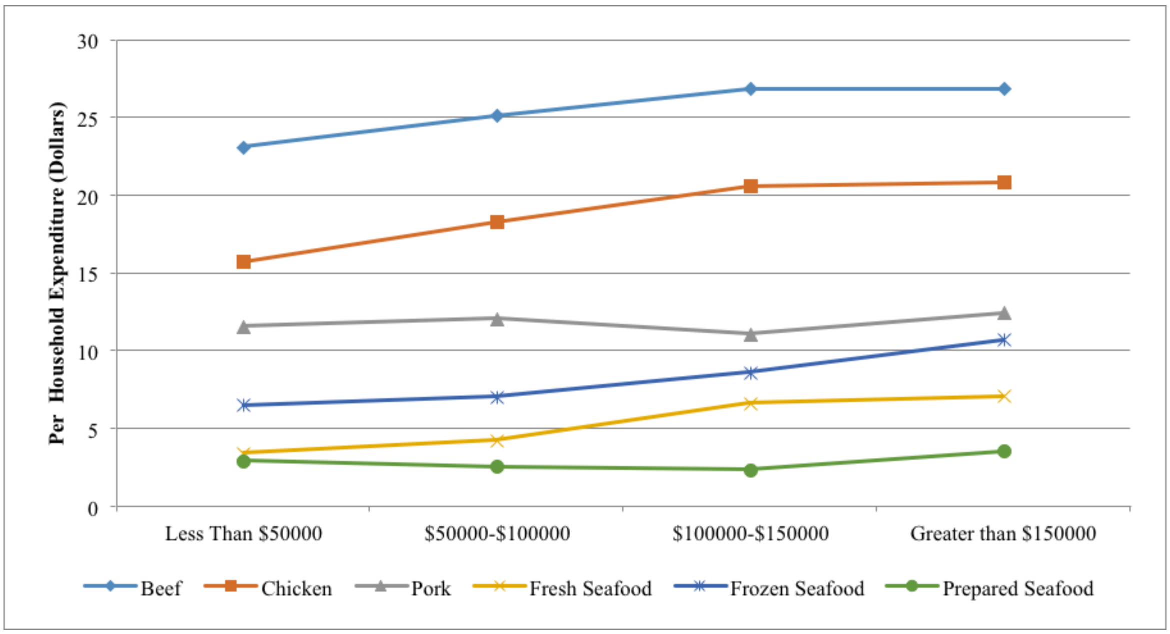



Figure 3.1 Average Monthly Protein Sources Per Household Expenditure by Income Class 2005-2006

Figure 3.1 presents information on expenditures for the different products for at-home consumption at different levels of household income. As indicated, seafood expenditures rise throughout the relevant income range while expenditures on beef and chicken also rise with an increase in household income though there is a leveling off at the highest income category. The same information on quantity purchased of the different protein commodities for at-home consumption is presented in Figure 3.2.

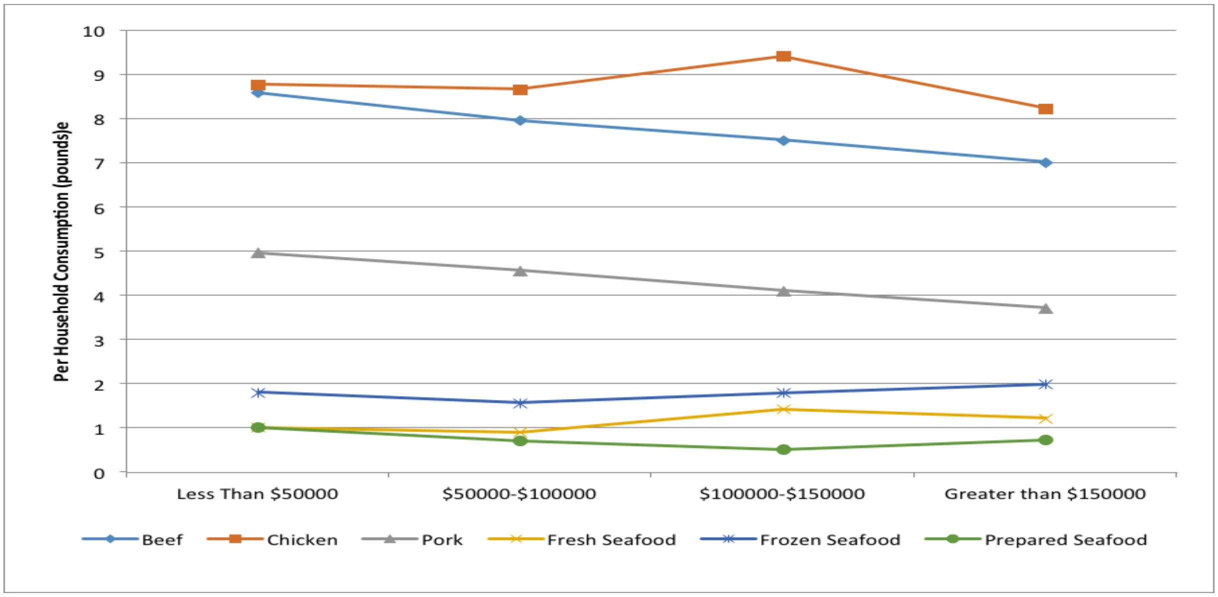
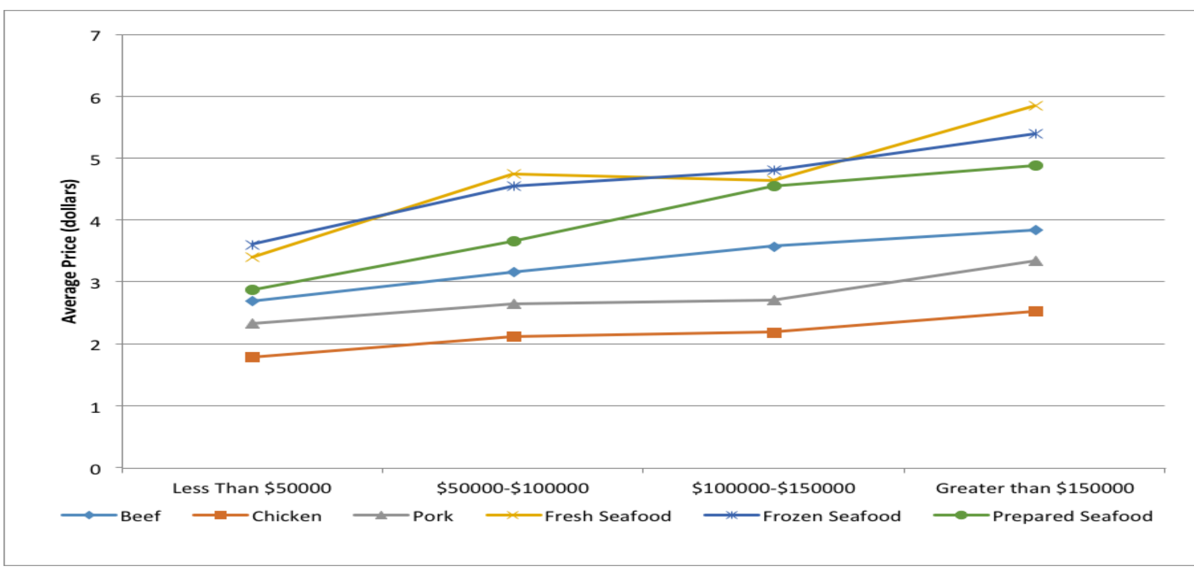



Figure 3.2 Average Monthly Protein Sources Per Household Consumption by Income Class 2005-2006

As indicated, there is no evidence of increasing quantity with income associated with any of the four goods (beef, chicken, pork, and seafood). In fact, the purchased quantities of both beef and pork fall sharply with respect to income category.[49] Figure 3.3 presents information on the price per pound paid for the respective products.




d

Figure 3.3 Average Monthly Protein Sources Price by Income Class 2005-2006

[49] In general, one might think that increases in income result in higher quantities being purchased for at-home consumption. There are two reasons that may not be the case. First, increases in income may result in increases in meals consumed away from home. Second, households with higher incomes may purchase more processed/prepared products than their counterparts with lower incomes. For example, as income increases, households may increasingly purchase filleted fish rather than whole fish or chicken breasts rather than whole chickens.

As indicated, the price for the different products increase in relation to income suggesting an increase in demand for quality in association with an increase in income.

The quality proxies used in this analysis were found to significantly influence respective expenditure shares with all own-product quality proxies (equal to the price of own product divided by household income) being positive and significant. These findings, if valid, imply that increases in household income result in the purchase of higher quality products (via a higher per pound price) which, in turn, positively influence expenditure shares on the respective products (equal to expenditure on the respective product divided by total expenditures on seafood and other animal protein commodities).

The cross-product quality proxies are also, in many cases, statistically significant and negative. With respect to fresh seafood for example, its own-product quality proxy was estimated to equal 0.0009 while all cross-product quality proxies (i.e., the proxy for beef, chicken, pork, frozen seafood, and prepared seafood) were found to be negative (though the parameter estimate associated with beef was not found to be statistically significant). These findings, in general, suggest a tradeoff; specifically, higher qualities associated with one product imply a reduction in qualities for other products. In the fresh seafood equation. for example, results suggest that purchases of higher quality pork, chicken, and competing seafood products (i.e., frozen and prepared seafood) leads to the purchase of lower quality fresh seafood, *ceteris paribus*.

### 3.5.2 Results: Cox and Wohlgenant Quality Adjusted Model

Parameter estimates associated with the second model (Cox and Wohlgenant quality adjusted model) are presented in Table 3.7.

Table 3.7 Estimated parameters associated with seafood product forms and other animal protein commodities (Cox and Wohlgenant quality adjusted model).

| | Beef | Chicken | Pork | Fresh Seafood | Frozen Seafood | Prepared Seafood |
|---|---|---|---|---|---|---|
| Intercept | 0.452269[a] (0.0229) | 0.650353[a] (0.0214) | 0.068095[a] (0.0169) | -0.0809[a] (0.0132) | -0.08659[a] (0.0169) | 0.007122 (0.0118) |
| pbeef | 0.071537[a] (0.00380) | -0.04616[a] (0.00257) | -0.03648[a] (0.00246) | 0.007414[a] (0.00197) | 0.008847[a] (0.00237) | -0.00516[a] (0.00185) |
| pchicken | -0.04616[a] (0.00257) | 0.059191[a] (0.00317) | -0.01628[a] (0.00220) | -0.00084 (0.00176) | -0.001151 (0.00212) | -0.005609 (0.00165) |

(Table 3.7 continued)

| | Beef | Chicken | Pork | Fresh Seafood | Frozen Seafood | Prepared Seafood |
|---|---|---|---|---|---|---|
| ppork | -0.03648[a] (0.00246) | -0.01628[a] (0.00220) | 0.024887[a] (0.00324) | 0.011064 (0.00197) | 0.01054[a] (0.00227) | 0.006236[a] (0.00195) |
| pfresh | 0.007414[a] (0.00197) | -0.00084 (0.00176) | 0.011064 (0.00197) | 0.00376[c] (0.00243) | -0.00506[b] (0.00202) | -0.01617[a] (0.00186) |
| pfrozen | 0.008847[a] (0.00237) | -0.001151 (0.00212) | 0.01054[a] (0.00227) | -0.00506[b] (0.00202) | -0.0052[a] (0.00310) | -0.00743[a] (0.00208) |
| pprepared | -0.00516[a] (0.00185) | -0.005609 (0.00165) | 0.006236[a] (0.00195) | -0.01617[a] (0.00186) | -0.00743[a] (0.00208) | -0.016908[a] (0.00277) |
| beta | -0.00391[b] (0.00184) | -0.05012[a] (0.00173) | 0.002232 (0.00137) | 0.026403[a] (0.00108) | 0.02793[a] (0.00137) | -0.00253[c] (0.000956) |
| Work | 0.01152[a] (0.00330) | 0.009061[a] (0.00308) | -0.00169 (0.00244) | -0.00593[a] (0.00192) | -0.0092[a] (0.00244) | -0.00375[c] (0.00170) |
| Ownhouse | -0.00221 (0.00392) | -0.01151[a] (0.00366) | 0.007684[a] (0.00290) | -0.00101 (0.00229) | 0.011791[a] (0.00290) | -0.00475[b] (0.00203) |
| Midwest | 0.04581[a] (0.00463) | -0.00963[b] (0.00433) | 0.029529[a] (0.00343) | -0.06518[a] (0.00270) | -0.00168 (0.00342) | 0.001147 (0.00239) |
| South | 0.031412[a] (0.00480) | 0.000102 (0.00407) | 0.018074[a] (0.00323) | -0.04597[a] (0.00255) | -0.00861[b] (0.00323) | 0.004992[b] (0.00225) |
| West | 0.035098[a] (0.0048) | 0.002369 (0.00448) | -0.00409 (0.00355) | -0.04211[a] (0.00280) | 0.006131[c] (0.00355) | 0.002605 (0.00248) |
| Married | -0.00188 (0.00378) | 0.027372[a] (0.00353) | 0.000274 (0.00279) | -0.00235 (0.00220) | -0.00787[a] (0.00279) | -0.01555[a] (0.00195) |
| College | -0.03056[a] (0.00328) | 0.015593[a] (0.00306) | -0.01655[a] (0.00242) | 0.021392[a] (0.00192) | 0.008644[a] (0.00242) | 0.001479 (0.00170) |
| Male | 0.006955[b] (0.00341) | -0.00702[a] (0.00318) | 0.002452 (0.00252) | 0.004044[b] (0.00199) | -0.01301[a] (0.00253) | 0.006571[a] (0.00176) |
| Spring | 0.024491[a] (0.00439) | -0.00039 (0.00410) | -0.00636[b] (0.00325) | 0.006222[a] (0.00256) | -0.01447[a] (0.00324) | -0.00949[a] (0.00227) |
| Summer | 0.027001[a] (0.00434) | 0.000234 (0.00405) | -0.00939[a] (0.00321) | 0.001139 (0.00253) | -0.01122[a] (0.00321) | -0.00777[a] (0.00225) |
| Autumn | 0.015666[a] (0.00432) | 0.020686[a] (0.00404) | -0.00752[b] (0.00320) | -0.00652[b] (0.00252) | -0.0148[a] (0.00319) | -0.00751[a] (0.00223) |
| Black | -0.09372[a] (0.00552) | 0.028883[a] (0.00515) | 0.006542 (0.00409) | 0.022756[a] (0.00325) | 0.018069[a] (0.00409) | 0.017474[a] (0.00288) |
| Other | -0.06342[a] (0.00761) | -0.01668[b] (0.00710) | 0.0037 (0.00563) | 0.026149[a] (0.00444) | 0.042764[a] (0.00562) | 0.007486[c] (0.00394) |
| Hispanic | -0.01753[a] (0.00660) | 0.016946[b] (0.00616) | -0.00975[b] (0.00488) | 0.001646 (0.00385) | 0.006587[c] (0.00487) | 0.002105 (0.00340) |
| Lppage | -0.04054[a] (0.00564) | -0.07545[a] (0.00528) | 0.027741[a] (0.00417) | 0.03335[a] (0.00329) | 0.03475[a] (0.00417) | 0.020153[a] (0.00291) |

(Table3.7 continued)

| | Beef | Chicken | Pork | Fresh Seafood | Frozen Seafood | Prepared Seafood |
|---|---|---|---|---|---|---|
| Lpphhsize | 0.022855[a] (0.00361) | 0.008942[a] (0.00337) | 0.009792[a] (0.00267) | -0.02092[a] (0.00210) | -0.0139[a] (0.00267) | -0.00677[a] (0.00186) |
| Ppmsacat | -0.02308[a] (0.00408) | 0.010593 (0.00381) | -0.01329[a] (0.00302) | 0.013849[a] (0.0238) | 0.01783[a] (0.00302) | -0.00591[a] (0.00211) |
| Ppt016 | -0.00112[a] (0.000334) | -0.00008 (0.000312) | 0.000143 (0.000247) | 0.000852[a] (0.000195) | 0.000447[c] (0.000247) | -0.00024 (0.000172) |

With few exceptions, parameter estimates associated with the discrete variables in the Cox-Wohlgenant model (Table 3.7) tend to mimic those yielded from the Wellman-type model (Table 3.4) with those parameters being significant and positive (negative) in the Cox-Wohgenant Quality Adjusted Model also being significant and positive (negative) in the Wellman-type Quality Adjusted model. When significant, the parameter estimates associated with the two models were also stable. This finding also holds for the non-price continuous variables (i.e., household size and number of children six or under).

While the parameter estimates associated with discrete variables and the non-price continuous variables tended to be stable between models when statistically significant, many of the price-related variables tended to differ. While the own-price parameter estimates for beef in the two models were found to be almost identical between the two models (i.e., 0.454 in the Wellman-type model compared to 0.452 in the Cox-Wohgenant model), for example, the own-price parameters associated with fresh seafood tended to differ substantially between the two models (i.e., -0.033 in the Wellman-type model compared to 0.004 in the Cox- Wohlgenant model). Large differences in the price-related parameters will, of course, lead to significant differences in the Marshallian and Hicksian own-and-cross price elasticities which are presented in Tables 3.8 and 3.9, respectively. These differences are considered in greater detail in Section 3.5.4.

