Demand for Farmed and Wild-Caught Fish and Seafood

Shaonan Wang
University of Georgia, Athens (formerly)
wsn930125@gmail.com

Abigail Okrent
USDA Economic Research Service
Abigail.okrent@usda.gov

Chen Zhen
University of Georgia, Athens
czhen@uga.edu

Hwangwon Lee
University of Georgia, Athens
Hwangwon.lee@uga.edu

Selected paper prepared for presentation at the Agricultural and Applied Economics Association Annual Meeting, New Orleans, LA, July 28-30, 2024

Introduction

Over the past two decades, total U.S. demand for fish and seafood has increased while U.S. aquaculture production has been stagnant and the number of aquaculture farms has decreased (Abaidoo et al. 2021). Changing consumer preferences for fish and seafood and the large volume of it originating from imports presents an opportunity to develop the U.S. aquaculture sector in support of rural economic development, particularly in historically underserved communities. The U.S. Department of Agriculture has a stated interest in providing information about U.S. aquaculture industries and markets to its stakeholders and policymakers as part of the next Farm Bill (Johnson 2023).

Growth in fish and seafood consumption has been uneven across consumer segments, species, and mode of production (farmed versus wild caught). Since the 1990s, per capita consumption of most farm-raised species of fish and seafood have increased while that of wild species has declined (Shamshak et al. 2019). Despite increases in consumption of farm-raised species, mean intake of fish and seafood remains well below recommendations in the Dietary Guidelines for Americans (U.S. Department of Agriculture and U.S. Department of Health and Human Services 2020), varying considerably across income, race and ethnicity, age, and immigrant status (Zeng et al. 2019, Terry et al. 2018; Church et al. 2021). In addition, consumption of fish and seafood by mode of production follows a socioeconomic gradient (Love et al. 2022). The question arises as to the primary drivers and barriers to accessing fish and seafood in the context of growing aquaculture supply. Understanding the determinants of demand for fish and seafood across sociodemographic groups is necessary for estimating the impacts of aquaculture policies on not just the fish and seafood industry but also on nutrition and dietary health of the U.S. population.

Prices and product attributes are found to be key drivers of demand for fish and seafood. A number of recent demand studies examined demand for fish and seafood at the market or national level data and find considerable variation in price responsiveness across species (e.g., salmon and tuna), subspecies (e.g., Atlantic salmon and Chinook Salmon), form (e.g., fresh, frozen, shelf-stable and prepared in meal), geographies, seasons and product origin (Muhammad and Jones 2011; Chidmi et al. 2012; Singh et al. 2012; Singh et al. 2014; Nguyen et al. 2013; Surthkal et al. 2017; Ray et al. 2023). Because these studies are based on national or subnational data, little is known about how socioeconomic factors may affect demand for fish and seafood and explain disparate trends in fish and seafood consumption across socioeconomic groups.

Another set of studies examined demand for fish and seafood by mode of production across consumer segments using stated choice approaches. This is primarily due to scant purchase and price information on fish and seafood by mode of production. In their systematic review, Cantillo et al. (2020) identified 39 studies that used discrete choice experiments to measure willingness to pay for finfish products and found that consumers are willing to pay a significant premium for wild caught fish and seafood over its farm-raised counterpart. However, they conclude that consumers' knowledge of aquaculture practices are low and marketing strategies to inform consumers about different production practices may be able to change such preferences. In their meta-analysis, Smetana et al. (2022) identified 45 willingness-to-pay estimates for farm-raised fish and seafood and concluded that in general consumers are willing to pay more for products that are farmed in addition to it being produced domestically, sustainable and sold fresh. Although these studies provide valuable information on how attributes like mode of production can affect demand across different consumer segments, these studies give no information on how preferences for substitute or complimentary products may affect demand and how the income constraint affects food purchasing decisions.

Another gap in the literature is most of these studies focus solely on fish and seafood purchased at retail establishments. However, roughly 60 percent of fish and seafood purchases by U.S. households are made in foodservice establishments (Love et al. 2022). In addition, about 30% percent of quantities of fish and seafood consumed are at foodservice establishments (Zeng et al. 2019). This is largely due to very little information regarding fish and seafood purchases at foodservice establishments. Only a handful of older studies examine fish and seafood purchased at foodservice venues and found very different socioeconomic drivers of demand for each (Nayga and Capps 1995; Dellenbarger et al. 1992).

This research fills the highlighted shortcomings of the current literature by estimating demand for fish and seafood products by mode of acquisition (retail versus foodservice) and production (farmed versus wild caught). Because no data set includes all the information necessary to do this, we use a two-stage budgeting framework, which allows us to estimate demand for fish and seafood using multiple datasets.