Table 3.8 Estimates of Marshallian Own-Price, Cross-Price and Expenditure Elasticities (Cox- Wohlgenant Model).

| | Beef | Chicken | Pork | Freshs | Frozens | Prepareds | Expenditure elasticity |
|---|---|---|---|---|---|---|---|
| Beef | -0.77365[a] (0.0120) | -0.13856[a] (0.00808) | -0.11123[a] (0.00769) | 0.022926[a] (0.00612) | 0.027934[a] (0.00738) | -0.01525[a] (0.00578) | 0.987837[a] (0.00573) |
| Chicken | -0.1116[a] (0.00993) | -0.69988[a] (0.0120) | -0.02859[a] (0.00836) | 0.010845 (0.00676) | 0.017715[b] (0.0132) | 0.03418[a] (0.00633) | 0.81037[a] (0.00654) |
| Pork | -0.20654[a] (0.0140) | -0.09533[a] (0.0123) | -0.86397[a] (0.0180) | 0.061586[a] (0.0109) | 0.05808[a] (0.0126) | 0.033865[a] (0.0109) | 1.019865[a] (0.00859) |

(Table 3.8 continued)

| | Beef | Chicken | Pork | Freshs | Frozens | Prepareds | Expenditure elasticity |
|---|---|---|---|---|---|---|---|
| Freshs | -0.02162 (0.0318) | -0.09172[a] (0.0277) | 0.102544[a] (0.0312) | -0.93669[a] (0.0384) | -0.09815[a] (0.0319) | -0.28279[a] (0.0295) | 1.417769 (0.0171) |
| Frozens | 0.017681 (0.0211) | -0.11277[a] (0.0189) | 0.050354 (0.0202) | -0.04415[b] (0.0178) | -1.05502[a] (0.0275) | -0.08182[a] (0.0184) | 1.247389[a] (0.0121) |
| Prepareds | -0.07498[a] (0.0327) | 0.115033[a] (0.0285) | 0.116096[a] (0.0339) | -0.2811[a] (0.0323) | -0.12748[a] (0.0360) | -0.70362[a] (0.0482) | 0.95606[a] (0.0166) |

Table 3.9 Estimates of Hicksian Own-Price, Cross-Price and Expenditure Elasticities (Cox- Wohlgenant Model)

| | Beef | Chicken | Pork | Freshs | Frozens | Prepareds | Expenditure elasticity |
|---|---|---|---|---|---|---|---|
| Beef | -0.45577[a] (0.0118) | 0.122521[a] (0.00794) | 0.066775[a] (0.00765) | 0.085538[a] (0.00612) | 0.13946[a] (0.00738) | 0.041648[a] (0.00576) | 0.988238[a] (0.00574) |
| Chicken | 0.149176[a] (0.00967) | -0.4857[a] (0.0119) | 0.117347[a] (0.00830) | 0.06206 (0.00674) | 0.109206[a] (0.00810) | 0.080857[a] (0.00631) | 0.807719[a] (0.00654) |
| Pork | 0.130217[a] (0.0142) | 0.095422[a] (0.0127) | -0.68154[a] (0.0180) | 0.117003[a] (0.0109) | 0.156277[a] (0.0127) | 0.0937[a] (0.0108) | 1.012385[a] (0.00759) |
| Freshs | 0.434622[a] (0.0312) | 0.283001[b] (0.0281) | 0.358024[a] (0.0311) | -0.84709[a] (0.0384) | 0.063996[a] (0.0319) | -0.20112[a] (0.0295) | 1.412794[a] (0.0171) |
| Frozens | 0.419091[a] (0.0211) | 0.216918[a] (0.0187) | 0.275133[a] (0.0201) | 0.034588[b] (0.0178) | -0.91419[a] (0.0275) | -0.00997 (0.0184) | 1.243962[a] (0.0121) |
| Prepareds | 0.232677[a] (0.0322) | 0.36772[a] (0.0284) | 0.288375[a] (0.0339) | -0.22078[a] (0.0323) | -0.01954[a] (0.0361) | -0.64855[a] (0.0481) | 0.972249[a] (0.0166) |

### 3.5.3 Results: Non-Quality Adjusted Model

To more fully examine the role of quality, the analysis was also conducted without taking into account the role of quality. The estimated parameter estimates associated with this analysis are presented in Table 3.10.

Table 3.10 Estimated parameters associated with seafood product forms and other animal protein commodities (non-quality adjusted model)

| | Beef | Chicken | Pork | Fresh Seafood | Frozen Seafood | Prepared Seafood |
|---|---|---|---|---|---|---|
| Intercept | 0.461995[a] (0.0227) | 0.649874[a] (0.0211) | 0.066461[a] (0.0168) | -0.0834[a] (0.0133) | -0.10429[a] (0.0166) | 0.009389 (0.0117) |
| pbeef | 0.107828[a] (0.00430) | -0.00261[a] (0.00247) | -0.03279[a] (0.00265) | 0.009523[a] (0.00223) | -0.00916 (0.00249) | -0.01233[a] (0.00183) |
| pchicken | -0.00261[a] (0.00247) | 0.102302[a] (0.00420) | -0.01618[a] (0.00268) | -0.01893[a] (0.00227) | -0.00494 (0.00248) | -0.00044 (0.00184) |
| ppork | -0.03279[a] (0.00265) | -0.01618[a] (0.00268) | 0.030895[a] (0.00325) | 0.001121 (0.00204) | 0.008144[a] (0.00218) | 0.011221[a] (0.00165) |

(Table 3.10 Continued)

| | Beef | Chicken | Pork | Fresh Seafood | Frozen Seafood | Prepared Seafood |
|---|---|---|---|---|---|---|
| pfresh | 0.009523[a] (0.00223) | -0.01893[a] (0.00227) | 0.001121 (0.00204) | -0.01077[a] (0.00265) | -0.00842[a] (0.011654) | 0.011654[a] (0.00150) |
| pfrozen | -0.01119 (0.00248) | -0.06285 (0.00326) | 0.008144[a] (0.00218) | -0.00842[a] (0.011654) | -0.002994[a] (0.00284) | -0.0179[a] (0.00157) |
| pprepared | -0.00916 (0.00249) | -0.00044 (0.00184) | 0.011221[a] (0.00165) | 0.011654[a] (0.00150) | -0.0179[a] (0.00157) | -0.006701[a] (0.00165) |
| beta | -0.00415[c] (0.00182) | -0.05048[a] (0.00169) | 0.003516[a] (0.00135) | 0.024015[a] (0.00107) | 0.028171[a] (0.00134) | -0.00107 (0.000938) |
| Work | 0.01075[a] (0.00327) | 0.007741[a] (0.00303) | -0.00103 (0.00242) | -0.00513[a] (0.00192) | -0.00905[a] (0.00240) | -0.00329[c] (0.00168) |
| Ownhouse | -0.00043 (0.00389) | -0.01232[a] (0.00360) | 0.00821[a] (0.00288) | -0.00239 (0.00229) | 0.014333[a] (0.00286) | -0.0074[a] (0.00200) |
| Midwest | 0.044973[a] (0.00460) | -0.01053[a] (0.00426) | 0.028082[a] (0.00341) | -0.06371[a] (0.00270) | -0.00175 (0.00338) | 0.002945 (0.00237) |
| South | 0.02883[a] (0.00431) | -0.00049 (0.00400) | 0.01752[a] (0.00320) | -0.04454[a] (0.00254) | -0.00503 (0.00317) | 0.003698[c] (0.00222) |
| West | 0.035104[a] (0.00476) | -0.00016 (0.00442) | -0.0054[c] (0.00353) | -0.04069[a] (0.00281) | 0.009636[a] (0.00350) | 0.001514 (0.00245) |
| Married | -0.00259 (0.00375) | 0.026242[a] (0.00347) | 0.001318 (0.00278) | -0.00158[a] (0.00220) | -0.00806[a] (0.00275) | -0.01533[a] (0.00193) |
| College | -0.03523[a] (0.00324) | 0.015403[a] (0.00300) | -0.0165[a] (0.00240) | 0.021052[a] (0.00191) | 0.008483[a] (0.00238) | 0.004086[a] (0.00167) |
| Male | 0.006864[a] (0.00338) | -0.0081[a] (0.00313) | 0.002485 (0.00250) | 0.00414[b] (0.00199) | -0.012[a] (0.00248) | -0.006608[a] (0.00174) |
| Spring | 0.022746[a] (0.00435) | -0.00258 (0.00403) | -0.00649[c] (0.00323) | 0.008597[a] (0.00256) | -0.01309[a] (0.00320) | -0.00918[a] (0.00224) |
| Summer | 0.026382[a] (0.0043) | -0.00215 (0.00398) | -0.01003[a] (0.00319) | 0.003772 (0.00253) | -0.01068[a] (0.00316) | -0.00729[a] (0.00221) |
| Autumn | 0.015262[a] (0.00428) | 0.019884[a] (0.00397) | -0.0072[a] (0.00317) | -0.0055[b] (0.00252) | -0.01337[a] (0.00315) | -0.00908[a] (0.0220) |
| Black | -0.09043[a] (0.00543) | 0.028459[a] (0.00503) | 0.005743 (0.00403) | 0.02472[a] (0.0032) | -0.019576[a] (0.00399) | 0.011928[a] (0.00281) |
| Other | -0.05949[a] (0.00751) | -0.02024[a] (0.00696) | 0.000835 (0.00557) | 0.026559[a] (0.00442) | 0.046996[a] (0.00552) | 0.005334 0.00387 |
| Hispanic | -0.01802[a] (0.00653) | 0.017882[a] (0.00605) | -0.01039[a] (0.00484) | 0.02906 (0.00384) | 0.005509[a] (0.00480) | 0.002105 0.00336 |
| Lppage | -0.04222[a] (0.00560) | -0.07425[a] (0.00520) | 0.027375[a] (0.00415) | -0.032001 (0.00330) | 0.0037824[a] (0.00412) | 0.019259[a] (0.00289) |
| Lpphhsize | 0.023266[a] (0.00358) | 0.008594[a] (0.00332) | 0.008375[a] (0.00265) | -0.01887[a] (0.00211) | -0.01418[a] (0.00263) | -0.00719[a] (0.00184) |

(Table 3.10 continued)

| | Beef | Chicken | Pork | Fresh Seafood | Frozen Seafood | Prepared Seafood |
|---|---|---|---|---|---|---|
| ppmasat | -0.0226[a] (0.00404) | 0.008867[b] (0.00374) | -0.012[a] (0.00299) | 0.014106[a] (0.00238) | 0.018879[a] (0.00297) | -0.00726 (0.00208) |
| Lppt06 | -0.00116[a] (0.000332) | -0.00008 (0.000307) | 0.000079 (0.000246) | 0.000904[a] (0.000195) | 0.000518[b] (0.000244) | -0.00026 (0.000171) |

A comparison of the results associated with this model with the other two models suggest that the parameter estimates associated with the discrete variables, when significant, tend to be very stable as do the non-price continuous variables. However, while some of the price-related parameter estimates are quite stable between all three models (e.g., beef own price which was found to equal 0.462 when no quality adjustment is made compared to 0.454 and 0.452 for the other two models), some substantial differences are apparent with respect to other price-related variables (e.g., own-price parameter estimate equal to -0.011 when no quality adjustment is made compared to 0.004 for the Cox- Wohgenant model and -0.033 in the Wellman-type model).

Table 3.11 Estimates of Marshallian Own-Price, Cross-Price and Expenditure Elasticities (non-quality adjusted model)

| | Beef | Chicken | Pork | Freshs | Frozens | Prepareds | Expenditure elasticity |
|---|---|---|---|---|---|---|---|
| Beef | -0.66077[a] (0.0135) | 0.030408[a] (0.00695) | -0.09956[a] (0.00826) | 0.123591[a] (0.00963) | -0.027[a] (0.00776) | -0.03414[a] (0.00571) | 0.987093[a] (0.00566) |
| Chicken | -0.18125[a] (0.0126) | -0.56245[a] (0.0158) | -0.02679[a] (0.0102) | -0.05957 (0.00862) | 0.11678 (0.00939) | 0.009344 (0.00698) | 0.80899[a] (0.00640) |
| Pork | -0.18822[a] (0.0150) | -0.09493[a] (0.0149) | -0.84529[a] (0.0179) | 0.004976 (0.0113) | 0.043306[a] (0.0122) | 0.061091[a] (0.00916) | 1.019511[a] (0.00750) |
| Freshs | 0.0284[a] (0.0358) | 0.40002[b] (0.0358) | -0.05078 (0.0322) | -0.94405[a] (0.0570) | -0.17614[a] (0.0317) | 0.162518[a] (0.0238) | 1.37998[a] (0.0170) |
| Frozens | -0.16142[a] (0.0224) | -0.08909[a] (0.0219) | 0.027672 (0.0194) | -0.09033[a] (0.0178) | -0.76298[a] (0.0252) | -0.17296[a] (0.0139) | 1.249524[a] (0.0119) |
| Prepareds | -0.18891[a] (0.0324) | -0.00272[a] (0.0319) | 0.197967[a] (0.0287) | 0.203501[a] (0.0262) | -0.30875[a] (0.0273) | -0.88259 (0.0287) | 0.981498[a] (0.0163) |

Table 3.12 Estimates of Hicksian Own-Price, Cross-Price and Expenditure Elasticities (non-quality adjusted model)

| | Beef | Chicken | Pork | Freshs | Frozens | Prepareds | Expenditure elasticity |
|---|---|---|---|---|---|---|---|
| Beef | -0.34312[a] (0.0134) | 0.064952[a] (0.0101) | 0.07831[a] (0.00822) | 0.098702[a] (0.00689) | 0.084444[a] (0.00772) | 0.02272[a] (0.00569) | 0.987063[a] (0.00566) |
| Chicken | 0.079082[a] (0.0123) | -0.34863[a] (0.0159) | 0.122641[a] (0.0102) | -0.00844 (0.00859) | 0.103013[a] (0.00934) | 0.055942[a] (0.00696) | 0.80899[a] (0.0064) |
| Pork | 0.153539[a] (0.0152) | 0.09529[a] (0.0152) | -0.66157[a] (0.0179) | 0.062128[a] (0.0113) | 0.142961[a] (0.0121) | 0.121279[a] (0.00914) | 1.0195[a] (0.0075) |

(Table 3.12 continued)

| | Beef | Chicken | Pork | Freshs | Frozens | Prepareds | Expenditure elasticity |
|---|---|---|---|---|---|---|---|
| Freshs | 0.472478[a] (0.0353) | -0.03529[b] (0.0359) | 0.1978[a] (0.0322) | -0.85684[a] (0.020) | -0.02034[a] (0.0238) | 0.242005[a] (0.0238) | 1.37998[a] (0.0170) |
| Frozens | 0.241029[a] (0.0220) | 0.241155[a] (0.0219) | 0.2528[a] (0.0193) | 0.01149[a] (0.0177) | -0.62191[a] (0.0251) | -0.10098[a] (0.0139) | 1.249524[a] (0.0119) |
| Prepareds | 0.126934[a] (0.0318) | 0.256693[a] (0.0319) | 0.3748[a] (0.0286) | 0.265433[a] (0.0261) | -0.19793[a] (0.0272) | -0.82606[a] (0.0287) | 0.981498[a] (0.0163) |

### 3.5.4 Results: Comparison among Models

As noted, parameter estimates associated with the discrete variables included in the three alternative model specifications appeared to be extremely stable across models while the parameter estimates associated with the price variables were less stable. The lack of stability among estimated price parameters results, of course, in differences in elasticity estimates. This is illustrated in Table 3.13

Table 3.13 Estimated Hicksian Own-Price Elasticities Associated with the Three Alternative Complete Demand Specifications

| | Wellman-type quality adjusted model | Cox and Wohlgenant quality adjusted model | Non-quality adjusted model |
|---|---|---|---|
| Beef | -0.456 | -0.458 | -0.343 |
| Chicken | -0.431 | -0.486 | -0.349 |
| Pork | -0.790 | -0.682 | -0.662 |
| Freshs | -1.451 | -0.847 | -0.857 |
| Frozens | -0.953 | -0.914 | -0.622 |
| Prepareds | -1.137 | -0.649 | -0.826 |

with respect to the Hicksian own-price elasticities. Comparison of the own-price beef elasticities across the three models indicate that the Wellman-based quality adjusted elasticity and the Cox-Wohlgenant quality adjusted elasticities are similar but that the non-quality adjusted beef own-price elasticity is substantially lower. This same finding was found with respect to the own-price elasticities for chicken. This pattern, however, begins to pork and is magnified with respect to fresh seafood. Specifically, whereas the Cox-Wohlgenant quality adjusted and the non-quality adjusted own-price elasticities for these two products are very close in magnitude, the Wellman-type quality adjusted own-price elasticities associated with these two products are higher and, in the case of fresh fish, the difference approaches 70%. This relationship, however, is once again reversed when examining the own-price elasticities associated with frozen seafood. Finally, the pattern with respect to prepared seafood tends to be different than that associated with any of the other products. Specifically, the smallest own-price elasticity was that associated with the Cox-Wohlgenant quality adjusted model which was the only product for which this finding was observed. As with the other products, however, the Wellman-type own-price elasticity was the largest of the three.

Unfortunately, as discussed, no systematic trend can be observed in the comparison of estimated own-price elasticities associated with the three alternative complete-demand system specifications though, in general, the Wellman-type model specification appears to yield larger own-price elasticities. The observed differences between models, however, do appear to be magnified in relation to the percentage of unobserved price data associated with each product. The highest percentage of unobserved price data, for example, was associated with fresh seafood and with this product the Wellman-type own-price elasticity estimate (-1.451) exceed that of the other two models by about 70%. Conversely, with respect to chicken, where the percentage of non-zero price observations was the largest (87.5%) the estimated own-price elasticity associated with the Wellman-type model approximated that of the Cox-Wohlgenant model and was only about 30% larger than that observed when no attempt is made to adjust for quality.

Additional insight can be gleaned in comparing the cross-price elasticities between the three alternative complete demand system specifications. Summary tables of the cross-price elasticities for the three generic seafood product forms are given in Tables 3.14 through 3.16.

Table 3.14 Estimated Hicksian Cross-Price Elasticities Associated with the Three Alternative Complete Demand Specifications: Fresh Seafood

| | Beef | Chicken | Pork | Frozens | Prepareds |
|---|---|---|---|---|---|
| Wellman-type model | 0.629 | 0.055 | 0.027 | 0.181 | 0.314 |
| Cox-Wohlgenant model | 0.434 | 0.283 | 0.358 | 0.064 | -0.201 |
| Non-quality adjusted model | 0.472 | -0.035 | 0.198 | -0.020 | 0.242 |

Table 3.15 Estimated Hicksian Cross-Price Elasticities Associated with the Three Alternative Complete Demand Specifications: Frozen Seafood

| | Beef | Chicken | Pork | Freshs | Prepareds |
|---|---|---|---|---|---|
| Wellman-type model | 0.344 | 0.273 | 0.321 | 0.101 | -0.085 |
| Cox-Wohlgenant model | 0.419 | 0.217 | 0.275 | 0.035 | -0.010 |
| Non-quality adjusted model | 0.241 | 0.241 | 0.258 | 0.011 | -0.101 |

Table 3.16 Estimated Hicksian Cross-Price Elasticities Associated with the Three Alternative Complete Demand Specifications: Prepared Seafood

| | Beef | Chicken | Pork | Freshs | Frozens |
|---|---|---|---|---|---|
| Wellman-type model | 0.201 | 0.253 | 0.505 | 0.345 | -0.167 |
| Cox-Wohlgenant model | 0.233 | 0.368 | 0.289 | -0.221 | -0.020 |
| Non-quality adjusted model | 0.127 | 0.257 | 0.375 | 0.265 | -0.198 |

With respect to the fresh seafood equations, all cross-price elasticities associated with the Wellman-type quality adjusted model were found to be positive (Table 3.14) indicating all other animal protein commodities are substitutes for fresh seafood. Prepared seafood was found to be a complement to fresh seafood in the Cox-Wohlgenant quality adjusted model and in the non-quality adjusted model both chicken and frozen seafood were found to be complements to fresh seafood. The complementary nature of these products with fresh seafood is difficult to reconcile with economic theory.

With respect to frozen seafood (Table 3.15), prepared seafood was found to be a complement to frozen seafood in each of the three alternative model specifications while all other products were found to be substitutes. With the exception of beef, furthermore, the degree of substitution was found to be higher in the Wellman-type model than in the other two models. In general, however, the cross-price elasticities with respect to frozen seafood were relatively close between the three alternative models.

When considering the Wellman-type quality adjusted model, all products, with the exception of frozen seafood, were found to be substitutes for prepared seafood. This was also the case with respect to the non-quality adjusted model. With respect to the Cox-Wohlgenant quality adjusted model, however, both fresh seafood and frozen seafood were found to be complements to prepared seafood.

Finally, a comparison of the expenditure elasticities across the three alternative complete demand system specifications shows extreme stability. In each model, the expenditure elasticity associated with fresh seafood is the largest (at approximately 1.40) while that associated with chicken is the smallest (at approximately 0.80). In between these two extremes fall frozen seafood (at approximately 1.24), pork (at approximately 1.02), and prepared seafood (at approximately 0.97).

### 3.6 Conclusions

The overall goal of this chapter was to estimate seafood (by generic product form) and alternative animal protein commodities in a complete demand system framework with attention being paid to the role of quality. To do so, three forms of seafood were considered (fresh, frozen, and prepared) along with the three primary animal protein products (beef, chicken, and pork). Furthermore, three separate complete demand systems were estimated; two which either indirectly or indirectly attempted to account for variation in quality by product and one that made no attempt to adjust for quality variation.

In general, results appear to be satisfactory with all own-price elasticities exhibiting the expected negative sign (indicating that the quantity demanded decreases as price increases) and, with few exceptions, cross-price elasticities were positive (indicating substitutability). Across all three models, beef and chicken tended to exhibit the lowest own-price elasticities while, with one or two notable exceptions, the seafood products exhibited the largest own-price elasticities. Cross-price elasticities associated with the three seafood equations, while generally of the expected sign, were also generally small with some notable exceptions. With respect to fresh seafood, for example, the largest cross-price elasticities (for the three alternative specifications) tended to be those associated with beef. Somewhat surprising, the cross price elasticities between fresh seafood and frozen seafood were relatively small (the largest being 0.181 in the Wellman-type quality adjusted model) suggesting very limited substitutability of frozen seafood for fresh seafood.

Unfortunately, the method by which quality is taken into account (or not taken into account) does appear to influence own-price elasticities and the influence tends to become larger in association with unobserved prices (or zero expenditures). The Wellman-type approach used in the current analysis can be questioned due to the fact that it violates the 'spirit' of the complete demand system. This method of taking quality into account consistently resulted in the largest own-price elasticities associated with the three seafood products. The Cox-Wohlgenant method for adjusting for quality has also been criticized, however, due to the fact that (a) it lacks theoretical justification and (b) it introduces heteroskedasticity. In general, the Cox-Wohlgenant mehod for adjusting for quality closely approximated those based on the Wellman approach for indirectly controlling for quality with the excpetion that the own-price elasticities for fresh seafood and prepared seafood were much lower based on the Cox-Wohlgenant procedure than with the Wellman procedure. The noted differences in elasticities associated with products that have a high percentage of missing prices (or zero expenditures) suggest that there may be a tradeoff with refinement in analysis, in terms of the number of products, being considered and the reliability of the associated estimated parameters. Specifically, the precision of parameter estimates may decline as the number of commodities included in the analysis increases due to an increased proportion of non-consuming households of any particular commodit

# CHAPTER 4 A BIVARIATE MODEL OF SEAFOOD DEMAND

## 4.1 Introduction

In the previous chapter (i.e., Chapter 3) the demand for seafood, examined by generic product form, was in conjunction with other animal protein commodities that would compete for the limited at-home food budget estimated in a complete demand framework. While the issue of quality was considered in that chapter, quality was considered exogenous in the analysis. The argument has been made, however, that household demand for quality associated with a given commodity (and measured via price) and the quantity demanded for that commodity are simultaneously determined. While the argument is not new, the complicated statistical properties associated with estimation when using micro-oriented data (where many of the prices are unobserved and expenditures equal zero) delayed empirical testing of the argument until 1998 when Dong et al. (1998) developed an econometric, two equation, model that handles the issue of sample selectivity and the correlation of the correlation between the unit value (price) and the error term in the quantity equation. The authors used this model to examine the demand for beef steaks and roasts and conclude that the bivariate modeling approach was superior, at least in that analysis, to the approach suggested by Cox and Wohlgenant (1986) which was presented in the previous chapter (and used in the estimation of the complete demand systems).

Though the model developed by Dong et al. (1998) for cross-sectional demand analysis involving micro level data is appealing, it has been only sparingly employed.[50] Use of the model to examine at-home seafood demand is a 'fruitful' area of research, however, for a couple of reasons. First, at a more aggregate level (say, total seafood), there are a large number of species varying in quality and, hence, large variation in unit price. Second, there is a wide variety of processing associated with seafood products (from, say, the whole fish to fillets) which can influence the unit value and observed quantity. Finally, and perhaps of greatest relevance, analysis of seafood demand at the retail level is very limited and, with the exception of analysis by Cheng and Capps (1986), the demand for individual species virtually lacking. This study, based on 1981 data, is outdated and thus updated analysis of at-home demand by species is warranted.

[50] Specifically, the onlly other published study employing this procedure is that by Myrland et al. (2007), in a study of Norwegian at-home salmon demand and the influence of advertising on demand.

Based on the forgoing discussion, the primary objective associated with this chapter is to analyze the at-home demand for seafood in aggregate and by individual species taking into account the possible simultaneity between quantity demanded and the demand for quality (as measured by the unit value). To achieve this objective, the theoretical aspects associated with the model, from both an economic perspective and an econometric perspective, are first presented. Then the data, including the variables used for analysis, is discussed. This is followed by a brief discussion of the model which is followed by the results. Conclusions and suggestions for additional research are presented in the last section.

### 4.2 The Economic and Econometric Models

#### 4.2.1 The Economic 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.

Following Cramer (1973), the Engel curve describes how a household's expenditure on a particular good or service varies with its income. The expenditure x can be expressed in relation to price p and quantity q as:

(1) $\log x = \log q + \log p$

and the income (y) elasticities can be expressed as :

(2) $\dfrac{\partial \log x}{\partial \log y} = \dfrac{\partial \log q}{\partial \log y} + \dfrac{\partial \log p}{\partial \log y}$

When Engel curves deal with the composite commodities rather than elementary goods, price is not constant and the last term in equation (2) represents the quality elasticity. If prices are excluded from the respective models, the quality elasticity can be easily derived by subtracting the quantity elasticity from the expenditure elasticity. As noted by Cox et al. (1984) in an analysis of the USDA's 1977-78 Nationwide Food Consumption Survey, however, observed prices for disaggregated commodities (though not necessarily at the elementary good level) are anything but constant across households and, as noted by Cox et al. (1986), "[f]ailure to adequately specify cross-sectional price effects could result in biased and misleading demand elasticities (Polinsky)." The authors further argue that much of the reason for price variation across households for a given commodity reflect "quality" effects and correction of these effects need to be considered prior to estimation[51].

Houthakker (1952) and Theil (1952) were the first to theoretically address the influence of quality on demand in a systematic framework. They proposed that consumers attempted to maximize their utility (demand) subject to a hedonic price constraint. Furthermore, the hedonic price model was considered as the price/quality tradeoff that allowed the authors to represent the quantity demanded and quality demanded within a simultaneous equation system as follows

$$(3)\ \underset{q\geq 0, b\geq 0}{Max}\, U(x_1, \ldots, x_k)$$
$$\sum_{i=1}^{k} p_i x_i = Y$$

$$(4)\ P_i = \alpha_i + \sum_j \gamma_{ij} b_{ij}$$

Where equation 3 simply represents maximization of utility to subject to a budget constraint while equation 4 represents the price quality tradeoff specified as a hedonic price model.

Cox and Wohlgenant (1986), in their analysis of the vegetable market, adapted Houthakker-Theil framework but they estimated the unit value equation (i.e., price was estimated in a hedonic framework) independently from the demand rather than in simultaneous equation framework. Based on the simplifying assumption that consumers have made a prior decision about the quality of composite goods prior to the decision of whether to purchase the goods, Cox and Wohlgenant (1986) were able simplify the model systems to a single-equation Tobit model. This procedure circumvented the issue of having to estimate simultaneous equations within a Tobit framework and the potential issue of corner solutions.

[51] As subsequently discussed, more recent research suggests that quality effects should be taken into account during the estimation process.

While the analysis by Cox et al. (1984) and Cox and Wohlgenant (1986) controlled for the influence of quality on demand, as pointed by Nelson (1991), analysis using this procedure failed to account for the influence of quality on quantity demanded. Nelson (1991) argued that the simple sum of physical quantities couldn't 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):

$$(5) Max U(Q_1,...,Q_n)$$
$$s.t. \sum_{G=1}^{n} P_G Q_G = I$$

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 I is defined as the consumer's income. Hicks' composite commodity theorem assumes that the prices of goods within the group G move proportionally:

$$(6) i \in G \Rightarrow p_i = P_G p_i^*$$

Where $p_i^*$ is the "base" price for each elementary goods i and $Q_G$ can be defined as:

$$(7) \quad Q_G = \sum_{i \in G} P_i^* x_i$$

Combining equations (6) and (7) implies an expenditure equation which can be expressed as:

$$(8) E_G = \sum_{i \in G} p_i x_i = \sum_{i \in G} P_G p_i^* x_i = P_G \sum_{i \in G} p_i^* x_i = P_G Q_G$$

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:

$$(9) V_G = E_G / q_G = P_G Q_G / q_G = P_G v_G$$

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:

$$(10) v_G = \sum_{i=G} \left( \frac{x_i}{q_G} \right) p_i^* = \frac{\sum_{i \in G} p_i^* x_i}{q_G}$$

The unit value equation is based on the relationship

$$(11)\ln V_G = \ln p_G + \ln v_G$$ (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 demand function of a composite good can be expressed by equation 12:

$$(12)Q_G = g(\ln V_G, I, SE, DE)$$

**4.2.2 The Econometric Model**

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 demand function equation 12 is given by:

$$(13)Q_i^* = \beta_0 + \beta_1 * \ln V_i + \beta_2 * I_i + \beta_3 * SE_i + \beta_4 * DE_i + \mu_{1i}$$

Such that Q=Q* if Q*>0 and

Q=0, otherwise

Because V is left truncated on 0, LnV rather than V is included as an argument in the expenditure equation. .

Empirically, equation 11 can be expressed as:

$$(14)LnV_i = \alpha_i + \sum \beta_i x_i + \mu_{2i}$$

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

$\alpha$ represents $\ln P_G$ in equation 11 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 11).

The Log likelihood function is based on the joint probability distribution function. When simultaneously consider both quantity and quality effects for the analysis of seafood consumption behavior, $\mu_1$ and $\mu_2$ are assumed jointly and normally distributed with mean 0 and covariance matrix

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

A bivariate normal density function n ( $\mu_{1i}$ , $\mu_{2i}$ ; 0,∑) is noted as a joint probability density function for both the purchasing and non-purchasing household. In addition, a marginal density function for the non-purchasing household can be derived from n:

$$(15)\, prob(Q_i = 0) = \int_{-\infty}^{+\infty} \int_{-\infty}^{-\beta_0+\beta_1*\ln v_i+\beta_2*I_i+\beta_3*SE_i+\beta_4*DE_i} n(\mu_{1i}, \mu_{2i}; 0, \Sigma) d\mu_{1i} d\mu_{2i} = \Phi(-\theta)$$

The likelihood function for N households, assuming that t of these N household did consume the the commodity being considered:

$$(16) L(Q, \ln V; \alpha, \beta, \Sigma) = \prod_{i=1}^{t} n(\mu_{1i}, \mu_{2i}; 0, \Sigma) \prod_{i=t+1}^{N} \Phi(-\theta)$$

Furthermore, taking the logarithm of it is often mathematically easier to derive the maximum value. This log-likelihood function then has the form:

$$(17) \log L = \sum_{i=1}^{t} \left\{ -\frac{1}{2} \ln |\Sigma| - \frac{1}{2} \mu_i^{'} \Sigma^{-1} \mu_i \right\} + \sum_{i=t+1}^{N} \ln \Phi(-\theta)$$

Taking the partial derivative of the log-likelihood function allows one to derive values for parameters that maximize this equation.

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 purchase effect and unit value effect. The Equation (18) and (19) show the expected value of expenditure and unit value. While $\omega_1 = (\sigma_1^2 + 2\sigma_1\sigma_2 + \sigma_2^2)^{1/2}$ ,which can be derived from the covariance matrix. $\Phi$ (.) represents the standard normal Cumulative distribution function and $\varphi$ (.) indicates the standard normal probability density function.

$$(18) E(Q) = \Phi(\theta)[(X\beta)\alpha_1 + Z\alpha_2] + \omega_1\varphi(\theta)$$

$$(19)\, E(\ln V) = X\beta,$$

Given the unit value, the expected purchase effect can be derived from equation

$$(20) E(Q/V) = \Phi(\delta)(\ln V\alpha_1 + Z\alpha_2] + \omega_2\varphi(\delta)$$

In equation 20, the probability of household who purchase seafood given unit value V during the survey period is represented by $\varphi(\delta)$.

$$(21)\ \delta = [\ln V\alpha_1 + Z\alpha_2 + \frac{\sigma_{12}}{\sigma_2^2}(\ln V - X\beta)] / \omega_2,\ and\ \ \omega_2 = (\varsigma - \frac{\sigma_{12}^2}{\sigma_2^2})^{1/2}$$

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 $\sigma_{12}$ (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.

**4.3 The Data**

The data used for the analysis, as noted, is the 2005/06 NOAA Fisheries Seafood Consumption Survey which consists of 10,632 completed interviews, 5,311 of which were fresh cross-sectional interviews.[52] While the unbalanced nature of the dataset makes analysis in a panel structure infeasible, it does allow for pooling of all observations. Variables used in the study, as well as a description of these variables, are presented in Table 4.1. As indicated, monthly at-home seafood purchases averaged 2.7082 pounds per household with shrimp accounting for more than one-third of the total. More than 60% of the survey respondents had some college education. When considered by region, 20 percent respondents reside in Northeast, 24% reside in the Midwest, 34% reside in South and 22% reside in West. Almost 80% of the survey respondents identified themselves as White, 10% as Black, and 6% as Hispanic. In addition, the average age of household manager is 48.7. 31% of the respondents are male and 82% reside in an urban setting.

[52] A more detailed discussion of the data used in this analysis can be found in Chapter 3.

Table 4.1 Variable Name and Description

| Variable name | Description | Mean | Standard Deviation |
|---|---|---|---|
| Quantity | Household Purchase of Finfish And Shellfish (Lbs.) | 2.7028 | 5.4236 |
| ShellfishQ | Household Purchases of Shellfish (Lbs.) | 1.2936 | 3.0725 |
| ShrimpQ | Household Purchases of Shrimp (Lbs) | 1.0022 | 2.9593 |
| CrabQ | Household Purchases of Crab (Lbs) | 0.2492 | 1.7526 |
| FinfishQ | Household Purchases of Finfish (Lbs.) | 1.4092 | 2.9248 |
| CatfishQ | Household Purchases of Catfish (Lbs.) | 0.2879 | 2.2839 |
| Canned TunaQ | Household Purchase of Canned Tuna (Lbs.) | 0.1953 | 1.1085 |
| Noncanned SalmonQ | Household Purchases of Noncanned Salmon (Lbs.) | 0.3058 | 1.1258 |
| SeafoodP | Seafood Unit Price ($) | 5.2817 | 3.9354 |
| ShellfishP | Shellfish Unit Price($) | 6.2289 | 3.6825 |
| ShrimpP | Shrimp Unit Price($) | 6.4342 | 4.1044 |
| CrabP | Crab Unit Price($) | 7.6221 | 6.0323 |
| FinfishP | Finfish Unit Price($) | 4.7377 | 4.2769 |
| CatfishP | Catfish Unit Price($) | 3.7192 | 2.8809 |
| Canned TunaP | Canned Tuna Unit Price($) | 4.6301 | 6.1451 |
| Noncanned SalmonP | Noncanned Salmon Unit Price($) | 5.3820 | 3.2038 |
| Northeast(omitted category)<br>Midwest<br>South<br>West | Region variable | 0.20<br>0.24<br>0.34<br>0.22 | 0.40<br>0.24<br>0.34<br>0.22 |
| Spring(omitted category)<br>Summer<br>Autumn<br>Winter | Season Variable | 0.24<br>0.25<br>0.25<br>0.26 | 0.43<br>0.42<br>0.42<br>0.39 |
| Income | Annul Household Income | $51909 | $37252 |

(Table 4.1 continued)

| Variable name | Description | Mean | Standard Deviation |
|---|---|---|---|
| Pphhsize | Household Size | 2.53 | 1.38 |
| Ppt018 | Number of household members younger than 18 years | 0.53 | 0.0093 |
| White (omitted category)<br>Black<br>Other<br>Hispanic | Race Variable | 0.79<br>0.10<br>0.04<br>0.06 | 0.41<br>0.30<br>0.21<br>0.25 |
| Work | Employment status of household manager | 0.56 | 0.50 |
| College | At least some college education | 0.62 | 0.49 |
| Married | Equal to 1 if married; zero otherwise | 0.61 | 0.49 |
| Ownhouse | Equal to 1 if household owns house; zero otherwise | 0.73 | 0.44 |
| Awayexp | Away_from_home total seafood expenditure | 31.53 | 45.97 |

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 purchases. Similarly, aggregation across the shellfish species and finfish species and respective product forms provided an estimate of shellfish and finfish purchases. Finally, aggregation across the individual products for any given species - such as shrimp, crab, catfish, canned tuna and noncanned salmon – yields an estimate of purchases of that species.