Data

For the first stage of the analysis, we use the National Household Food Acquisition and Purchase Survey (FoodAPS-1) to estimate demand for broad categories of FAH and FAFH, treating fish and seafood purchases across both types of establishments as separate from other foods. FoodAPS-1 is a stratified probability sample of U.S. households that collects information on food acquisitions (quantities and expenditures for items that were purchased) in 2012-13. The survey includes data from 4,826 households, who keep a 7-day diary of food acquisitions for all individuals within the household. Of the 4,826 households, 87 did not report any food acquisition during the 7-day period. Therefore, estimation of the first-stage demand relies on the 4739 households that acquired food. Sampling weights are available to project the sample to be representative of the U.S. household population based on income and food assistance participation (U.S. Department of Agriculture 2022).

We use the restricted-use FoodAPS-1 data to estimate demand for 28 categories of goods and services with fish and seafood for at-home and away-from-home consumption as two separate categories. FAH purchases are grouped into 25 categories, following tier 2 of the ERS Food Purchase Groups: whole grains; non-whole grains; starchy vegetables; tomatoes; dark green vegetables; other vegetables; whole fruits; fruit and vegetable juices; whole milk and yogurt; low-fat/skim milk and yogurt; cheese; red meat; poultry; fish and seafood; nuts and seeds; processed meat; eggs; beans and tofu; ready-to-eat (RTE) meals, sides and salads; ready-to-heat (RTH)/ready-to-cook (RTC) meals, sides and salads (combines frozen, canned and packaged RTH and RTC foods); fats and oils; sauces, gravies and condiments; beverages; sweeteners and sweets; and salty snacks. FAFH purchases were grouped into two categories: fish and seafood and other FAFH.[1] Nonfood, or the numeraire, was constructed as nondurable expenditures[2] less food expenditures.

Fish and seafood tended to be the least purchased (grams per adult male equivalent per week or g/AME-week) and had the highest unit value (dollars per 100 grams or $/g) compared to most other foods (table 1). Low-income households (those at or below the 185 percent of federal

---

[1] Vitamins and meal supplements, baby food, infant formula and not coded items are excluded from the analysis.
[2] Total nondurable expenditure consists of weekly household expenses on shelter, rental/homeowner's insurance, property taxes, public transport, health insurance and copays, doctor/hospital bills, prescription drug, child care, child support, and food.

poverty guideline) purchased 126 g/AME-week while high-income households purchased 112 g/AME-week, the lowest reported among protein foods with the exception of nuts and seeds. FAFH fish and seafood purchase quantity was also considerably less than other FAFH. This is mostly caused by high rate of households purchasing zero fish and seafood in the sample (around a 80% rate of censoring). Compared to other protein foods in FAH, fish and seafood was also the highest priced at $0.90/100 grams for low-income households and $1.23/100 grams for high-income households. Similarly, the unit value for FAFH fish and seafood was more than double than that for FAFH all other.

[Table 1: Weekly spending, purchase quantity and unit values for FoodAPS-1 households]

Methods

We estimate the demand for the 28 categories using a two-way Exact Affine Stone Index (EASI) demand system (Lewbel and Pendakur 2009) and instrument for potential price endogeneity using price indexes of neighboring geographies constructed from Circana's retail scanner data. The EASI model expresses demand, measured as a share of the budget on food group, as a function of its own price, prices of complements and substitutes, income, and household sociodemographic characteristics. The EASI demand system is more flexible than the traditional demand system approaches (e.g., Deaton and Muellbauer's (1980) Almost Ideal Demand System) by allowing income to enter the model as a higher-order polynomial, which allows for nonlinear Engel curves, and also includes interactions between income and prices, allowing differential price responses across household income.[3] In particular, the budget share on food group i for household h, w_{hi}, is

$$(1)\quad w_{hi} = \sum_{j=1}^{J} \left(a_{ij} \ln p_{hj} + a_{ijy} y_h \ln p_{hj} \right) + \sum_{r=1}^{L} b_{ir} y_h^r + \sum_{k=1}^{K} g_{ik} z_{hk} + u_{hi}\ , i = 1, \ldots, J-1,$$

where p_{hj} is the price of food group j, z_{hk} is the kth demand shifter for household h (with z_{h1} as the constant), y_h is log deflated total expenditure (i.e., $\ln x_h - \sum_{j=1}^{J} w_{hj} \ln p_{hj}$ with x_h being household h's per capita weekly income), u_{hi} is the error term, and a, b, and g are coefficients to be estimated. L the highest order of polynomial for y_h, which is set to four. The number of

[3] The EASI demand system in Eq. (3) is "two-way" because of the interactions between y_h and p_{hj}. This allows the Hicksian price effects to vary with total expenditures and is unique to the EASI functional form. In the family of almost ideal demand systems (Deaton and Muellbauer 1980), only Marshallian price effects differ for lower- and higher-income households through the income effects.

food categories plus the *numeraire* (i.e., all other goods), or J, is 28 for the first stage and 13 for the second stage. The demand shifters or z, include Census division and calendar month fixed effects, household size, mean age of household heads, and ratios of Black, Hispanic, College-educated, and male members in the household. Many households reporting in FoodAPS-1 report zero expenditures for many of the food categories, and the large mass of zeros in the data can result in inconsistent and biased estimates if (1) is estimated with standard linear regression. Following the censored demand system literature (e.g., Perali and Chavas 2000; Dong, Gould and Kaiser 2004; Meyerhoefer, Ranney, and Sahn 2005; and Zhen et al. 2014), we use the Tobit model to characterize the zeros in food group-level purchases, where the latent budget share w_{hi}^* is related to the observed budget share w_{hi} by $w_{hi} \equiv \max(w_{hi}^*, 0)$.