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 households for seafood in aggregate and disaggregated are provided in Table 4.2. Shrimp, as indicated, accounted for 78.5% total shellfish purchases and 38.2% of the total seafood purchases. Catfish, canned tuna and noncanned salmon represented more than 58.81% of the total finfish purchases and 30.03% of the total seafood purchases.[53]

Table 4.2 Descriptive Statistics of Household Purchase on Total Seafood, Finfish, Shellfish and Selected Species

| Categories | Number of Nonzero Values | Average of Quantity Over All Households | Average Only Among Consuming Households | Total Finfish Pounds Share | Total Shellfish Pounds Share | Total Pounds Share |
|---|---|---|---|---|---|---|
| Total Finfish | 3274 | 1.4092 | 4.3912 | 100% | --- | 51% |
| Catfish | 499 | 0.2879 | 6.1769 | 21.53% | --- | 10.99% |
| Canned Tuna | 851 | 0.1953 | 2.4548 | 14.56% | --- | 7.43% |
| Noncanned Salmon | 1097 | 0.3058 | 2.9771 | 22.72% | --- | 11.61% |
| Total Shellfish | 3190 | 1.2936 | 4.2887 | --- | 100% | 49% |
| Shrimp | 2755 | 1.0022 | 3.8997 | --- | 78.53% | 38.18% |
| Crab | 527 | 0.2492 | 4.7807 | --- | 18.41% | 8.95% |
| Total Seafood | 4635 | 2.7028 | 6.8621 | --- | --- | 100% |

**4.4 The Empirical Model**

The model as originally proposed by Dong et al. (1998) and more recently adapted by Myrland et al (2007) is employed to estimate at-home seafood household demand functions with the variables included in the analysis are given in Table 4.1. While the own-price is included in each of the estimated models (i.e., nine models covering the species/groups in Table 4.2 and 18 equations), no attempt is made to include prices of (potential) substitutes in the individual models. The decision not to include prices of competing products was based on three considerations. First, correctly identifying the appropriate substitute species would be a difficult task. Second, in the only detailed analysis of retail at-home demand for seafood by species, Cheng and Capps (1986) found little statistical significance associated with substitute prices included in their analysis of ten seafood species/groups.[54] Finally, inclusion of prices (unit values) of possible substitute good is complicated by the fact that, given the model specification, unit values (prices) are considered endogenous (and provides information on the quality of that substitute commodity. Inclusion of additional endogenous unit values in any equation would substantially complicate the estimation process.

[53] The selection of these species is based on the discussion in Chapter 2.
[54] For possible substitutes for seafood species/groups, Cheng and Capps (1986) included the price of red meats and poultry. Of the 20 estimated cross price elasticities included in the ten equations, the authors found only five to be significant at the 10% level and one was found to be negative.

The model for any species (group of species) is presented in equations 22 (unit value equation) and 23.

$$Q_i^* = \beta_0 + \beta_1 * \ln V_i + \beta_2 * I_i + \beta_3 * SE_i + \beta_4 * DE_i + \mu_{1i}$$

$$(22) \ln V_i = \alpha_i + \sum \beta_i x_i + \mu_{2i}$$

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

$$(23) Q_i^* = \beta_0 + \beta_1 * \ln V_i + \beta_2 * I_i + \beta_3 * SE_i + \beta_4 * DE_i + \mu_{1i}$$

With respect to the unit value equation, the unit value is hypothesized to be positively related to income implying that as income increases the demand for quality also increases. Conversely, an increase in family size is hypothesized to result in a reduction in unit value due to the ability of larger households to 'economize' on a given purchase. With respect to the quantity equation, purchases are hypothesized to be negatively related to the unit price but positively related to income. The expected relationship between quantity and other factors in the quantity equation is less certain which is also the situation with respect to the unit value equations.

**4.5 Estimation Results**

Given the purchase 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, as reported in Table 4.3, are found by setting the gradient vector to zero.

As indicated by the information in Table 4.3, the parameter estimates associated with the logarithm of unit value were negative and statistically significant in all of the eight quantity equations except for noncanned salmon. The negative sign implies the inverse relationship of quantity and quality and consumers sacrifice quantity for higher quality.

The results were consistent with the expectations regarding income and family size. The coefficients of income among these seafood categories are positive and statistically significant for both unit value equation (except canned tuna and noncanned salmon) and the quantity equation (except canned tuna and noncanned salmon) and, as such, supports the hypothesis of positive influence of income on the demand for both quantity demanded and quality. Furthermore, as one moves from the finfish commodity (an aggregate of finfish species) to the individual species one can observe a diminishment in the parameter estimates of income in the unit value equation (i.e., the influence of income diminishes as one moves from an aggregated level to a more disaggregated level). Similarly, as one moves from total seafood (0.0939) to total shellfish (0.0840) to shrimp (0.0459), the parameter estimates associated with income show a similar pattern. With respect to the quantity equation, the positive sign of income associated with each seafood category indicate that purchase increase in relation to increasing income.

There is also significantly negative relationship between the household size and the unit-value. This negative relationship may reflect economies of scale in purchasing, the purchasing of a lower quality commodity, or some amalgam. For example, American family with larger households may be able to buy seafood in a 'bulk' at a lower price per unit than when making smaller purchases.[55] A similar finding is apparent when considering the quantity equation in which all the coefficient of ppt018 are negative and statistically significant except for crab and canned tuna.

As indicated by the information in Table 4.3, 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 income since the influence of this factor is included in the model.

With respect to region, quantity demanded for region midwest were statistically less than that of the base (east) for all the seafood categories except for catfish and canned tuna. With respect to region south, results are consistent for noncanned salmon, total finfish and total seafood. For the household who lives in the west region was found to statistically consume less shrimp and seafood than the household live in region east.

Away from home total seafood expenditure is another important factor to influence the US household seafood consumption. Surprisingly, it is positive and statistically significant for all seafood categories (except canned tuna).

[55] It is also possible that larger households 'economize' by shopping at larger retail outlets, such as a Walmart store, where prices are relatively lower than smaller stores. Unfortunately, information on where the seafood was purchased is not included in the dataset and thus there is no way to test this hypothesis.

This result may reflect the consumer preference in purchasing. For example, household prefers to order seafood at restaurant also like to consume seafood at home.

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 4.3 Parameter Estimate of Different Seafood Categories

| Variables | Canned Tuna | Noncanned Salmon | Catfish | Total finfish | Crab | Shrimp | Total Shellfish | Total seafood |
|---|---|---|---|---|---|---|---|---|
| Unit Value equation | | | | | | | | |
| Constant | 1.7223[a] (0.3813) | 2.1000[a] (0.2698) | 0.5680[a] (0.3254) | 0.4398[a] (0.1395) | 1.5641[a] (0.4005) | 1.7728[a] (0.1577) | 1.0651[a] (0.1405) | 0.7210[a] (0.1178) |
| Work | 0.0488 (0.0451) | 0.0348 (0.2094) | 0.0032 (0.0103) | 0.0575[a] (0.0140) | 0.0318 (0.7724) | 0.0340[a] (0.0157) | 0.0765[a] (0.0298) | 0.0526[a] (0.0120) |
| Lincome | 0.0717[b] (0.0365) | 0.0079 (0.0231) | 0.1424[a] (0.0321) | 0.1035[a] (0.0132) | 0.1296[a] (0.0344) | 0.0459[a] (0.0145) | 0.0840[a] (0.0131) | 0.0939[a] (0.0111) |
| Lpphhsize | -0.0861[c] (0.0452) | -0.0184 (0.0186) | -0.1874[a] (0.0553) | -0.0878[a] (0.0158) | -0.0456 (0.0384) | -0.0685[a] (0.0166) | -0.0634[a] (0.0145) | -0.0705[a] (0.0126) |
| Black | 0.1995[a] (0.0848) | -0.0021 (0.0558) | -0.3613[a] (0.0691) | -0.2187[a] (0.0278) | -0.3253[a] (0.0845) | -0.1694[a] (0.0290) | -0.1738[a] (0.0261) | -0.2079[a] (0.0244) |
| Other | 0.2649[a] (0.1164) | -0.1474[b] (0.0738) | -0.2041[a] (0.0531) | -0.1651[a] (0.0304) | -0.3253[a] (0.0933) | -0.1576[a] (0.0352) | -0.1849[a] (0.0321) | -0.1489[a] (0.0252) |
| Hispanic | 0.0793 (0.0839) | -0.0342 (0.0654) | -0.1496[a] (0.0428) | -0.0762[a] (0.0250) | -0.0926[a] (0.0662) | -0.1291[a] (0.0309) | -0.0654[a] (0.0242) | -0.0548[a] (0.0213) |
| College | -0.1899[a] (0.0552) | 0.1266[a] (0.0392) | 0.0702[a] (0.0249) | -0.0019[a] (0.0130) | -0.0206 (0.0319) | 0.0088 (0.0149) | 0.0115 (0.0122) | -0.0015a (0.0113) |
| Quantity Equation | | | | | | | | |
| Constant | 0.1338 (0.2426) | -4.0084[a] (1.0198) | -0.2094 (0.6543) | -0.0600 (0.4095) | 0.4219 (0.6444) | 1.1783[a] (0.3030) | 1.5797[a] (0.4736) | 12.1717[c] (4.1827) |
| Awayexp | 0.0001 (0.0001) | 0.0005[a] (0.0000) | 0.0004[a] (0.0001) | 0.0012[a] (0.0000) | 0.0004[a] (0.0001) | 0.0005[a] (0.0000) | 0.0011[a] (0.0000) | 0.0141[a] (0.0004) |
| Lincome | 0.0035 (0.0141) | 0.0700[b] (0.0351) | 0.1069[a] (0.0900) | 0.3369[a] (0.0574) | 0.1748[a] (0.0651) | 0.1070[a] (0.0191) | 0.2589[a] (0.0497) | 3.9200[a] (0.5670) |
| PPT018 | 0.0145 (0.0197) | -0.0171 (0.0153) | -0.1244[a] (0.0428) | -0.0940[a] (0.0241) | 0.0058 (0.0290) | -0.0170[c] (0.0096) | -0.0486[b] (0.0202) | -0.8031[a] (0.2318) |
| Midwest | 0.0280 (0.0269) | -0.1457[a] (0.0344) | 0.2741[a] (0.0943) | -0.2034[a] 0.0591 | -0.1509[a] (0.0725) | -0.0818[a] (0.0250) | -0.2402[a] (0.0508) | -2.8925[a] (0.6032) |
| South | -0.0067 (0.0247) | -0.1265[a] (0.0312) | 0.5978[a] (0.0902) | -0.2143[a] 0.0541 | -0.0154 (0.0626) | -0.0115 (0.0229) | 0.0659 (0.0446) | -1.7055[a] (0.5379) |
| West | 0.0590 (0.0262) | -0.0179 (0.0328) | 0.1536 (0.1003) | -0.0845 0.0576 | 0.0526 (0.0695) | -0.0454[c] (0.0256) | -0.0725 (0.0497) | -1.0073[a] (0.5957) |
| Ownhouse | -0.0056 (0.0215) | 0.0486 (0.0225) | 0.0286 (0.0692) | 0.0713 (0.0461) | 0.2598 (0.2146) | 0.0016 (0.0196) | -0.0045 (0.0371) | 0.4977 (0.4389) |

(Table 4.3 continued)

| Variables | Canned Tuna | Noncanned Salmon | Catfish | Total finfish | Crab | Shrimp | Total Shellfish | Total seafood |
|---|---|---|---|---|---|---|---|---|
| Spring | 0.0174 (0.0230) | 0.0038 (0.0236) | 0.0314 (0.0444) | -0.0428 (0.0542) | -0.0505[a] (0.0693) | -0.0371[c] (0.0209) | -0.0737[a] (0.0253) | -1.0446[a] (0.5140) |
| Summer | 0.0242 (0.0228) | 0.0257 (0.0310) | 0.0093 (0.0426) | -0.0612 (0.0565) | -0.0156 (0.0568) | -0.0232 (0.0211) | -0.0479[b] (0.0287) | -1.0030[a] (0.5168) |
| Autumn | 0.0275 (0.0263) | 0.0418 (0.0243) | 0.0028 (0.0434) | -0.0683 (0.0532) | -0.1139 (0.0711) | -0.0327[a] (0.0253) | -0.0853[a] (0.0241) | -1.4946[a] (0.5267) |
| Log unit value | -0.4160[a] (0.0981) | 1.0565[a] (0.4492) | -1.8433[a] (0.5737) | -2.9042[a] (0.3830) | -1.4651[a] (0.3386) | -1.2703[a] (0.1750) | -2.6716[a] (0.3792) | -34.6921[a] (3.8680) |
| Covariance | -0.0957 (0.2465) | 0.5917[a] (0.0496) | 0.2612[a] (0.1855) | 0.4760[a] (0.0368) | 0.4745[a] (0.1638) | -0.4187[a] (0.0686) | 0.4952[a] (0.0424) | 0.4344[a] (0.0344) |

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

The simultaneous quantity and quality equations complicates the estimation of elasticity. For example, a household with a higher income might purchase more seafood but the higher income may also potentially encourage the household to consume seafood of a higher quality. Therefore, these two factors have to be taken into consideration when estimating income elasticity. The income elasticity and Ppt18 elasticity of demand with respect to equations 18 and 20, evaluated at the sample means, are given in Table 4.4. It is evident that seafood demand is positively associated with the household income. It also suggests that household income has a larger impact on demand when conditioning on the given unit value for total seafood, shellfish, finfish and shrimp rather than on not conditioning on the given unit value. This result may be interpreted as the conditional elasticity captured both quantity effect and quality effect. However, the income effect is offset by the quality effect with respect to the unconditional elasticity. Therefore these results need to be interpreted with caution.

Table 4.4 Estimated Elasticities of Different Seafood Categories

| Disaggregation level | Elasticity | Income | Ppt018 | Unit Value |
|---|---|---|---|---|
| Seafood | E(Q)[1] | 0.001[a] (6.964) | -0.241[a] (-3.413) | ----- |
| | E(Q/lnv)[2] | 0.001 (0.035) | -0.384[a] (-3.301) | -1.584[a] (-7.133) |
| Shellfish | E(Q)[1] | 0.314[a] (6.964) | -0.013[a] (-2.366) | ----- |
| | E(Q/lnv)[2] | 0.206[a] (5.048) | -0.001 (-0.121) | -2.138[a] (-7.047) |
| finfish | E(Q)[1] | 0.351[a] (6.897) | -0.024[a] (-3.823) | ---- |
| | E(Q/lnv)[2] | 0.243[a] (5.540) | -0.025[a] (-3.899) | -2.094[a] (-7.210) |

(Table 4.4 continued)

| Disaggregation level | Elasticity | Income | Ppt018 | Unit Value |
|---|---|---|---|---|
| shrimp | E(Q)[1] | 0.265[a] (6.482) | -0.004[c] (-1.734) | ----- |
| | E(Q/lnv)[2] | 0.195[a] (6.234) | -0.006[c] (-1.724) | -2.322[a] (-9.692) |
| Canned Tuna | E(Q)[1] | 0.022 (0.351) | -0.001 (-0.423) | ----- |
| | E(Q/lnv)[2] | 0.026 (0.367) | -0.002 (-0.420) | -2.108[a] (-6.042) |
| Noncanned Salmon | E(Q)[1] | 0.193[a] (2.118) | -0.006 (-0.439) | ----- |
| | E(Q/lnv)[2] | 0.108[a] (2.125) | -0.006[a] (-0.437) | -1.36[b] (-2.69) |
| Catfish | E(Q)[1] | 0.395 (1.386) | -0.007 (-0.751) | ----- |
| | E(Q/lnv)[2] | 0.709 (1.264) | -0.002 (-0.75) | -2.52[a] (-5.739) |
| Crab | E(Q)[1] | 0.364[a] (6.445) | -0.007 (0.841) | ----- |
| | E(Q/lnv)[2] | -0.262[a] (3.083) | -0.012 (-0.843) | -2.192[a] (-5.949) |

The value in the parenthesis is the t-value
1.Unconditional elasticity of expected values of purchase
2.Conditional elasticity of expected values of purchase given the log unit

Another key demographic variable—ppt018, number of household members under 18 - is found to have a negative effect. Unconditional elasticity implies that an increase in the number of children under 18 in the household results in less seafood being consumed at home. When ppt018 elasticity is estimated on a given unit value, the absolute value decreases because household with more children can buy low-quality seafood at on-sale price and increase the quantity consumed.

The unit value elasticity of demand is only available when the unit value is given in the purchase equation. The conditional unit value elasticity can be explained as given the fixed unit value, the 1% change in unit value result in how much percentage change in the quantity purchased and household cannot adjust their purchase bundle for quality. For example, the unit value elasticity of the bivariate model in Table 4.4 indicates that a 1% increase in unit value will result in a decrease the seafood purchases (i.e., quantity) by 1.58%. The unit value elasticities associated with shellfish and finfish were approximately the same with estimates equaling -2.14 and -2.09, respectively.

The unit value elasticities for the finfish species included in the analysis ranged from a low of -1.36 (noncanned salmon) to a high of -2.52 (catfish). The weighted average of the four three species (catfish, canned tuna, and noncanned salmon) equaled -1.23 (weighted by their respective shares of the finfish budget) which is equal to approximately 58.8% of the estimated unit value of aggregate finfish (i.e., -2.09). This 58.8% closely approximates the combined shares of these four species (0.2153+0.1456+0.2272) as a percentage of the total seafood budget.