Another issue with these data is that prices/unit values are endogenous, reflecting both supply- and demand-induced variation (e.g., quality of foods, time spent in price searching). Following Allcott et al. (2019), we use prices of the same chain in other counties as instruments. For the two FAFH categories in the first-stage demand, we use the country dummy method to remove household fixed effects from the FAFH prices and use them as instruments. Details of the instrumentation strategy are described in Zhen et al. (2024).

Using the estimated coefficients in (1), we estimate own-price, cross-price and expenditure elasticities of demand for each household (see Lewbel and Pendakur 2009 for price elasticity formulas and Zhen et al. 2014 for the correct expenditure elasticity formula).

Results

For the first stage, we find fish and seafood demand to be generally more price and expenditure elastic than other foods. The own-price elasticity of demand for fish and seafood purchased at retail establishments to be -2.16, one of the most price elastic products purchased at retail stores (table 1). In contrast, fish and seafood purchased at foodservice establishments is price inelastic (-0.73) but more elastic than other FAFH (-0.23) with variations across sociodemographic groups. Both FAH and FAFH fish and seafood are expenditure elastic and the largest across most foods and the numeraire.

[Table 1. Own-price and Expenditure Elasticities of Demand for First Stage]

The cross-price elasticities indicate that fish and seafood has limited substitute or complementary relationships with other foods with some notable exceptions (figure 1). Most of the cross-price elasticities are less than 1.0. However, the demand for FAH fish and seafood with respect to the price of frozen, canned, or packaged meals and sides was 1.56, indicating substantial substitution between these products. In contrast, the cross-prices elasticity for FAH fish and seafood and FAFH other is -1.34, indicating substantial complementarity between these products. FAFH and FAH fish and seafood are found to be complements but this relationship is relatively small.

[Figure 1. Elasticities of Demand for All Goods and Services for the First Stage]

Next steps

We plan on estimating demand for farmed and wild-caught species of fish and seafood for at-home consumption as separable from other FAH. Using both the first stage and second stage estimates, we will approximate unconditional demand for these species using Carpentier and Guyomard (2001).

For the second stage, we will use Circana's (formerly known as IRI) household and retail scanner data to estimate demand for species of fish and seafood for at-home consumption (see figure 2). Because the scanner data contains very limited information on mode of production (i.e., wild caught versus farmed), we use Harmonized Tariff Schedule (HTS) data and Food and Agriculture Organization's production data to proxy for primary mode of production of each species consumed in the United States.

[figure 2: Conceptual Model and Data Sets Used to Examine U.S. Demand for Fish and Seafood]

HTS trade and FAO fish production data

With FAH fish and seafood, we model demand for different species of fish and seafood to proxy for mode of production—farmed and wild caught. Even though fish and seafood labels include mode of production information, this information is unavailable in the Circana scanner data. To overcome this challenge, we will adopt a novel approach developed by Love et al. (2022), which assigns each species of fish and seafood in the scanner data to primary modes of production based on estimated U.S. availability of each species and how it was produced.

Love et al. calculated consumption availability of each species by mode of production in the United States as domestic production plus imports less exports. The underlying source data for the domestic production will be FAO FishStat (2024), which contains information on freshwater and marine species of fish and seafood and mode of production (i.e., wild-caught or farm-raised). These data will be linked to the Harmonized Tariff Schedule (HTS) data by country and specific fish and seafood products (e.g., HTS codes starting with 03), and provides information on fish and seafood exports into and out of the United States.[4]

As reported by the FAO FishStat (2024) for 2018-2021, total production of fish and seafood farmed (F) and wild caught (WC) for each country, *c*, and species, *s*, is

$$P_{c,s} = P^{F}_{c,s} + P^{WC}_{c,s} \ .$$

The share of *s* by mode of production for each *c* is:

$$\%P^{F}_{c,s} = \frac{P^{F}_{c,s}}{P_{c,s}},$$

$$\%P^{WC}_{c,s} = \frac{P^{WC}_{c,s}}{P_{c,s}}.$$

These shares are then applied to imports of *s* from *c* into the United States ($I_{c \neq US,s}$) from the HTS database to estimate U.S. imports of s that are farmed ($I^{F}_{US,s}$) and wild caught ($I^{WC}_{US,s}$):

$$I^{F}_{US,s} = \sum\nolimits_{c \neq US} I_{c,s} * \ \%P^{F}_{c,s},$$

$$I^{WC}_{US,s} = \sum\nolimits_{c \neq US} I_{c,s} * \ \%P^{WC}_{c,s}.$$

Similarly, we apply the farmed/wild-caught proportions to exports of *s* from the United States from the HTS database to get US exports of s that are farmed ($X^{F}_{US,s}$) and wild caught ($X^{WC}_{US,s}$):

$$X^{F}_{US,s} = X_{US,s} * \%P^{F}_{US,s},$$

$$X^{WC}_{US,s} = X^{c}_{US,s} * \%P^{WC}_{US,s}.$$

Lastly, availability (*A*) of each *s* for consumption in the United States by farmed and wild caught is then:

[4] Fish and seafood items not fit for human consumption, such as ornamental fish or pellets for freshwater or marine species were excluded. The dataset provides descriptions of seafood products, detailing whether the items were processed into forms like fillets or stakes, and noting the condition of the products, such as salty, frozen, live, or chilled. The HTS descriptions for imports and exports only record the weight of processed seafood products, which will underestimate our estimates of availability.

$$A^{F}_{US,c} = \left(P^{F}_{US,s} - X^{F}_{US,s}\right) + I^{F}_{US,s},$$

$$A'^{WC}_{s} = \left(P^{WC}_{US,s} - X^{WC}_{US,s}\right) + I^{WC}_{US,s}.$$

Each species is deemed farmed if $A^{F}_{US,c} > A'^{WC}_{s}$, otherwise, it is considered wild caught. For this analysis, we will analyze the top five species by mode of production. Some fish and seafood expenditures in the data cannot be identified and are included in an aggregate all other category.

Circana Consumer Network

Circana (formerly IRI) household scanner data will be used to estimate demand for the thirteen fish and seafood categories within FAH. Circana's static panel includes about 60,000 households each year that regularly report their food expenditures. Selected households record all retail food purchases, including random-weight perishable foods, using barcode scanners (Muth et al., 2016).

Our study will use 2018-2021 household scanner data. First, we will filter the barcode-level seafood products from consumer panel using EFPG-UPC mapping data created by ERS USDA (Sweitzer et al. 2024). Then, we will identify seafood species based on product details such as categories, product names, and UPC descriptions, and so on. These seafood species are then classified by mode of production using the proportion of domestic availability that are wild caught and farmed. Seafood expenditures will be aggregated at the household-monthly level and then merged with households' demographic and socioeconomic characteristics, such as household heads' age, household size, education, race and ethnicity, and income level.

Our demand model includes the top five fish and seafood species that are farmed, an aggregate of all other farmed fish and seafood, top five fish and seafood species that are wild caught, an aggregate of all other wild-caught fish and seafood, and fish and seafood not elsewhere classified. In the demand model, we also need the price of each seafood category. We use retail prices rather than the prices paid by households in the model to control for price endogeneity arising from household preferences for quality of food and price searching.

Circana OmniMarket Core Outlet

The Circana retail scanner provides aggregate weekly sales and sales quantities at the barcode level. Similar to household scanner data, we will use EFPG-UPC mapping data to identify seafood sales at the barcode level in stores. We will then aggregate these sales at the store-monthly-barcode level. Some retailers provided data only at the retailer marketing area (RMA) level. In such cases, we will aggregate sales and sales quantities at the RMA-monthly-barcode level and then evenly distribute sales across the stores encompassed by the RMA. We will then merge the store-monthly-barcode level data with the store's county information (county FIPS code) and aggregate them into roughly 50 IRI markets.

The unit price for each UPC-level seafood product will be calculated by dividing sales by quantity. Due to (1) our concerns with price endogeneity in household-level prices, (2) missing unit value information for some foods in the Circana Consumer Network[5], and (3) missing price information for censored items, we will construct MSA price indexes to proxy for seafood prices from household purchases.

Within each seafood group, many similar products are available at very different prices due to quality, size, or other attributes. Simply averaging the product prices may bias variations in the prices of specific items. Additionally, consumers might substitute cheaper products for more expensive ones when prices change. This substitution effect may bias the actual change in prices that consumers are paying for the same products. To correct the unit value bias, we will calculate the Törnqvist index using barcode-level prices and sales. The Törnqvist index is a superlative index that is exact to the non-homothetic translog function, which allows us to well approximate the cost-of-living index without estimating demand system.

The Törnqvist index will be calculated as:

$$P_{jmt} = \exp\left(0.5 \cdot \sum_{v} (s_{v0} + s_{vmt}) \cdot \ln\left(\pi_{vmt}/\pi_{v0}\right)\right)$$

where π_{vmt} and s_{vmt} are the price and budget share (within food group j) of UPC v for market m in period t. π_{v0} and s_{v0} are the base price and budget share of UPC v. We will set the base at the national average over the period. MSA price indexes are merged with households in the Consumer Network based on county FIPS codes.

Lastly, we combine the first and second stage elasticities of demand to approximate unconditional elasticities of demand for detailed retail fish and seafood products and fish and

[5] Price information is missing for random weight items, or items that are purchased per pound (e.g., meat, bakery goods, deli foods, fruits and vegetables) in the household scanner data.

seafood purchased at foodservice establishments. This is done using unconditional elasticity formulas developed by Carpentier and Guyomard (2001). This method allows us to evaluate substitution across fish and seafood products purchased from retail and foodservice establishments as well as between detailed retail fish and seafood products and other food categories under less restrictive assumptions established by Gorman (1959).