The ability to directly compare elasticities from this study to those estimated in previous research is very limited because (a) previous research is limited and (b) the technique used in the current study varies substantially from that of previous research. With these caveats, however, some comparisons can be made based on the analysis by Cheng and Capps (1986). With respect to own-price elasticites, Cheng and Capps report a range in elasticities for individual finfish species (cod, flounder/sole, haddock, perch, and snapper) from -0.450 to -0.972 with the own-price elasticity for finfish in aggregate equaling -0.675. With respect to three shellfish species considered by Cheng and Capps, own –price elsticities ranged from -0.696 to -1.13 with shellfish in aggregate exhibiting an own-price elasticity equal to -0.8885. Thus, it is obvious that the own-price elasticities derived in this study exceed those found by Cheng and Capps (1986) by a factor of more than two. Reasons for the differences are unclear but may be the result of the current analysis being able to analyze both the change in probability of a household entering/exiting a market for a seafood product due to a price change and a change in quantity purchased by households existing in the market as the price for that commodity changes.

### 4.6 Conclusion

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.

Future research can build upon the analysis originally proposed by Dong et al. (1998) by including substitute prices in the analysis. There are a couple of different means by which this can be achieved and these different methods will be explored. The first method, of course, is to examine at-home seafood demand (and demand for individual products) in a multivariate simultaneous framework. While this method may prove fruitful, specification of the appropriate likelihood functions is likely to be very complicated.[56] A second approach would be to run bivariate simultaneous models for substitute products (meat, poultry, etc) and use results from these analyses to 'retrieve' the unit values for the substitute products and use these estimated unit values in the bivariate simultaneous seafood demand models. The weakness to this approach is the potential bias that may arise from the initial exclusion of substitute prices in each bivariate model. Finally, substitute prices can be derived using either the 'zero order' or 'first order' methods as proposed by Cox et al. (1984) and Cox et al. (1986). The limitations associated with this technique are also obvious. Specifically, while quality and quantity demanded for seafood would be estimated in a simultaneous framework, this method implies that the quality of substitute products do not enter as arguments in the demand for seafood. Given the modeling state, however, this assumption may need to be imposed.

[56] Taking this approach to its natural conclusion, one could specify a complete demand system with appropriate theoretical restrictions.

# CHAPTER 5 CONCLUSIONS AND IMPLICATIONS

## 5.1 Conclusions

As noted in the Introduction, the overall goal of this research was to provide an empirical analysis of U.S. at-home demand for seafood taking into account the influence of socioeconomic factors on quality. This goal was accomplished with some of the salient findings presented here.

In Chapter 3, a complete demand system for generic seafood products (fresh, frozen, and prepared) and other animal protein commodities was developed and estimated. As with complete demand systems, the estimated system included own-and-substitute prices and expenditures. Given the cross-sectional nature of the data, furthermore, the analysis included various demographic factors (geographical location, urbanization, work status, etc.) believed to influence demand for the different commodities in the system. Also, the influence of quality on demand was taken into consideration using two alternative methods and compared to results associated with not controlling for quality.

In Chapter 4, a bivariate model to examine seafood demand, wherein quality demanded and quantity are simultaneously determined, was developed and estimated. The model was used to determine the demand for seafood in aggregate, by groups of seafood species (finfish and shellfish) and individual species (shrimp, crabs, noncanned salmon, canned tuna, and catfish).

Considering the results from these two separate analyses in total, three factors become immediately apparent. The first is 'demand for seafood by generic product form (fresh, frozen, and prepared) and for individual products is influenced by demographic factors such as race and geographic region of residence.' The second is 'price matters.' The third is 'quality matters.'

Beginning with quality, all nine estimated bivariate models in Chapter 4 (i.e., aggregate seafood, shellfish, finfish, shrimp, crabs, noncanned salmon, canned tuna, and catfish) provided a strong indication that quality and quantity are simultaneously determined. With respect to the complete demand systems estimated in Chapter 3, results when taking quality into consideration were shown to vary, in some cases significantly, from those results when quality is not considered.

When interpreting the results relevant to quality, however, one must use caution with respect to how quality is defined. Specifically, take, for example, shrimp. As defined for purposes of analysis, the commodity shrimp consists of numerous elementary goods having undergone different levels of value-added activities (e.g., heads-on shrimp, headless shrimp, peeled shrimp, breaded shrimp). All of these value added activities add value to the final product but, in doing so, there is a transformation in the weight of the final product. This transformation can be an addition or a subtraction of weight. However, in all but one (noncanned salmon) of the nine estimated quantity was found to statistically and negatively related to its own unit value. This finding held even for canned tuna which is the closest to a ‘pure’ elementary good of the nine commodities examined and wherein transformation of product by weight should not be a major factor.

Incorporating quality into the analysis, as noted, also generally influenced the estimated price parameters in the complete demand system. While the Wellman-type approach that was used for accounting for quality consistently yielded higher own-price elasticities than was the case when quality was not taken into consideration, this was not consistently the case when the Cox and Wohlgenant technique was employed.

The second factor, as noted, that becomes apparent when considering the overall results of the different estimated models is that price matters. With respect to the complete demand systems that were estimated in Chapter 3, increases (decreases) in the price of a commodity were consistently found to result in decreases (increases) in the expenditure share associated with that commodity. Cross-price elasticities were also found to be generally statistically significant and, with few exceptions, the effects were positive. With respect to the nine bivariate models that were estimated in Chapter 4, all but one of the unit values in the quantity equations were found to be negative and statistically significant implying that increases in the unit value results in a decrease in quantity demanded of that commodity. This decrease reflects a combination of the influence of quality on quantity demanded and the elementary effect.

The third factor that becomes apparent when evaluating the results of the different models in the two relevant chapters is that non-price variables play a significant role in determining demand. With respect to the complete demand system presented in Chapter 3, a large percentage of the demographic factors included in the six expenditure share equations were found to influence relative expenditure shares. Similarly, the demographic factors included in the nine bivariate models estimated in Chapter 3 were, in general, found to influence the unit value (if included in that equation) or quantity (if included in that equation) or both.

### 5.2 Implications

A number of implications can be drawn from the results presented in this study. The first pertains to marketing. Specifically, given that demographic factors were found to statistically influence expenditure shares, marketing efforts can take advantage of these findings to target specific households (groups) based on specific demographic factors. As just one specific example, the results associated with the complete demand system analysis indicated that black households exhibited higher expenditure shares on all generic seafood products (fresh, frozen, and prepared) than did their white household counterparts, even after controlling for other factors. This was also found for 'other' households. This raises the question though; which group should be targeted; those with the higher expenditure shares or those with the lower expenditure shares? The answer to this question, of course, depends on the costs associated with targeting the different groups relative to the benefits of doing so. It may, for example, be more cost effective to encourage additional consumption among 'high frequency' at-home seafood consumers than to encourage increased consumption among those who only infrequently consume seafood at home. Unfortunately, this analysis cannot address this issue.

The other implication, associated with 'price matters' is that, based on the analysis in Chapter 3, seafood competes, in terms of price, with other animal protein products. Over the past several decades, the prices associated with several seafood products has fallen in real terms due to the significant expansion in aquaculture output. Without this expansion, the real price of seafood, in aggregate, would almost certainly have increased substantially. This calls into question the issue of how much aquaculture production of 'desired' species will continue to increase and the trade patterns associated with any increased production. As the income among Asian countries, especially China grows, much of the Asian production, which would otherwise have been destined for the United States or the European Union, remains in Asia. With the continued growth in aquaculture production and with the growth in Asian demand for aquaculture-produced products, the U.S imports price for aquaculture products may increase. This may, based on analysis presented in Chapter 3, result in an increase relative price for seafood in the United States vis-à-vis alternative animal proteins sources and, hence, a decrease in quantity demanded.

### 5.3 Future Research

The analysis presented in the last two chapters lends itself to several areas of potential research. One relates to the issue of value-added activities and the transformation of weight associated with these activities. As such, conversion of weights to a combine denominator prior to analysis appears to be a 'fruitful' area of research (or at least, refinement of research efforts). With respect to shrimp, for example, available conversion factors could be employed to 'standardize' all shrimp products in terms of the amount of shrimp in that 'elementary' good. Such conversions, to the extent they are valid, would allow for a more 'thorough' analysis of unit value effect and quantity effect in the bivariate model presented in Chapter 4.

The issue of substitution also warrants additional research endeavors. The issue of inclusion (possible) substitute commodities was discussed in detail in the Conclusion section of Chapter 5 but further refinement of the issue in the complete demand system (i.e., Chapter 4) is also warranted. Whether refinement would significantly alter results is speculative but certainly warrants additional research.

Finally, as noted in Chapter 2, the vast majority of seafood consumption occurs in the away-from-home-market. Due, primarily, to the paucity of data in this market, analysis of seafood demand in this market is, for all intents and purposes, nonexistent. Any 'solid' analysis that is able to estimate seafood demand in this market is warranted.

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# APPENDICES

## A1 Theory of consumer demand

### A1.1 Theory

The theory of consumer demand is an analysis of the relationship of consumers demand for commodity and service and their prices. Although the focus given her is on demand behavior in the marketplace, it is worthwhile keeping in mind that attempts must be made to integrate the consumer behavior, preference and objectives into the demand behavior research. Such integration will introduce demand systems reconciling the utility functions with the assumptions on preference, separability, and demand functions.

The major approach to demand analysis emphasized here is that of utility maximization subject to the budget constraint. Some additional assumptions are usually provided to satisfy the empirical requirement in order to allow all kinds of empirical data to be explained by the demand equations. These assumption, however, are also relatively strict, allowing the model to generate more suitable hypotheses about consumer behavior.

The fundamental assumptions of consumer preference have been incorporated into the demand theory through the specification of the utility function. In microeconomics, the utility measures the level of satisfaction received by the consumer from consuming certain goods and service. Technically, the utility function provides a convenient measuring of the consumers' preference. For applied demand analysis, it is kind of an easy way to directly work with the preference relation. Especially, when someone would like to adopt calculus method, it will be much easier to use the utility function. The general utility function can be denoted by:

(1) $U = u(q)$

where $q = q_i$ is the quantity demanded for good i.

Economists usually assume that the utility function is strictly increasing, quasi-concave and twice continuously differentiable. For a function $g(x)$, if $x_2 \succ x_1$, and $g(x_2) > g(x_1)$ can be derived, we say the function $g(x)$ is strictly increasing. The preservation of quasi-concavity requires that for both $x_1$ and $x_2$ belong to the interval (a, b), $g[\lambda x_1 + (1-\lambda)x_2] \geq \min[g(x_1), g(x_2)]$. In addition to these two fundamental assumptions, the restrictions of continuous shows that $\lim_{x\to a} g(x)$ and $g(a)$ exists and $\lim_{x\to a} g(x) = g(a)$. This assumption also ensures the differentiability of the utility function. The first partial derivatives of the utility function with respect to commodity i is denoted by the marginal utility. Effectively, under the restriction of strict quasi concavity the marginal utility is diminishing. In other words, increasing amounts of commodity and service consumer, the subsequent increase drops. The second derivatives of the utility function can be interpreted as how much the marginal utility will change with respect to the consumption levels of other commodities.

From a practical point of view, some properties of utility function called additivity, homothetic and seperability hold. $f(x)$ *is an additive utility function if and only if it is a utility function and there exist function* $f_{1,} ..., f_n$ *such that* $f(x_1,...,x_n) = f_1(x_1) + ... + f_n(x_n)$. Additive utilities are attractive because they are usually expressed by a simple mathematical function and can be easily and quickly computed. Another advantage of the additive utilities is the some kinds of independence exist in the preference between different bundles of goods. In economics, *a homothetic utility function is a monotonic transformation of function which is homogenous of degree1*. For a function $f(x)$ if $f(x) = g(h(x))$, g is a strictly increasing function and h is homogenous of degree 1, we say that function $f(x)$ is homothetic.

Under the assumption of homothetic, even the households have different income level, they will consume the same amount of commodities or service if they face the same price. Both the additivity and homothetic conditions are considerable convenience in practical demand analysis.

Under all these assumptions, the consumers' behavior problem can thus be represented equivalently to the problem of maximizing the utility subject to the budget constraint. Formally, the utility maximization problem can be specified by:

$$(2) \quad \begin{aligned} &Max\ u(q) \\ &s.t.\ p*q < y \end{aligned}$$

To solve this problem, we can rewrite the budget constraint p*q-y<0 and form the associated Lagrangian equation:

$$(3) \quad L(q,\lambda) = u(q) - \lambda(p*q - y)$$

Where λ is the Lagrangian multiplier and the measure of the marginal utility of income. The Kuhn-Tucker method will be applied here because it is a first order necessary problem to optimize the nonlinear programming equation allowing the inequality constraint.

Following the Kuhn-Tucker conditions, we have:

$$(4)\ \frac{\partial L}{\partial q} = U_q - \lambda * p = 0$$

$$p * q - y = 0$$

Where $U_q$ is the partial derivatives of the utility function with respect to the quantities.

Clearly, if the consumer behavior has some certain characteristics, it wills leads to the demand behavior in the marketplace also has some characteristics, alternatively the theoretical restrictions on the consumer demand functions.

Recall the first order conditions of the Lagrangian equation with respect to the quantities demanded, if we take the partial derivative of this equation with respect to income y, we will obtain:

$$(5) \sum_j \frac{\partial^2 u}{\partial q_i \partial q_j} \frac{\partial q_j}{\partial y} = p_i \frac{\partial \lambda}{\partial y}$$

$$(i = 1, 2, \ldots .n)$$

$$\sum_j p_j \frac{\partial q_j}{\partial y} = 1$$

To help see this, a matrix form is given:

$$(6) UQ_y = \lambda_y p$$

$$P'Q_y = 1$$

where $Q_y' = (\partial q_1 / \partial y, \ldots ., \partial q_n / \partial y)$ and $\lambda_y = \partial \lambda / \partial y$ which is interpreted as the marginal utility of income.

Taking the first derivative of equation (4) with respect to the price of commodity k yields:

(7)
$$\sum_j \frac{\partial^2 u}{\partial q_i \partial q_j}\frac{\partial q_j}{\partial p_k} = p_i \frac{\partial \lambda}{\partial p_k} \ (i = 1, 2, ..., n; i \neq k)$$
$$\sum_j \frac{\partial^2 u}{\partial q_i \partial q_j}\frac{\partial q_j}{\partial p_k} = \lambda + p_i \frac{\partial \lambda}{\partial p_i} \ \text{(i=k)}$$
$$\sum_j p_j \frac{\partial q_j}{\partial q_k} = -q_k$$

The matrix form equations (7) are given by:

(8)
$$UQ_p = p\lambda_p' + \lambda I$$
$$P'Q_p = -q'$$

Where

(9)
$$Q_p = \begin{bmatrix} \frac{\partial q_1}{\partial p_1} & \frac{\partial q_1}{\partial p_2} & \cdots & \frac{\partial q_1}{\partial p_n} \\ \frac{\partial q_2}{\partial p_1} & \frac{\partial q_2}{\partial p_2} & \cdots & \frac{\partial q_2}{\partial p_n} \\ : & : & : & : \\ \frac{\partial q_n}{\partial p_1} & \frac{\partial q_n}{\partial p_2} & \cdots & \frac{\partial q_n}{\partial p_n} \end{bmatrix} \text{ and } \lambda_p' = [\frac{\partial \lambda}{\partial p_1}, \quad ..., \quad \frac{\partial \lambda}{\partial p_n}]$$

Barton (1989) stated that the fundamental matrix for demand systems is exactly the combination of equations (6) and (8).

(10)
$$\begin{bmatrix} \mathrm{U} & \mathrm{P} \\ \mathrm{P}' & 0 \end{bmatrix}\begin{bmatrix} \mathrm{Q_y} & \mathrm{Q_p} \\ -\lambda_\mathrm{y} & -\lambda_\mathrm{p}' \end{bmatrix} = \begin{bmatrix} 0 & \lambda \mathrm{I} \\ 1 & -\mathrm{q}' \end{bmatrix}$$

The solution of the fundamental matrix is given by:

$$(11.a)\lambda_y = (p'U^{-1}p)^{-1}$$
$$(11.b)Q_y = \lambda_y U^{-1}p$$
$$(11.c)\lambda_p = -\lambda Q_y - \lambda_y q$$
$$(11.d)Q_p = \lambda U^{-1} - \frac{\lambda}{\lambda_y} Q_y Q_y' q'$$

We already modeled the consumer’s preference, utility function and objectives, as well as the corresponding assumptions and properties. This theory of consumer behavior can be employed to estimate consumer demand in the marketplace. Therefore, the derived demand functions from utility maximization will involve some properties for practical convenience. Generally, we set up the restrictions –adding up, slustky symmetry and homogeneity—for the demand systems.

(a) adding up

By multiplying the transpose of price vector, equation (11.b) yields:

$$(12) P'Q_m = P'\lambda_m U^{-1} P = \lambda_m P' U^{-1} P = 1$$

This adding up property can also be expressed by differentiating the budget constraint with respect to income y:

$$(13) \sum_i p_i \frac{\partial q_i}{\partial y} = \sum_i \frac{\partial (p_i q_i)}{\partial y} = 1$$

Recall that the Marshallian demand function can be derived from utility maximization subject to the budget constraint. It turns out that the budget constraint will always create pressure on price and quantities. Thus the sum of the expenditures on different commodities must equal total expenditures. In applied demand analysis, a system of demand functions which has the expenditure share as the dependent variable will add up 1.

(b) Slustky symmetry

Slustky (1915) noted that the demand change with respect to the price change stems from two effects: the substitution effect and the income effect. The Slutsky equation is given by:

$$(14) \frac{\partial x_i(p,y)}{\partial p_j} = \frac{\partial h_i(p,u)}{\partial p_j} - \frac{\partial x_i(p,y)}{\partial y} x_j(p,y)$$

The first term of the right-hand side of the equation represents the substitution effect---how much the quantity demanded will change when price changes while holding income constant. The latter term gives the income effect—how much the demand will change if the income change multiplied by the demand function keeping utility at a fixed level. When we plus equation (11.d) with $Q_y p'$, the matrix notion of Slustky equation is given:

$$(15) Q_p + Q_y q' = \lambda U^{-1} - \frac{\lambda}{\lambda_y} Q_y Q_y{}' q' + Q_y q'$$

The formula in (11) implies that the Hessian matrix $U^{-1} = u_{ij} = u_{ji}$ is symmetric. In addition, $Q_y = \lambda_y U^{-1} p$, it follows that $Q_p + Q_y q'$ is also symmetric. Therefore the symmetry restriction in a set of demand systems requires that the parameter associated with the i-th commodity price in demand equation for commodity j must be equal to the parameter associated with the j-th commodity price in demand equation of i commodity.