References

Abaidoo, Eric, Max Melstrom, and Trey Malone. "The Growth of Imports in US Seafood Markets." *Choices* 36, no. 4 (2021): 1-10.

Allcott, Hunt, Benjamin B. Lockwood, and Dmitry Taubinsky. "Should we tax sugar-sweetened beverages? An overview of theory and evidence." *Journal of Economic Perspectives* 33, no. 3 (2019): 202-227.

Cantillo, Javier, Juan Carlos Martín, and Concepción Román. "Discrete choice experiments in the analysis of consumers' preferences for finfish products: A systematic literature review." *Food Quality and Preference* 84 (2020): 103952.

Carpentier, Alain, and Hervé Guyomard. "Unconditional elasticities in two-stage demand systems: An approximate solution." *American Journal of Agricultural Economics* 83, no. 1 (2001): 222-229.

Chidmi, Benaissa, Terry Hanson, and Giap Nguyen. "Substitutions between fish and seafood products at the US national retail level." *Marine Resource Economics* 27, no. 4 (2012): 359-370.

Church, Hannah, Sayaka Nagao-Sato, Francine Overcash, and Marla Reicks. "Associations between seafood intake frequency and diet and health indicators among US adults: NHANES 2011–2016." *Journal of Food Composition and Analysis* 102 (2021): 104054.

Deaton, Angus, and John Muellbauer. *Economics and consumer behavior*. Cambridge university press, 1980.

Dellenbarger, Lynn E., James Dillard, Alvin R. Schupp, Hector O. Zapata, and Brian T. Young. "Socioeconomic factors associated with at-home and away-from home catfish consumption in the United States." *Agribusiness* 8, no. 1 (1992): 35-46.

Dong, Diansheng, Brian W. Gould, and Harry M. Kaiser. "Food demand in Mexico: An application of the Amemiya-Tobin approach to the estimation of a censored food system." *American Journal of Agricultural Economics* 86, no. 4 (2004): 1094-1107.

Food and Agriculture Organization. 2024. Available at https://www.fao.org/fishery/en/fishstat. Accessed on 13 May 2024.

Johnson, R. 2023. Farm Bill Primer: USDA Support for Aquaculture Operations. Congressional Research Service. Available at https://crsreports.congress.gov/product/pdf/IF/IF12275. Accessed on 14 May 2024.

Gorman, William M. "Separable utility and aggregation." *Econometrica: Journal of the Econometric Society* (1959): 469-481.

Lewbel, Arthur, and Krishna Pendakur. "Tricks with Hicks: The EASI demand system." *American Economic Review* 99, no. 3 (2009): 827-863.

Love, David C., Andrew L. Thorne-Lyman, Zach Conrad, Jessica A. Gephart, Frank Asche, Dakoury Godo-Solo, Acree McDowell, Elizabeth M. Nussbaumer, and Martin W. Bloem. "Affordability influences nutritional quality of seafood consumption among income and race/ethnicity groups in the United States." The American journal of clinical nutrition 116, no. 2 (2022): 415-425.

Meyerhoefer, Chad D., Christine K. Ranney, and David E. Sahn. "Consistent estimation of censored demand systems using panel data." *American Journal of Agricultural Economics* 87, no. 3 (2005): 660-672.

Muhammad, Andrew, and Keithly G. Jones. "Source-based preferences and US salmon imports." *Marine Resource Economics* 26, no. 3 (2011): 191-209.

Muth, Mary K., Megan Sweitzer, Derick Brown, Kristen Capogrossi, Shawn A. Karns, David Levin, Abigail Okrent, Peter Siegel, and Chen Zhen. "Understanding IRI household-based and store-based scanner data." (2016).

Nayga, Rodolfo M., and Oral Capps. "Factors affecting the probability of consuming fish and shellfish in the away from home and at home markets." *Journal of Agricultural and Applied Economics* 27, no. 1 (1995): 161-171.

Nevo, Aviv. "Measuring market power in the ready-to-eat cereal industry." *Econometrica* 69, no. 2 (2001): 307-342.

Nguyen, Giap V., Terrill R. Hanson, and Curtis M. Jolly. "A demand analysis for crustaceans at the US retail store level." *Aquaculture Economics & Management* 17, no. 3 (2013): 212-227.

Perali, Federico, and Jean-Paul Chavas. "Estimation of censored demand equations from large cross-section data." *American Journal of Agricultural Economics* 82, no. 4 (2000): 1022-1037.

Ray, Kevin D., Daniel K. Lew, and Rosemary Kosaka. "A Random Coefficients Model of Seafood Demand: Implications for Consumer Preferences and Substitution Patterns." *Marine Resource Economics* 38, no. 2 (2023): 113-133.

Sweitzer, M., Byrne, A. T., Page, E. T., Carlson, A., Kantor, L., Muth, M. K., Karns, S., & Zhen, C. (2024). Development of the food-at-home monthly area prices data (Report No. TB-1965). U.S. Department of Agriculture, Economic Research Service.