(c) Homogeneity of degree zero

By multiplying equation (11.d) by P, one can obtain the homogeneity condition:

$$(16) Q_p p = \lambda U^{-1} p - (\lambda / \lambda_y) Q_y Q_y{}' p - Q_y q' p = (\lambda / \lambda_y) Q_y - (\lambda / \lambda_y) Q_y - Q_y y = -Q_y y$$

Note that if both the price and income multiply by a factor k, and then substitute them back to equation (4), the quantity demanded remains unchanged. In order words, the demand functions are homogeneous of degree zero in income and price. Given the homogeneity restriction, the sum of the parameters of all commodity prices in each demand function should be zero.

The utility maximization problem will yield a system of Marshallian Demand functions $Q_i(P_1,...,P_{n,}Y)$. It specifies quantities demanded of the commodity and service at each set of price and income. Alternatively, it is also noted as uncompensated demand function. This terminology comes from that the income does not compensate for the varying price. Hotelling (1932) substituted the optimized Marshallian demand bundle back to the direct utility functions and derived indirect utility functions.

$$(17) V(q(p, y)) = U(q)$$

The 'indirect 'here indicates that the consumer maximizes his/her utility in terms of the quantities instead of the price of goods. Court (1941) proved that maximizing the indirect utility function which has price and income as its arguments subject to the budget constraint act exactly same as the maximizing the direct utility function which has quantity as its argument subject to the budget constraint.

Mckenzie (1957), Shepard (1953),Diewert (1978),Hanoch (1978) and Weymark(1980) provided an alternative way to solve the problem of consumer preference. They adopt the duality concepts to address the problem of minimization of expenditure and achieve a fixed level of utility and a certain bundle of quantities demanded. The dual relationship of expenditure and utility function suggests the consumer allocation problem can be expressed in the following context:

$$(18) \begin{array}{l} Min\ e(P, U^*) = \sum_i P_i q_i \\ s.t.\ \mathrm{V(q)=U} \end{array}$$

Where $h(P, U^*)$ represents the Hicksian demand function or income-compensated system of demand equation instead. It is the consumption bundle that minimizes total expenditure and achieves a target level of utility. It is not easy to directly observe the Hicksan demand because it is a function of utility. In this case, the Marshallian Demand Function has the advantage of easily being observed since it is expressed as a function of income and price.

Compared to the traditional utility maximization framework, this method is convenient in mathematical manipulation. Roy (1947) provides that the Marshallian Demand Function can be derived from the ratio of partial derivatives of indirect utility function with respect to price and income. This lemma is also defined as Roy's Identity.

$$(19) Q_i(p, y) = -(\partial v / \partial p_i) / (\partial v / \partial y)$$

Solving the equations (18) yields the target utility $u^*$ and price. By replacing the price and quantity in equation (18), we will obtain the description of minimized cost function or minimized expenditure

function:

$$(20)\ Min\ e(P, U^*) = \sum_i P_i q_i = c(u, p)$$

In applied demand analysis, we can switch the consumer utility maximization problem to the minimized expenditure problem.

**A1.2 Aggregation and Separability**

An empirical work of household demand is complicated by the fact that a complete set of demand functions is related to all commodities and service demanded by the consumer. Therefore, the estimation of demand function for a particular commodity needs to predict a large number of parameters associated with all goods in a complete demand system. This issue in applied demand analysis is considered as the problem of aggregation. Usually additional restrictions must be imposed on the system to overcome this problem.

One approach that can be utilized to circumvent this problem is commodity aggregating. Consider, instead of estimating n commodities, we can partition these n commodities into m groups. For example we can aggregate individual shellfish species (e.g., shrimp, crabs, and lobsters) to a group shellfish and aggregate individual finfish species (e.g., tuna, salmon and trout) to form a single finfish group. This approach is tractable in empirical analysis because it will reduce the number of structural parameters to estimate. However some other important economic issues will be raised in this process; specifically the difficulties to incorporate this addition restriction to the demand functions as well as how to distinguish the aggregate group price from the commodity price. Thus a further research is motivated to solve these problems. That is theorem of weak separability.

Leontief (1947) developed this theory and then it was studied by Sono (1961), Strotz (1957), Goldman and Uzawa (1964) and Blackorby et al. (1978). As mentioned above, the n commodities are replaced by m groups and the commodity $n_m$ (m=1, 2, …, m) is involved in each subgroup $n = \sum_n m$. The separability theorem suggests that *it is a necessary and sufficient condition for a function to be seperable, that the marginal rate of substitution between any two variables belonging to the same group be independent of the value of any variable in any other group.* Goldman and Uzawa (1964) formed the utility function under the condition of weak separability:

$$(21) U = g(q_1, q_2, ..., q_m)$$

$$U = G(u_1(q_1), u_2(q_2)......)$$

If commodities I and j belong to the group g, commodity k is outside of group g, then weak separabilty implies;

$$(22) \frac{d(u_i / u_j)}{dq_k} = 0$$

Estimation of demand systems is greatly simplified by assuming weak separability. However, the problem one is confronted with is determining what goods/commodities are separable from other goods/commodities. A formal separability test (Table A1) is conducted to determine an appropriate aggregation level for Almost Ideal Demand System in chapter 3.

TableA1 Separability Test between meat and seafood product forms

| Test | Type | Statistic | Pr>ChiSq | Critical value (0.01) |
|---|---|---|---|---|
| Chicken/beef and frozen seafood | L.R. | 0.07 | 0.7972 | 6.63 |
| Chicken/beef and prepared seafood | L.R. | 2.29 | 0.1303 | 6.63 |
| Pork/beef and fresh seafood | L.R. | 4.31 | 0.0379 | 6.63 |

The Likelihood Ratio test suggested:

$H_0$: pork and beef in group meat are separable from fresh seafood in group seafood

$H_1$: pork and beef in group meat are not separable from fresh seafood in group seafood

Since LR test <critical value when the significant level is at 0.01, we accept the null hypothesis. Which means that when seafood is disaggregated into fresh, frozen and prepared seafood, fish can be modeled separately from meat products.

### A1.3 The Demand Curve

One most important objective of empirical demand analysis involves the estimation of the effect of price and income on demand (or quantity demanded). The measure that is typically used is that of the ‘elasticity.’ The price elasticity of demand is defined as the percentage change in the quantity demanded for a good with respect to a one-percent change in the price of that good. Hence, the elasticity is independent of the units of measurement of commodities, price and income.

When examining the influence of price and income on demand, we usually derive the demand curve and Engel curve geometrically from the utility maximization. In a simple two goods economy, keeping one goods price and income constant, when another goods price increase, the budget line will rotate inward. By tracing the tangency point of indifference curve and budget line, we will get price-consumption path; from which the demand curve can be derived. For a normal good, the demand curve suggests that if price increases, the quantity demand will decrease.

### A1.4 Functional Forms

To specify the demand models, we must choose the appropriate functional form. A number of demand functional forms including the Linear Expenditure System, the Rotterdam Demand System, the Almost Ideal Demand System, and Lewbel EASI model – have been proposed. These functional forms are briefly outlined in this section.

(1)Klein and Rubin (1947-1948) provided the Linear Expenditure System:

$$(23) W_i = p_i\gamma_i + \mu_i(m - \sum_j p_j\gamma_j)$$

$W_i$ is the budget share, $\gamma_i$ denoted the minimum consumption level, $\mu_i = \frac{\alpha_i}{\sum_i \alpha_i}$ is interpreted as the marginal budget share. $m = pq$ which is the budget constraint or income.

A Extended Linear Expenditure True System (ELES) was developed by Lluch (1973) and he combined the saving-consumption term with the Linear Expenditure True System:

$$(24) W_i = p_i\gamma_i + \beta\mu_i(m - \sum_j p_j\gamma_j)$$

Where $\beta$ is a saving propensity values. The linear Expenditure System is a broadly applied demand model. It is computation simplicity and economizes in terms of parameters that need to be estimated. But it still suffers some limitations; including the assumption of linear Engel curves.

(2) An alternative demand system is Indirect Addilog System (Houthakker 1960). Compared with the linear Expenditure System, it not only allows the nonlinear Engel curve, elastic demand, negative cross price elasticities but also it has the advantage of simplicity as Linear Expenditure System. The Indirect Addilog System is based on a specified indirect utility function:

$$(25) V(p,m) = \sum_i \alpha_i (m / p_i)^{b_i}$$

While the demand model can be specified by:

$$(26) q_i = \frac{a_i b_i m_i^b p_i^{-b_i - 1}}{\sum_j \alpha_j b_j m_j^{b-1} p_j^{-b_j}}$$

where $a_i$ and $b_i$ are the parameters, $b_i \geq -1, \alpha_i b_i \geq 0$. The properties of the demand: homogeneity, additivity and Slustky symmetry can be easily verified in this demand system. Although the Indirect Addilog demand system is more competitive than Linear Expenditure System, there are still some questions about the cross price elasticity which are the same for a certain price.

(3)Christensen et al. (1975) provided an Indirect Translog Function with the price as an exogenous variable. The quadratic utility function form is:

$$(27) \ln V = \sigma_0 + \sum_i \sigma_i \ln(p_i / m) + 1/2 \sum_i \sum_j \beta_{ij} \ln(p_i / m) \ln(p_j / m)$$

The demand function can be derived from the indirect utility function by using Roy's Identity:

$$(28) \frac{p_i q_i}{m} = \frac{\sigma_i + \sum_j \beta_{ij} \ln(p_j / m)}{\sum_j \sigma_j + \sum_j \sum_i \beta_{ij} \ln(p_j / m)}$$

This model suffers some deficiencies including the fact that the number of parameters one needs to estimate is large and local approximation leads to the inconsistency of model estimation.

(4) Deaton and Muellbauer (1980) proposed a demand system which is called Almost Ideal Demand System (AIDS). They derived this demand system from Price Independent Generalized Log or PIGLOG cost system. The AIDS possesses the nonlinear Engel curve and it automatically satisfies the basic properties of consumer demand.

Moreover it is easy to compute and the system allows for economization in terms of the number of parameters that need to be estimated. The demand function of AIDS is interpreted as an aggregated share equation:

$$(29) W_i = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \ln(\frac{x}{p})$$

Where the price index is defined by:

$$(30) \ln p = \alpha_0 + \sum_j \alpha_k \ln p_k + \frac{1}{2} \sum_j \sum_k \gamma_{ij} \ln p_k \ln p_j$$

Owning to its many advantages, the AIDS model has become a commonly employed model in empirical demand analysis. Bunk, Blundell and Lewbel extended the AIDS model to the Quadratic Almost Ideal Demand Systems which involved the square of log of income in the budget share equation.

(5) All four demand systems previously considered are derived from the utility function. Barten (1977) suggested a direct specified demand system—Rotterdam Demand System. The demand function is usually expressed as the differentials of the logarithmic demand:

$$(31) d(\ln q_i) = \sum_j e_{ij} d(\ln p_j + \eta_i d(\ln m^*)$$

where $e_{ij}$ is the cross price elasticity and $\eta_i$ is the income elasticity.

**A2 Survey Questionnaire**

Screener Questionnaire

[RADIO]

[PROMPT IF SKIP]

S1. To your knowledge, has anyone in your household purchased seafood (fish or shellfish) in a retail outlet (e.g., a grocery store, fish or meat market, convenience store or multipurpose store such as Costco or Wal-Mart) for consumption at home in the last 12 months?

Yes No

[IF Q1=NO OR SKIP ]

[PROMPT IF SKIP]

[RANDOMIZE LIST AND ALLOW UP TO THREE ANSWERS]

S2. What are the most important reasons that led your household to not purchase any seafood (fish or shellfish) in a retail outlet for consumption at home in the last 12 months? Please select up to three reasons.

Seafood is too expensive.

No seafood is available where I live.

I don’t like / my household doesn’t like seafood.

No one in my household knows how or likes to prepare seafood.

I am / we are concerned that seafood may be of poor quality or may not be fresh.

I / we eat seafood we catch or friends give us.

I am / we are concerned about the environmental effects of catching fish or shellfish

I am / we are concerned about the health risks of eating seafood.

[RADIO]

[ALL]

S2a. How many people (including yourself) in your household are of the Italian ancestry?

Everyone in my household is of the Italian ancestry

Some are of the Italian ancestry, but some aren't

No one in my household is of the Italian ancestry

[RADIO]

[ALL]

S2b. How many people (including yourself) in your household are of the Portuguese ancestry?

Everyone in my household is of the Portuguese ancestry

Some are of the Portuguese ancestry, but some aren't

No one in my household is of the Portuguese ancestry

CONTINUE IF S1=YES. ELSE GO TO END.

| XCOHORT | XMONTH1 | XDATE1 | XMONTH1a |
|---|---|---|---|
| 1 | from February 1 to February 28 | March 1 | February |
| 2 | from March 1 to March 31 | April 1 | March |
| 3 | from April 1 to April 30 | May 1 | April |

(Table continued)

| | | | |
|---|---|---|---|
| 4 | from May 1 to May 31 | June 1 | May |
| 5 | from June 1 to June 30 | July 1 | June |
| 6 | from July 1 to July 31 | August 1 | July |
| 7 | from August 1 to August 31 | September 1 | August |
| 8 | from September 1 to September 30 | October 1 | September |
| 9 | from October 1 to October 31 | November 1 | October |
| 10 | from November 1 to November 30 | December 1 | November |
| 11 | from December 1 to December 31 | January 1 | December |
| 12 | from January 1 to January 31 | February 1 | January |

[DISPLAY]

S3. Congratulations! You are eligible to participate in an important and unique study funded by the National Oceanic and Atmospheric Administration (NOAA). The study will gather information on your typical food purchases and the results will help researchers better understand the patterns and changes in the foods people choose to buy.

[DISPLAY]

S3A. You will be awarded 7,500 bonus points for your participation in the study. To participate, we ask that you please complete the following two tasks:

1) Retain receipts for all household purchases of food at a restaurant or a retail outlet for [xmonth1]. A restaurant includes any fast food restaurants, more expensive restaurants, and school, hospital or other institutional cafeterias. A retail outlet includes any grocery stores, convenient stores, meat markets, fish markets, and multi-purpose stores such as Wal-Mart, Target, Costco, etc. In responding to the survey, you may find it useful to have annotated your receipts by filling in quantity and species purchased if this information is not automatically recorded on your receipt). You will receive (if you haven't already) a package from Knowledge Networks which contains a nicely designed 8½" by 11" envelop for you to store your receipts. Please use this envelop to collect your receipts and you do NOT need to mail them back to us. It is only provided as a convenient way for you to store your receipts.

2) Complete a survey that will be sent to you on or around [xdate1]. The survey will take an average person 10-15 minutes to complete. Please have the receipts with you when you complete that survey. The receipts you have retained from the previous month will help you answer survey questions.

[DISPLAY]

S4. We thank you in advance for your participation in this important study.

Again, we ask that you please retain all of your household's food receipts from restaurants and retail outlets for [xmonth1] and look for the survey invitation on or around [xdate1] to participate in the study. The survey invitation will arrive in an email with the subject "Household Food Purchases in [xmonth1a]". You will be awarded 7,500 bonus points after you complete that survey.

We look forward to receiving your responses then.

Main Questionnaire

| XCOHORT | XMONTH1 | XMONTH1a |
|---|---|---|
| 1 | from February 1 to February 28 | February |
| 2 | from March 1 to March 31 | March |
| 3 | from April 1 to April 30 | April |
| 4 | from May 1 to May 31 | May |
| 5 | from June 1 to June 30 | June |
| 6 | from July 1 to July 31 | July |
| 7 | from August 1 to August 31 | August |
| 8 | from September 1 to September 30 | September |
| 9 | from October 1 to October 31 | October |
| 10 | from November 1 to November 30 | November |
| 11 | from December 1 to December 31 | December |
| 12 | from January 1 to January 31 | January |

[DISPLAY]

Thank you for agreeing to participate in this important study funded by the National Oceanic and Atmospheric Administration (NOAA). As you know from a notification we sent you a couple of weeks ago, this survey will ask you about your household's food purchases <xmonth1>. The results will help researchers better understand the patterns and changes in the foods people choose to purchase.

In our notification, we also asked that you please retain your household's receipts for any food purchases <xmonth1>_from a restaurant or retail outlet. Restaurants includes any fast food chains, more expensive restaurants, schools, hospitals, or any institutional cafeterias. The retail outlets includes any grocery stores, fish or meat markets, convenience stores, multipurpose store such as Costco or Wal-Mart), or commissaries. The receipts will help you answer questions in today's survey.

[RADIO]

[PROMPT IF SKIP]

Q1. Which of the following statements best describes you regarding your retention of food purchase receipts in <xmonth1a>?

I was able to retain all of my household's food receipts.

I was able to retain most of my household's food receipts.

I was able to retain some of my household's food receipts.

I was able to retain only a few of my household's food receipts.

I was able to retain none of household's food receipts.

[DISPLAY]

[IF Q1=1 TO 4]

We ask that you please have your receipts in front of you before proceeding to the next screen. Please <u>only</u> think of the purchases made in <u><xmonth1a></u> when you answer the questions in this survey. When you are ready, please hit the "Continue" button to go to the next question.

[DISPLAY IN YELLOW LOWER LEFT CORNER OF EVERY SCREEN FROM NOW ON]

[BOLD THIS LINK]

Please only think of the purchases made <xmonth1>.

[RADIO]

[PROMPT IF SKIP]

Q2. To your knowledge, has any one in your household purchased fish or shellfish from a restaurant (for example, a fast food restaurant, a more expensive restaurant, or a school, hospital or other institutional cafeteria) in <xmonth1a>?

Yes

No

[CHECKBOX]

[IF Q2=1]

Q3. Which of the following shellfish did you or someone in your household purchase from a restaurant (for example, a fast food restaurant, a more expensive restaurant, or a school, hospital or other institutional cafeteria) in <xmonth1a>?

Clams

Crab

Crawfish

Lobster

Mussels

Oysters

Scallops

Shrimp

Other Shellfish (please specify:______)

[CHECKBOX]

[PROMPT IF SKIP]

[IF Q3=1]

Q3a. Which of the following types of clams did you or someone in your household purchase from a restaurant?

Hardshell / Quahog

Softshell

Surf

Other or unknown

[CHECKBOX]

[IF Q3=2]

Q3b. Which of the following types of crab did you or someone in your household purchase from a restaurant?

Blue

Dungeness

Jonah

King

Snow

Stone

Other or Unknown

[CHECKBOX]

[IF Q3=4]

Q3c. Which of the following types of lobster did you or someone in your household purchase from a restaurant?

American

Spiny

Other or unknown

[CHECKBOX]

[IF Q3=7]

Q3d. Which of the following types of scallops did you or someone in your household purchase from a restaurant?

Bay

Sea

Other or unknown

[CHECKBOX]

[IF Q3=8]

Q3e. Which of the following types of shrimp did you or someone in your household purchase from a restaurant?

Gulf

Other or Unknown

[CHECKBOX]

[IF Q2=1]

Q4. Which of the following fish did you or someone in your household purchase from a restaurant (for example, a fast food restaurant, a more expensive restaurant, or a school, hospital or other institutional cafeteria) in <xmonth1a>?

Calamari / Squid

Catfish

Cod

Drum, Black

Drum, Red

Flounder / Sole

Grouper [if ppstaten=95 then show; Grouper (Hapu'upu'u)]

Haddock

Hake / Whiting

Halibut

Herring

Mackerel

Mahimahi / Dolphinfish

Other Snapper (if ppstaten=91 or 92 or 93)

Pacific Rockfish / Snapper (if ppstaten=91 or 92 or 93)

Pollock

Rockfish [if ppstaten~=91 or 92 or 93]

Sablefish

Salmon

Snapper [if ppstaten~=91 or 92 or 93] [if ppstaten=95, then show: Snapper (Onaga, Opakapaka, Uku)][if ppstaten=95, then show: Snapper (Onaga, Opakapaka, Uku)]

Striped Bass [if ppstaten~=91 or 92 or 93]

Imitation crab, shrimp, or scallops

Swordfish [if ppstaten=95, then show: Swordfish (Shutome)]

Tilapia

Trout

Tuna [if ppstaten=95, then show: Tuna (Ahi, Aku, Tombo)]

Other Fish (Please specify_____)

[CHECKBOX]

[IF Q4=SALMON]

Q4a. Which of the following salmon did you or someone in your household purchase from a restaurant?

Atlantic or Farmed

Chinook / King

Chum

Coho / Silver

Pacific

Pink

Sockeye / Red

Other or Unknown

[CHECKBOX]

[IF Q4=TUNA]

Q4b. Which of the following tuna did you or someone in your household purchase from a restaurant?

Albacore

Bigeye

Bluefin

Skipjack

Yellowfin

Other or Unknown

[GRID BY NUMBER BOXES]

[ITEMS 1-999]

[PRICES 0.01 TO 999.99]

[REPEAT FOLLOWING FOR ALL SELECTED SPECIES, TYPES]

[TYPE COMES FROM ANSWERS IN Q3A-Q3E AND Q4A-Q4B]

[SPECIES COMES FROM ANSWERS IN Q3 AND Q4]

[CREATE DATA VARIABLES TO SHOW SPECIES AND TYPES CORRESPONDING TO EACH NUMBER]

Q5. How many times in <xmonth1a> did your household purchase the following fish or shellfish from a restaurant and what was the total expenditure?

| Fish or shellfish | Number of Seafood Menu Items (Appetizers, Entrees, or Sandwiches) Purchased in <xmonth1a> | Total Expenditure on Seafood Appetizers, Entrees, or Sandwiches |
|---|---|---|
| <SPECIES> (<TYPE>) | ☐☐☐ | $ ☐☐☐ . ☐☐ |

[GRID BY NUMBER BOXES]

[POUNDS 0.0-99.9]

[PRICES 0.00 TO 999.99]

Q6. For the following questions, please think of your purchases in a retail outlet (for example, a grocery store, a fish or meat market, a convenience store, a multipurpose store such as Costco or Wal-Mart, or a commissary). How much of the following product(s) did your household purchase from a retail outlet in <xmonth1a>? Please enter "0" if your household purchased none of the product(s)

| | Total Pounds Purchased | Total Expenditure |
|---|---|---|
| Chicken or other poultry | ☐☐ . ☐ | $ ☐☐☐ . ☐☐ |
| Beef Product(s) | ☐☐ . ☐ | $ ☐☐☐ . ☐☐ |
| Pork product(s) | ☐☐ . ☐ | $ ☐☐☐ . ☐☐ |

[NUMBER BOXE]

[ 0.00 TO 9999.99]

Q7. How much did your household spend on TOTAL food and beverage purchases in retail outlets (for example, a grocery store, a fish or meat market, a convenience store, a multipurpose store such as Costco or Wal-Mart, or a commissary) or in restaurants (for example, a fast food restaurant, a more expensive restaurant, or a school, hospital or other institutional cafeteria) in <xmonth1a>?

*Total Food Expenditures* $ [ ][ ][ ][ ] . [ ][ ]

(Restaurant & Retail Purchases)

<If Q7< Sum of Q6, show prompt message:

You indicated that you spent <sum of Q6> on chicken or other poultry, beef, and pork. You total food expenditure (including restaurants and product(s) purchased for at-home consumption) should not be less than what you spent on chicken or other poultry, beef, or pork. Please enter a number not less than <sum of Q6>.

[RADIO]

[PROMPT IF SKIP]

Q8. To your knowledge, has any one in your household purchased fish or shellfish from a retail outlet (for example, a grocery store, a fish or meat market, a convenience store, a multipurpose store such as Costco or Wal-Mart, or a commissary) in <xmonth1a>?

Yes

No

[CHECKBOX]

[IF Q8=1]

Q9. Which of the following shellfish did you or someone in your household purchase from a retail outlet (for example, a grocery store, a fish or meat market, a convenience store, a multipurpose store such as Costco or Wal-Mart, or a commissary) in <xmonth1a>?

Clams

Crab

Crawfish

Lobster

Mussels

Oysters

Scallops

Shrimp

Other Shellfish (please specify :______)

[CHECKBOX]

[PROMPT IF SKIP]

[IF Q9=1]

Q9a. Which of the following types of clams did you or someone in your household purchase from a retail outlet?

Hardshell / Quahog: Littlenecks

Hardshell / Quahog: Cherrystones

Hardshell / Quahog: Top Necks

Hardshell / Quahog: Chowder

Hardshell / Quahog: Other or unknown

Softshell

Surf

Other or unknown

[CHECKBOX]

[IF Q9=2]

Q9b. Which of the following types of crab did you or someone in your household purchase from a retail outlet?

Blue, Hardshell

Blue, Softshell

Dungeness

Jonah

King

Snow

Stone

Other or unknown

[CHECKBOX]

[IF Q9=4]

Q9c. Which of the following types of lobster did you or someone in your household purchase from a retail outlet?

American

Spiny

Other or unknown

[CHECKBOX]

[IF Q9=6]

Q9d. Which of the following types of oysters did you or someone in your household purchase from a retail outlet?

Eastern

European

Pacific

Other or unknown

[CHECKBOX]

[IF Q9=7]

Q9e. Which of the following types of scallops did you or someone in your household purchase from a retail outlet?

Bay

Sea

Other or unknown

[CHECKBOX]

[IF Q9=8]

Q9f. Which of the following types of shrimp did you or someone in your household purchase from a retail outlet?

Gulf (aka Pinks, Browns, Whites, Redtails, Mexicans, hoppers, skippers)

Chinese white

Freshwater (aka River, blue, Malaysian)

Pacific Whites (aka steelies, blue shrimp, Ecuadoran)

Tiger (aka Jumbo, Giant, Black)

[GRID CHECKBOX]

[IF Q9=1-9]

[GRID CHECK BOX BY CHECK BOX]

[IF Q9A-Q9F >=1 THEN SHOW ITEMS SELECTED IN Q9A-Q9F; ELSE SHOW ITEMS SELECTED IN Q9]

Q10. Of the following shellfish, which one(s) did you or someone in your household purchase live, fresh, frozen, prepared or processed from a retail outlet (for example, a grocery store, a fish or meat market, a convenience store, a multipurpose store such as Costco or Wal-Mart, or a commissary) in <xmonth1a>?

| | Live / Fresh | Frozen | Prepared or Processed |
|---|---|---|---|
| Clams | | | |
| Crab | | | |
| Crawfish | | | |
| Lobster | | | |
| Mussels | | | |
| Oysters | | | |
| Scallops | | | |
| Shrimp | | | |
| [other shellfish text] | | | |

[GRID]

[IF Q10=LIVE OR FRESH CLAMS]

Q11a. Which of the following live or fresh clam product(s) did you or someone in your household purchase from a retail outlet?

Shucked Meats

Whole (not live)

Whole (live)

Halfshell

Chopped or minced Meat

Show Fresh Clam Species Checked in Q10

[GRID]

[IF Q10=LIVE OR FRESH OYSTERS]

Q11b. Which of the following live or fresh oyster product(s) did you or someone in your household purchase from a retail outlet?

Shucked Meats

Whole (not live)

Whole (live)

Halfshell

Chopped or minced Meat

Show Fresh Oyster Species Checked in Q10

[CHECKBOX]

[IF Q10=LIVE OR FRESH MUSSELS]

Q11c. Did you or someone in your household purchase live or fresh mussel shucked meats from a retail outlet?

Yes

No

[GRID]

[IF Q10=LIVE OR FRESH SCALLOPS]

Q11d. Did you or someone in your household purchase live or fresh scallop shucked meats from a retail outlet?

Yes No

Show Fresh Scallop Species Checked in Q10

[CHECKBOX]

[IF Q10=LIVE OR FRESH CRAWFISH]

Q11e. Which of the following live or fresh crawfish product(s) did you or someone in your household purchase from a retail outlet?

Whole (not live)

Whole (live)

Softshell

Tail Meat

[GRID]

[IF Q10=LIVE OR FRESH LOBSTERS]

Q11f. Which of the following live or fresh lobster product(s) did you or someone in your household purchase from a retail outlet?

Picked Meat

Claw

Show Fresh Lobster Species Checked in Q10

[GRID]

[IF Q10=LIVE OR FRESH SHRIMP]

Q11g. Which of the following live or fresh shrimp product(s) did you or someone in your household purchase from a retail outlet?

Whole (not live)

Whole (live)

Tails

Show Fresh Shrimp Species Checked in Q10

[GRID]

[IF Q10=LIVE OR FRESH CRAB]

Q11h. Which of the following live or fresh crab product(s) did you or someone in your household purchase in a retail outlet?

Picked Meat

Whole (not live)

Whole (live)

Claws

Cocktail Claws

Snap-n-Eats claws

Legs

Sections

Show Fresh Crab Species Checked in Q10

[3 TEXT BOXES]

[IF Q10=LIVE OR FRESH OTHER]

Q11i. Please indicate specifically what live or fresh [text entered in Q9 for Other Shellfish] product(s) you or someone in your household purchased in a retail outlet?

[GRID]

[IF Q10= FROZEN CLAMS]

Q12a. Which of the following frozen clam product(s) did you or someone in your household purchase from a retail outlet?

Shucked Meats

Wholeshell

Halfshell

Chopped or minced Meat

Blocks

Show Frozen Clam Species Checked in Q10

[GRID]

[IF Q10=FROZEN OYSTERS]

Q12b. Which of the following frozen oyster product(s) did you or someone in your household purchase from a retail outlet?

Shucked Meats

Wholeshell

Halfshell

Chopped or minced Meat

Blocks

Show Frozen Oyster Species Checked in Q10

[CHECKBOX]

[IF Q10=FROZEN MUSSELS]

Q12c. Which of the following frozen mussel product(s) did you or someone in your household purchase from a retail outlet?

Shucked Meats

Wholeshell

Halfshell

Chopped or minced Meat

Blocks

[GRID]

[IF Q10=FROZEN SCALLOPS]

Q12d. Which of the following frozen scallop product(s) did you or someone in your household purchase from a retail outlet?

Meats

Blocks

Show Frozen Scallop Species Checked in Q10

[CHECKBOX]

[IF Q10=FROZEN CRAWFISH]

Q12e. Which of the following frozen crawfish product(s) did you or someone in your household purchase from a retail outlet?

Whole

Tails – shell on

Tail Meat

[GRID]

[IF Q10=FROZEN LOBSTERS]

Q12f. Which of the following frozen lobster product(s) did you or someone in your household purchase from a retail outlet?

Whole

Claws

Tails

Tail Medallions

Split

Meat

Show Frozen Lobster Species Checked in Q10

[GRID]

[IF Q10=FROZEN SHRIMP]

Q12g. Which of the following frozen shrimp product(s) did you or someone in your household purchase from a retai outlet?

Whole

Blocks

Split, butterfly, fantail

Pieces

IQF

Tails

Show Frozen Shrimp Species Checked in Q10

[GRID]

[IF Q10=FROZEN CRAB]

Q12h. Which of the following frozen crab product(s) did you or someone in your household purchase from a retail outlet?

Picked Meat

Whole

Claws

Cocktail Claws

Snap-n-Eats claws

Legs

Sections

Blocks

Show Frozen Crab Species Checked in Q10

[3 TEXT BOXES ]

[IF Q10=FROZEN OTHER]

Q12i. Please indicate specifically what frozen [text entered in Q9 for Other Shellfish] product(s) you or someone in your household purchased from a retail outlet?

[GRID]

[IF Q10=PREPARED OR PROCESSED CLAMS]

Q13a. Which of the following prepared or processed clam product(s) did you or someone in your household purchase from a retail outlet?

Breaded

Cakes

Canned

Clam juice

Pre-Fried Strips

Stuffed

Show Prepared or Process Clam Species Checked in Q10

[GRID]

[IF Q10=PREPARED OR PROCESSED OYSTERS]

Q13b. Which of the following prepared or processed oyster product(s) did you or someone in your household purchase from a retail outlet?

Breaded

Canned

Entrees

Fritters

Smoked

Show Prepared or Processed Oyster Species Checked in Q10

[CHECKBOX]

[IF Q10=PREPARED OR PROCESSED MUSSELS]

Q13c. Which of the following prepared or processed mussel product(s) did you or someone in your household purchase from a retail outlet?

Breaded or Battered

Canned

Marinated meats

Pickled

Smoked

Stuffed

[GRID]

[IF Q10=PREPARED OR PROCESSED SCALLOPS]

Q13d. Which of the following prepared or processed scallop product(s) did you or someone in your household purchase from a retail outlet?

Breaded

Entrees

Smoked

Show Prepared or Processed Scallop Species Checked in Q10

[CHECKBOX]

[IF Q10=PREPARED OR PROCESSED CRAWFISH]

Q13e. Which of the following prepared or processed crawfish product(s) did you or someone in your household purchase from a retail outlet?

Entrees

Marinated tail meat

Marinated whole

[GRID]

[IF Q10=PREPARED OR PROCESSED LOBSTERS]

Q13f. Which of the following prepared or processed lobster product(s) did you or someone in your household purchase from a retail outlet?

Canned

Entrees

Stuffed Tails

Show Prepared or Processed Lobster Species Checked in Q10

[GRID]

[IF Q10=PREPARED OR PROCESSED SHRIMP]

Q13g. Which of the following prepared or processed shrimp product(s) did you or someone in your household purchase from a retail outlet?

Breaded

Canned

Dried

Entrees

Show Prepared or Processed Shrimp Species Checked in Q10

[GRID]

[IF Q10=PREPARED OR PROCESSED CRAB]

Q13h. Which of the following prepared or processed crab product(s) did you or someone in your household purchase from a retail outlet?

Cakes

Canned

Pasteurized Meat

StuffedShow Prepared or Processed Crab Species Checked in Q10

[3 TEXT BOXES]

[IF Q10=PROCESSED OTHER]

Q13i. Please indicate specifically what prepared or processed [text entered in Q9 for Other Shellfish] product(s) you or someone in your household purchased from a retail outlet?

[GRID NUMBER BOX]

[POUNDS: 0.1-99.9]

[COUNTS: 1-999]

[COST: 0.01-999.99]

[USE ANSWERS IN Q10, Q11, Q12, Q13 TO FILL OUT SPECIES, TYPE, AND PRODUCT. FOR EXAMPLE, IF R SELECTS LIVE CLAMS IN Q10 AND HALFSHELL IN Q11A, THEN QUESTION SHOULD SAY "…PURCHASE LIVE CLAMS (HALFSHELL)…"]

[IF Q9=1,2,4,6,7,8, THEN USE Q10,Q11, Q12, Q13 TO FILL OUT SPECIES, TYPE, AND PRODUCT. FOR EXAMPLE, SHRIMP (AMERICAN) (FROZEN) (DRIED)]

[IF Q11, Q12, OR Q13 REFUSED, SHOW ONLY SPECIES AND TYPE FROM Q9A-F AND Q10]

[PLEASE CREATE DATA VARIABLES TO SHOW WHICH SPECIES, TYPES, OR PRODUCTS EACH NUMBER IS ASSOCIATED WITH]

Non-canned Shellfish:

Q19. How much of the following shellfish products did your household purchase from a retail outlet (for example, a grocery store, a fish or meat market, a convenience store, a multipurpose store such as Costco or Wal-Mart, or a commissary) in <xmonth1a> and what was the total expenditure?

| Total Pounds Purchased (Please enter 0.1-99.9) | OR | Total Count Purchased (Please enter 1-999) | Total Expenditure (Please enter 0.01-999.99) |
|---|---|---|---|
| [ ][ ] . [ ] | | [ ][ ][ ] | $ [ ][ ][ ] . [ ][ ] |

<TYPE SPECIES (PRODUCT)>

<TYPE SPECIES (PRODUCT)>

<TYPE SPECIES (PRODUCT)>

……

……

[GRID NUMBER BOX]

[TYPE OF FLUIDS: CHECK BOX]

[SIZE: 0.1-99.99]

[COUNTS: 1-99]

[COST: 0.01-999.99]

[USE ANSWERS IN Q13 TO FILL OUT SPECIES, TYPE, AND PRODUCT. FOR EXAMPLE, IF R SELECTS CANNED CLAMS IN Q13A, THEN QUESTION SHOULD SAY "…PURCHASE CLAMS (CANNNED)…"]

[IF Q9=1,2,4,6,7,8, THEN USE Q10,Q11, Q12, Q13 TO FILL OUT SPECIES, TYPE, AND PRODUCT. FOR EXAMPLE, SHRIMP (AMERICAN) (PREPARED AND PROCESSED) (CANNED)]

[IF Q13A=3 OR Q13B=2 OR Q13C=2 OR Q13F=1 OR Q13G=2 OR Q13H=2]

[PLEASE CREATE DATA VARIABLES TO SHOW WHICH SPECIES, TYPES, OR PRODUCTS EACH NUMBER IS ASSOCIATED WITH]

Canned Shellfish:

Q22. How much of the following shellfish product(s) did your household purchase from a retail outlet (for example, a grocery store, a fish or meat market, a convenience store, a multipurpose store such as Costco or Wal-Mart, or a commissary) in <xmonth1a>and what was the total expenditure?

| Total Cans & Pouches Purchased (Please enter 1-99) | Total Expenditure (Please enter 0.01-999.99) | Can or Pouch size (ounces /can or pouch) (Please enter 0.01-99.99) | Type of Fluid |
|---|---|---|---|
| | $ . | . oz | Water / Oil / Other |

< SPECIES (PRODUCT)>

< SPECIES (PRODUCT)>

< SPECIES (PRODUCT)>

……

……

[CHECKBOX]
[IF Q8=1]

Q14. Which of the following fish did you or someone in your household purchase from a retail outlet (for example, a grocery store, a fish or meat market, a convenience store, a multipurpose store such as Costco or Wal-Mart, or a commissary) in <xmonth1a>?