Shamshak, Gina L., James L. Anderson, Frank Asche, Taryn Garlock, and David C. Love. "US seafood consumption." *Journal of the World Aquaculture Society* 50, no. 4 (2019): 715-727.

Singh, Kehar, Madan M. Dey, and Prasanna Surathkal. "Analysis of a demand system for unbreaded frozen seafood in the United States using store-level scanner data." *Marine Resource Economics* 27, no. 4 (2012): 371-387.

Singh, Kehar, Madan M. Dey, and Prasanna Surathkal. "Seasonal and spatial variations in demand for and elasticities of fish products in the United States: an analysis based on market-Level scanner data." *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie* 62, no. 3 (2014): 343-363.

Smetana, Kerri, Richard T. Melstrom, and Trey Malone. "A meta-regression analysis of consumer willingness to Pay for aquaculture products." *Journal of Agricultural and Applied Economics* 54, no. 3 (2022): 480-495.

Surathkal, Prasanna, Madan M. Dey, Carole R. Engle, Benaissa Chidmi, and Kehar Singh. "Consumer demand for frozen seafood product categories in the United States." *Aquaculture economics & management* 21, no. 1 (2017): 9-24.

Terry AL, Herrick KA, Afful J, Ahluwalia N. Seafood consumption in the United States, 2013–2016. NCHS Data Brief, no 321. Hyattsville, MD: National Center for Health Statistics. 2018.

U.S. Department of Agriculture. 2022. FoodAPS National Household Food Acquisition and Purchase Survey: Documentation. Available at https://www.ers.usda.gov/data-products/foodaps-national-household-food-acquisition-and-purchase-survey/documentation/. Accessed on 30 April 2024.

U.S. Department of Agriculture and U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2020-2025. 9th Edition. December 2020. Available at DietaryGuidelines.gov.

Zeng, Luxian, Mengyuan Ruan, Junxiu Liu, Parke Wilde, Elena N. Naumova, Dariush Mozaffarian, and Fang Fang Zhang. "Trends in processed meat, unprocessed red meat, poultry, and fish consumption in the United States, 1999-2016." *Journal of the Academy of Nutrition and Dietetics* 119, no. 7 (2019): 1085-1098.

Zhen, Chen, Eric A. Finkelstein, James M. Nonnemaker, Shawn A. Karns, and Jessica E. Todd. "Predicting the effects of sugar-sweetened beverage taxes on food and beverage demand in a large demand system." *American journal of agricultural economics* 96, no. 1 (2014): 1-25.

Table 1. Weekly spending, purchase quantities, and unit values for FoodAPS-1 households

	Expenditures ($/week)		Purchase quantity (100g/AME-week)		Unit value ($/100g)	
Food category	low income	higher income	low income	higher income	low income	higher income
1. whole grain	0.73	1.31	1.68	2.42	0.45	0.53
2. non whole grain	2.44	2.6	7.47	6.66	0.31	0.39
3. starchy vegetable	0.58	0.69	4.01	3.6	0.15	0.19
4. tomatoes	0.55	0.77	2.65	3	0.2	0.25
5. dark green vegetables	0.3	0.52	0.63	0.88	0.46	0.56
6. other vegetable	1.71	2.15	5.37	5.68	0.3	0.37
7. whole fruit	2.88	3.97	8.44	10.12	0.33	0.39
8. 100% fruit/vegetable juice	0.53	0.67	3.51	4.03	0.15	0.16
9. whole milk, yogurt, & cream	0.57	0.48	4.35	2.78	0.12	0.16
10. low-fat/skim milk & low-fat yogurt	1.31	2.12	11.04	14.4	0.12	0.14
11. cheese	1.6	2.2	1.99	2.34	0.79	0.93
12. beef, pork, veal, & lamb	3.39	2.88	4.8	3.79	0.71	0.71
13. chicken, turkey	1.77	1.87	3.06	2.98	0.56	0.65
14. fish & seafood	1.14	1.37	1.26	1.12	0.9	1.23
15. nuts, nut butters, & seeds	0.52	1.04	0.67	0.99	0.76	0.99
16. bacon, sausage, lunch meat	2.53	2.45	3.16	2.57	0.76	0.93
17. eggs	0.55	0.51	1.8	1.46	0.3	0.35
18. tofu, meat substitutes, beans, lentil	0.24	0.26	0.56	0.53	0.41	0.47
19. prepared meal ready to eat	0.65	1.25	1.48	1.76	0.52	0.72
20. prepared meal, frozen, canned, packaged	3.44	3.98	7.16	7.22	0.47	0.55
21. table fats, oils, salad dressing	0.98	1.02	2.5	2.07	0.37	0.48
22. gravies, sauces, condiments, and spices	1.15	1.58	3.11	3.69	0.37	0.4
23. beverages	5.25	7.58	51.2	46.67	0.1	0.15
24. desserts, sweets, candies	4.78	5.5	9.99	12.16	0.46	0.45
25. salty snacks	1.49	2.01	1.96	2.25	0.77	0.88
26. FAFH fish & seafood	1.2	2.66	0.62	1.28	1.89	2.06
27. FAFH all other	15.51	29.57	19.99	29.81	0.74	0.98

Notes: FoodAPS. AME=adult male equivalent. FAFH bundles that include fish and seafood food codes are counted toward FAFH fish and seafood. Low-income households (N=2471) are those at or below 185 percent of federal poverty guideline, the rest (N = 2268) are higher income.

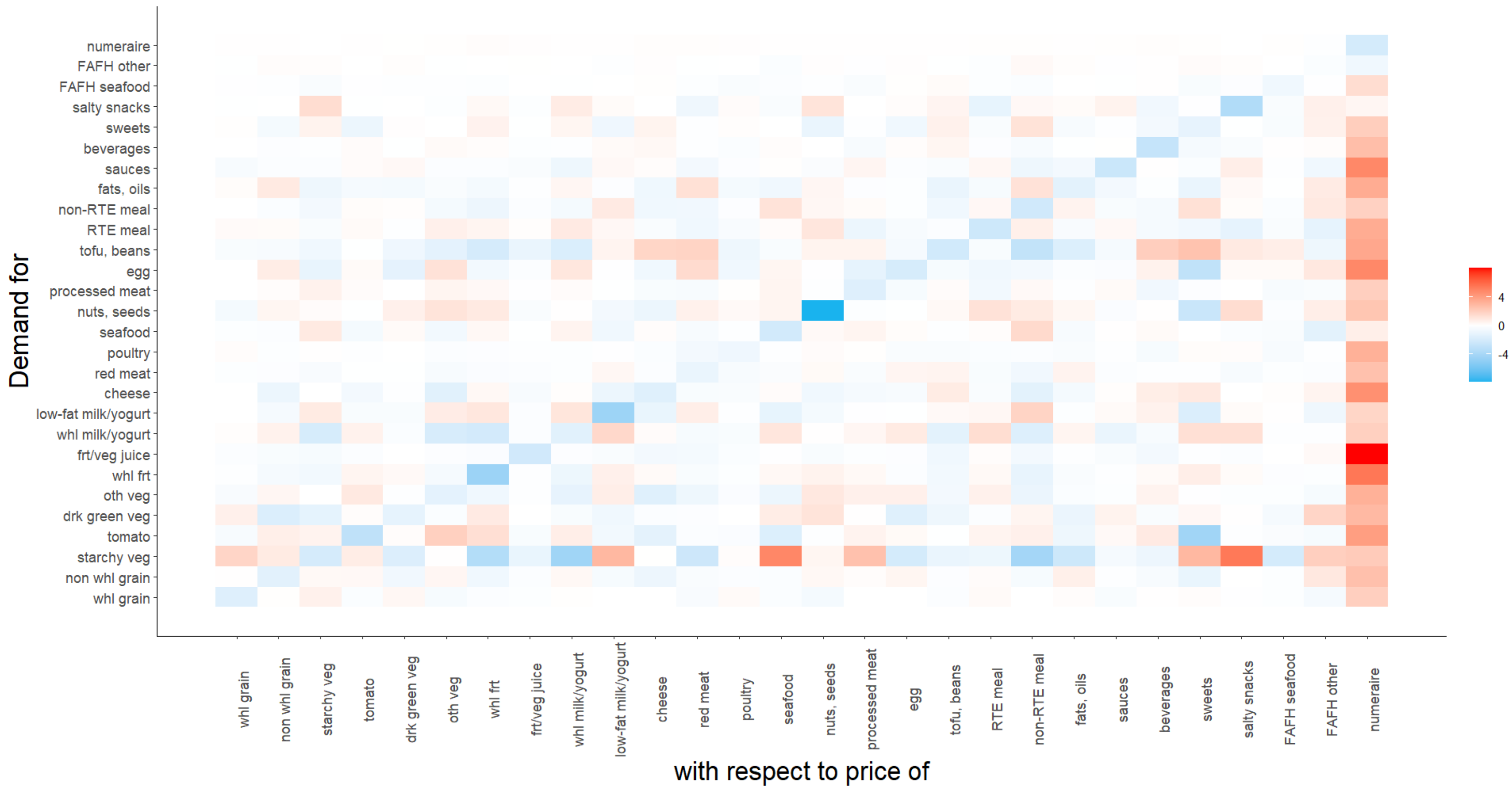
Source: Authors' calculations based on FoodAPS-1.