Calamari / Squid

Catfish

Cod

Drum, Black

Drum, Red

Flounder / Sole

Grouper [if ppstaten=95 then show; Grouper (Hapu'upu'u)]

Haddock

Hake / Whiting

Halibut

Herring

Mackerel

Mahimahi / Dolphinfish

Other Snapper (if ppstaten=91, 92, 93)

Pacific Rockfish / Snapper (if ppstaten=91, 92, 93)

Pollock

Rockfish [if ppstaten~=91, 92, 93]

Sablefish

Salmon

Snapper [if ppstaten~=91, 92, 93] [if ppstaten=95, then show: Snapper (Onaga, Opakapaka, Uku)]

Striped Bass [if ppstaten~=91, 92, 93]

Imitation crab, shrimp, or scallops

Swordfish [if ppstaten=95, then show: Swordfish (Shutome)]

Tilapia

Trout

Tuna [if ppstaten=95, then show: Tuna (Ahi, Aku, Tombo)]

Other Fish (please specify____)

[CHECKBOX]

[IF Q14=SALMON]

Q14a. Which of the following types of salmon did you or someone in your household purchase from a retail outlet?

Atlantic or Farmed

Chinook / King

Chum

Coho / Silver

Pacific

Pink

Sockeye / Red

Other or Unknown

[CHECKBOX]

[IF Q14=TUNA]

Q14b. Which of the following types of tuna did you or someone in your household purchase from a retail outlet?

Albacore

Bigeye

Bluefin

Skipjack

Yellowfin

Other or Unknown

[CHECKBOX]

[IF Q14=1-26]

[GRID CHECK BOX BY CHECK BOX]

[IF Q14A AND Q14B >=1, THEN SHOW SPECIES CHECKED IN Q14A AND Q14B; ELSE SHOW ITEMS SELECTED IN Q14]

Q15. Of the following fish, which one(s) did you or someone in your household purchase live, fresh, frozen, prepared or processed from a retail outlet (for example, a grocery store, a fish or meat market, a convenience store, a multipurpose store such as Costco or Wal-Mart, or a commissary) in <xmonth1a>?

| | Live / Fresh | Frozen | Prepared or Processed |
|---|---|---|---|
| Calamari / Squid | | | |
| Catfish | | | |
| Cod | | | |
| Drum, Black | | | |
| Drum, Red | | | |
| Flounder / Sole | | | |
| Grouper [if ppstaten=95 then show; Grouper (Hapu'upu'u)] | | | |
| Haddock | | | |
| Hake / Whiting | | | |
| Halibut | | | |
| Herring | | | |
| Mackerel | | | |
| Mahimahi / Dolphinfish | | | |

Other Snapper (if ppstaten=91, 92, 93)

Pacific Rockfish / Snapper (if ppstaten=91, 92, 93)

Pollock

Rockfish [if ppstaten~=91, 92, 93]

Sablefish

Salmon

Snapper [if ppstaten~=91, 92, 93] [if ppstaten=95, then show: Snapper (Onaga, Opakapaka, Uku)]

Striped Bass [if ppstaten~=91, 92, 93]

Imitation crab, shrimp, or scallops

Swordfish [if ppstaten=95, then show: Swordfish (Shutome)]

Tilapia

Trout

Tuna [if ppstaten=95, then show: Tuna (Ahi, Aku, Tombo)]

Other Fish (please specify____)

[CHECKBOX]

[IF Q15=LIVE OR FRESH 4-7, 9, 11-14, 16, , 18-22, , 25]

[SHOW ITEMS SELECTED LIVE OR FRESH IN Q15]

Q16a. Which of the following live or fresh fish product(s) did you or someone in your household purchase from a retail outlet?

Whole (not live) Whole (live) Dressed Headed & Gutted Fillets

Drum, Black

Drum, Red

Flounder / Sole

Grouper [if ppstaten=95 then show; Grouper (Hapu'upu'u)]

Hake / Whiting

Herring

Mackerel

Mahimahi / Dolphinfish

Other Snapper (if ppstaten=91, 92, 93)

Pacific Rockfish / Snapper (if ppstaten=91, 92, 93)

Pollock

Sablefish

Snapper [if ppstaten~=91, 92, 93] [if ppstaten=95, then show: Snapper (Onaga, Opakapaka, Uku)]

Striped Bass [if ppstaten~=91, 92, 93]

Imitation crab, shrimp, or scallops

Trout

[CHECKBOX]

[IF Q15=LIVE OR FRESH 15]

[IF Q14A >=1, THEN SHOW SPECIES CHECKED IN Q14A; ELSE SHOW SALMON]

Q16b. Which of the following live or fresh salmon product(s) did you or someone in your household purchase from a retail outlet?

Whole (not live)

Whole (live)

Dressed

Headed & Gutted

Fillets

Steaks

Tails

Roast

[CHECKBOX]

[TUNA: IF Q14B >=1, THEN SHOW SPECIES CHECKED IN Q14B; ELSE SHOW TUNA]

[IF Q15=LIVE OR FRESH 2, 3, 8, 10, 23, 26]

[SHOW ITEMS SELECTED LIVE OR FRESH IN Q15]

Q16c. Which of the following live or fresh fish product(s) did you or someone in your household purchase from a retail outlet?

Whole Whole Headed Fillets Steaks Loins Chunks Roast Strips

(not live) (live) &Gutted &Quarters &Sections &Nuggets

Catfish

Cod

Haddock

Halibut

Swordfish [if ppstaten=95, then show: Swordfish (Shutome)]

Tuna [if ppstaten=95, then show: Tuna (Ahi, Aku, Tombo)]

[CHECKBOX]

[IF Q15=LIVE OR FRESH 1]

Q16d. Which of the following live or fresh calamari/squid product(s) did you or someone in your household purchase from a retail outlet?

Whole (not live)

Whole (live)

Cleaned

[CHECKBOX]

[IF Q15=LIVE OR FRESH 17 AND FRESH 24]

Q16e. Which of the following live or fresh rockfish or tilapia product(s) did you or someone in your household purchase from a retail outlet?

| | Rockfish | Tilapia |
|---|---|---|
| Whole (live) | | |
| Whole (not live) | | |

[3 TEXT BOXES]

[IF Q15=LIVE OR FRESH OTHER]

Q16f. Please indicate specifically what live or fresh [text entered in Q14 for Other fish] product(s) you or someone in your household purchased from a retail outlet?

[CHECKBOX]

[IF Q15= FROZEN 4-9, 11-14, 16, 17,18, 20-22, 24, 25]

[SHOW ITEMS SELECTED FROZEN IN Q15]

Q17a. Which of the following frozen fish product(s) did you or someone in your household purchase from a retail outlet?

| | Whole | Dressed | Headed & Gutted | Fillets | Blocks |
|---|---|---|---|---|---|
| Drum, Black | | | | | |
| Drum, Red | | | | | |
| Flounder / Sole | | | | | |
| Grouper [if ppstaten=95 then show; Grouper (Hapu'upu'u)] | | | | | |
| Haddock | | | | | |
| Hake / Whiting | | | | | |
| Herring | | | | | |
| Mackerel | | | | | |
| Mahimahi / Dolphinfish | | | | | |
| Other Snapper (if ppstaten=91, 92, 93) | | | | | |
| Pacific Rockfish / Snapper (if ppstaten=91, 92, 93) | | | | | |
| Pollock | | | | | |
| Rockfish [if ppstaten~=91, 92, 93] | | | | | |
| Sablefish | | | | | |
| Snapper [if ppstaten~=91, 92, 93] [if ppstaten=95, then show: Snapper (Onaga, Opakapaka, Uku)] | | | | | |
| Imitation crab, shrimp, or scallops | | | | | |
| Tilapia | | | | | |
| Trout | | | | | |

[CHECKBOX]
[IF Q16=FROZEN 15]
[SALMON: IF Q14A >=1, THEN SHOW SPECIES CHECKED IN Q14A; ELSE SHOW SALMON]

Q17b. Which of the following frozen salmon product(s) did you or someone in your household purchase from a retail outlet?

Whole

Dressed

Headed & Gutted

Fillets

Steaks

Blocks

[CHECKBOX]

[IF Q15=FROZEN 2, 3, 10, 19, 23, 26]

[SHOW ITEMS SELECTED FROZEN IN Q15]

[TUNA: IF Q14B >=1, THEN SHOW SPECIES CHECKED IN Q14B; ELSE SHOW TUNA]

Q17c. Which of the following frozen fish product(s) did you or someone in your household purchase from a retail outlet?

| | Whole | Headed &Gutted | Fillets | Steaks | Loins &Quarters | Chunks &Sections | Roast | Strips &Nuggets |
|---|---|---|---|---|---|---|---|---|
| Catfish | | | | | | | | |
| Cod | | | | | | | | |
| Halibut | | | | | | | | |
| Striped Bass | | | | | | | | |
| Swordfish [if ppstaten=95, then show: Swordfish (Shutome)] | | | | | | | | |
| Tuna [if ppstaten=95, then show: Tuna (Ahi, Aku, Tombo)] | | | | | | | | |

[CHECKBOX]

[IF Q15=FROZEN 1]

Q17d. Which of the following frozen calamari/squid product(s) did you or someone in your household purchase from a retail outlet?

Whole

Cleaned

Tubes

Rings

Tentacles

[3 TEXT BOXES]

[IF Q15=FROZEN OTHER]

Q17e. Please indicate specifically what frozen [text entered in Q14 for Other fish] product(s) you or someone in your household purchased from a retail outlet?

[CHECKBOX]

[IF Q15= PROCESSED 2-10, 13-14, 16-25]

[SHOW ITEMS SELECTED PROCESSED IN Q15]

Q18a. Which of the following prepared or processed fish product(s) did you or someone in your household purchase from a retail outlet?

| | Breaded Or Battered | Marinated or Seasoned | Prepared Entrees (Blocks, Portions, Patties, or Other) | Smoked | Dried or Salted | Stuffed |
|---|---|---|---|---|---|---|
| Catfish | | | | | | |
| Cod | | | | | | |
| Drum, Black | | | | | | |
| Drum, Red | | | | | | |
| Flounder / Sole | | | | | | |
| Grouper [if ppstaten=95 then show; Grouper (Hapu'upu'u)] | | | | | | |
| Haddock | | | | | | |
| Hake / Whiting | | | | | | |
| Halibut | | | | | | |
| Mahimahi / Dolphinfish | | | | | | |
| Other Snapper (if ppstaten=91, 92, 93) | | | | | | |

Pacific Rockfish / Snapper (if ppstaten=91, 92, 93)

Pollock

Rockfish [if ppstaten~=91, 92, 93]

Sablefish

Snapper [if ppstaten~=91, 92, 93] [if ppstaten=95, then show: Snapper (Onaga, Opakapaka, Uku)]

Striped Bass [if ppstaten~=91, 92, 93]

Imitation crab, shrimp, or scallops

Swordfish [if ppstaten=95, then show: Swordfish (Shutome)]

Tilapia

Trout

[CHECKBOX GRID]

[IF Q15= PROCESSED 11,12,15,26]

[SHOW ITEMS SELECTED PROCESSED IN Q15]

[SALMON: IF Q14A >=1, THEN SHOW SPECIES CHECKED IN Q14A; ELSE SHOW SALMON]

[TUNA: IF Q14B >=1, THEN SHOW SPECIES CHECKED IN Q14B; ELSE SHOW TUNA]

Q18b. Which of the following prepared or processed fish product(s) did you or someone in your household purchase from a retail outlet?

Herring Mackerel Salmon Tuna [if ppstaten=95, then show: Tuna (Ahi, Aku, Tombo)]

Breaded or Battered

Marinated or Seasoned

Prepared Entrees (Blocks, Portions, Patties, Other)

Canned

Pouches

Pickled or Cured

Smoked

Dried or Salted

Stuffed

Roe

[CHECKBOX]

[IF Q15=PREPARED OR PROCESSED 1]

Q18c. Which of the following prepared or processed calamari/squid product(s) did you or someone in your household purchase from a retail outlet?

Breaded

Canned

Dried

Marinated

Smoked

Strips

Stuffed

Ink

[3 TEXT BOXES]

[IF Q15=PREPARED OR PROCESSED OTHER]

Q18d. Please indicate specifically what prepared or processed [text entered in Q14 for Other fish] product(s) you or someone in your household purchased from a retail outlet?

[GRID NUMBER BOX]

[POUNDS: 0.1-99.9]

[COUNTS: 1-999]

[COST: 0.01-999.99]

[USE ANSWERS IN Q15, Q16, Q17, Q18 TO FILL OUT SPECIES, TYPE, AND PRODUCT. FOR EXAMPLE, IF R SELECTS LIVE CATFISH IN Q15 AND WHOLE IN Q16C, THEN QUESTION SHOULD SAY "…PURCHASE LIVE CATFISH (WHOLE)…"]

[IF Q16, Q17, Q18 REFUSED, SHOW ONLY SPECIES AND TYPE FROM Q15]

[PLEASE CREATE DATA VARIABLES TO SHOW WHICH SPECIES, TYPES, OR PRODUCTS EACH NUMBER IS ASSOCIATED WITH]

Non-canned fish:

Q20. How much of the following fish product(s)did your household purchase from a retail outlet (for example, a grocery store, a fish or meat market, a convenience store, a multipurpose store such as Costco or Wal-Mart, or a commissary) in <xmonth1a>and what was the total expenditure?

| Total Pounds Purchased (Please enter 0.1-99.9) | OR | Total Count Purchased (Please enter 1-999) | Total Expenditure (Please enter 0.01-999.99) |
|---|---|---|---|
| [ ][ ] . [ ] | | [ ][ ][ ] | $ [ ][ ][ ] . [ ][ ] |

<TYPE SPECIES (PRODUCT)>

<TYPE SPECIES (PRODUCT)>

<TYPE SPECIES (PRODUCT)>

……

……

[GRID NUMBER BOX: 0-99]

[IF Q17B=CANNED OR POUCHED TUNA]

[TUNA: IF Q14B >=1, THEN SHOW SPECIES CHECKED IN Q14B; ELSE SHOW TUNA]

Q21.Which kinds cannned or pouched of tuna product did your household purchase from a retail outlet? Please enter the number of cans or pouches your household purchased for each category below.

Tuna species selected in Q14B

Light solid or fancy ____

Light chunk or bite size ____

White / albacore solid or fancy ____

White / albacore chunk or bite size ____

Snack Pack ____

Tuna Pouches ____

[GRID NUMBER BOX]

[TYPE OF FLUIDS: CHECK BOX]

[SIZE: 0.1-99.99]

[COUNTS: 1-99]

[COST: 0.01-999.99]

[USE ANSWERS IN Q18B TO FILL OUT SPECIES, TYPE, AND PRODUCT. FOR EXAMPLE, IF R SELECTS LIVE HERRING IN Q18B, THEN QUESTION SHOULD SAY "…PURCHASE HERRING (CANNED)…"]

[IF Q18B=CANNED OR POUCHED]

[PLEASE CREATE DATA VARIABLES TO SHOW WHICH SPECIES, TYPES, OR PRODUCTS EACH NUMBER IS ASSOCIATED WITH]

Canned fish:

Q23. How much of the following fish product(s) did your household purchase from a retail outlet (for example, a grocery store, a fish or meat market, a convenience store, a multipurpose store such as Costco or Wal-Mart, or a commissary) in <xmonth1a>and what was the total expenditure?

| Total Cans & Pouches Purchased (Please enter 1-99) | Total Expenditure (Please enter 0.01-999.99) | Can or Pouch size (ounces /can or pouch) (Please enter 0.01-99.99) | Type of Fluid |
|---|---|---|---|
| [ ][ ] | $ [ ][ ][ ] . [ ][ ] | [ ][ ] . [ ][ ] oz | Water [ ] Oil [ ] Other [ ] |

< SPECIES (PRODUCT)>

< SPECIES (PRODUCT)>

< SPECIES (PRODUCT)>

……
……

# VITA

Huabo Wang was born and raised in Heilongjiang, China. She attended Tianjin University of Commerce in 2000 and obtained her Bachelor of Science in Economics four years later. After working two years, she chose to continue her education at University of Windsor, CANADA and received a Master's degree of Art in Economics in 2007. Huabo began the pursuit of a PhD in agricultural economics at Louisiana State University in August, 2008. She started working for University of Louisiana at Monroe in December, 2013 and she is expected to be awarded the doctoral degree in August, 2014.