Table 2. Own-price and Expenditure Elasticities of Demand for the First Stage

	Own-price elasticity	Expenditure elasticity
Whole grain	-1.59	1.16
Non-whole grain	-1.41	0.90
Starchy vegetables	-2.01	1.02
Tomatoes	-3.02	1.36
Dark green vegetables	-1.19	0.86
Other vegetables	-1.29	1.33
Whole fruit	-4.47	1.09
Fruit and vegetable juice	-2.19	0.88
Whole milk, yogurt	-1.46	1.43
Low-fat/skim milk & yogurt	-4.42	1.48
Cheese	-1.54	1.56
Red meat	-1.00	1.31
Poultry	-0.76	1.06
Fish & seafood	-2.16	1.56
Nuts and seeds (inc. butters)	-7.86	1.35
Bacon, sausage, lunch meat	-1.58	0.64
Eggs and egg substitutes	-1.95	1.12
Tofu, meat substitutes, beans, lentils, peas, legumes	-2.16	2.35
RTE meals and sides	-2.35	1.28
frozen, canned, packaged meals and sides	-2.22	0.89
Fats, oils, salad dressings	-1.34	1.07
Gravies, sauces, condiments	-2.48	1.31
Beverages	-2.71	0.86
Desserts, sweets	-1.17	0.74
Salty snacks	-3.59	0.80
FAFH fish/seafood	-0.73	1.49
FAFH all other	-0.23	0.73
Numeraire	-2.05	0.98

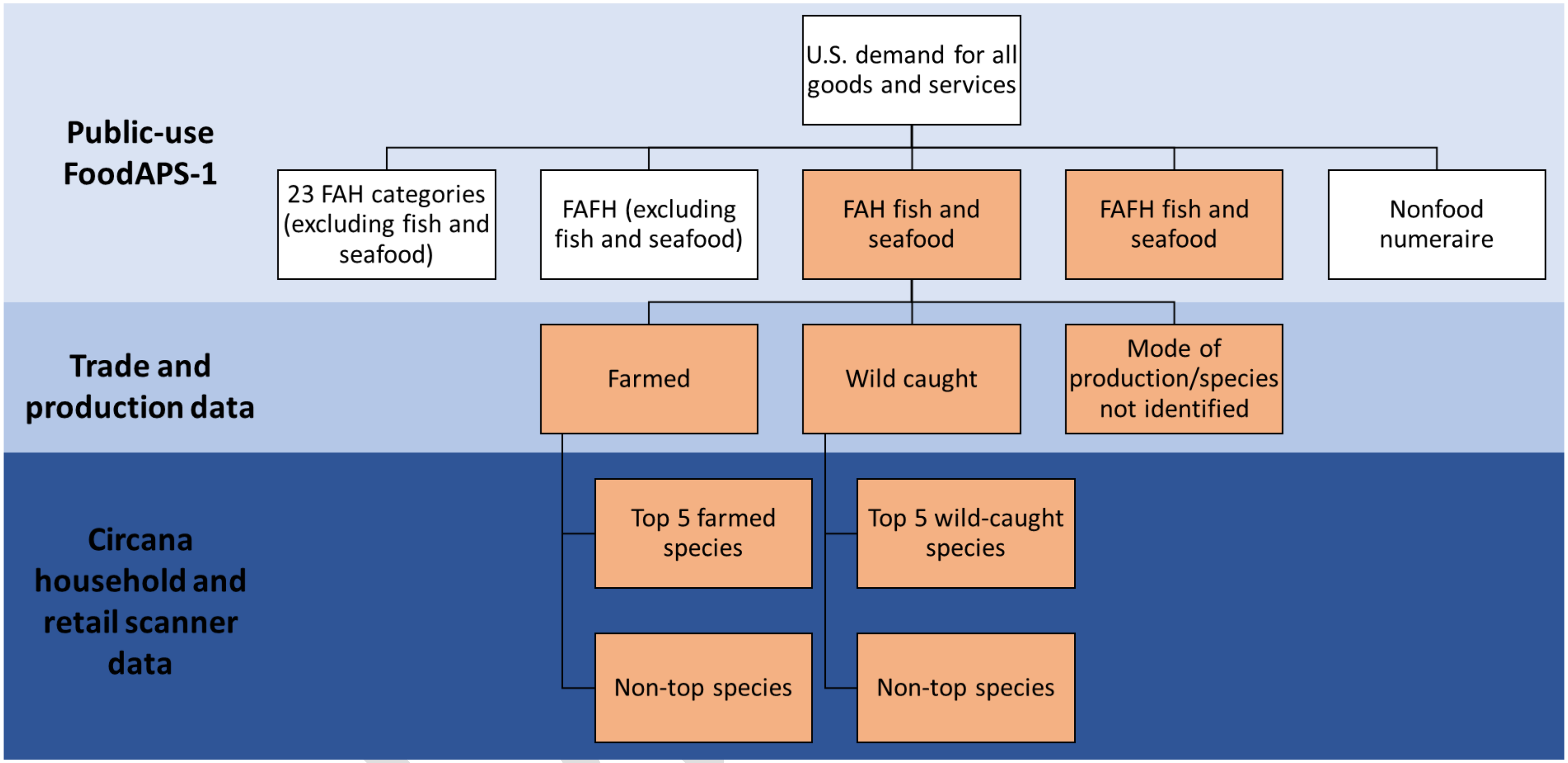
Source: Authors’ calculations based on FoodAPS-1.

Figure 1. Demand for Goods and Services from the First Stage



Source: Authors' calculations based on FoodAPS-1.

Figure 2: Conceptual Model and Data Sets Used to Examine U.S. Demand for Fish and Seafood



Notes: FAH = food at home; FAFH = food away from home

Source: Authors' rendering