A Disaggregated Analysis of Fish Demand in Myanmar

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ABSTRACT

We estimate demand elasticities for fish in Myanmar by fish supply sources and household groups, using a multistage budgeting approach combined with quadratic almost ideal demand system (QUAIDS). Our findings show that fish demand from all supply sources and household groups has increased with income. A substantial share of increasing demand for all fish groups is likely to come from poor and rural households because the income elasticity of demand for all fish groups is higher for poor (0.40) and rural households (0.32) than for nonpoor (0.26) and urban households (0.29). Farmed-fish consumption is the most income-responsive in all household groups. Demand for fish tends to be less price elastic for poor households because fish is their cheapest animal protein source, and substitutes are limited. Effective management policies and new technologies are essential to sustain fish supply from capture fisheries and aquaculture to meet the increasing fish demand in Myanmar.

Key words: Fish demand elasticities, Myanmar, QUAIDS model, three-stage budgeting framework.
JEL codes: D120, Q180, Q210, Q220, Q280.

INTRODUCTION

The fishery sector in Myanmar is crucial to the livelihoods of 6% of the population, and nearly half of the population resides in coastal areas (Gregory et al. 2016). This sector also plays an essential role in Myanmar's economic growth, job creation, and food and nutrition security (Tezzo

et al. 2018). Fish provides about 50% of animal-sourced food for household consumption and is a critical source of micronutrient supply in Myanmar (Belton et al. 2015), where more than 30% of the children under five years old are stunted, and 25% of the children are underweight (WFP 2020). Fish production for household consumption in Myanmar comes from three primary sources: marine capture fisheries, freshwater capture fisheries, and aquaculture (World Bank 2019). Freshwater and marine capture fisheries outputs are also processed by drying, fermenting, and salting. Capture from marine fisheries is more commonly used for these purposes than that from freshwater sources. Because of the dominance of rohu species, smoked and some fermented fish products are increasingly made with farmed-fish species.

Aquaculture has been growing rapidly in Myanmar and plays an increasingly important role in national fish supply (Belton et al. 2018). The Food and Agriculture Organization (FAO) has recently revised down Myanmar's reported fisheries production because of concerns that official production figures are inflated. According to the revised estimates by FAO, Myanmar aquaculture production has been growing rapidly in Myanmar, contributing 1.14 million tons, accounting for 36.5% of all fish produced in the country in 2018. Meanwhile, capture fisheries in Myanmar are in major decline, contributing 1.1 million tons per annum from marine fisheries and 0.89 million tons per annum from inland fisheries (FAO 2020). Regarding the evidence of the study by Hosch, Belton, and Johnstone (2021), catch per unit of effort of marine fisheries declined by between −27% and −64% across the five gear types, and catch efficiency fell due to the increasing average vessel size between 2009 and 2018. Radford and Lamb (2020) also report that the major challenges of the decline in inland capture fisheries and fishers' livelihoods are illegal fishing practices, limited federal regulation, an increasing number of fishers, and commercialization. Because of the predominance of very large fish farms, aquaculture in Myanmar is different from aquaculture production in most developing countries, where there is significant evidence of the contribution from small-scale aquaculture. Moreover, small-scale aquaculture in Myanmar is often not encouraged and is still overlooked in the government's development strategies (Belton et al. 2015). Given that small-scale farmers in most developing countries typically consume a considerable amount of what they produce at home, increasing farm production diversity on their farmland is often recognized as a promising strategy to improve households' dietary diversity and nutritional outcomes (Sibhatu and Qaim 2018).

A large number of studies investigate the demand for fish products (e.g., Liverpool-Tasie et al. 2021; Bronnmann, Loy, and Schroeder 2016; Toufique, Farook, and Belton 2017; Dey, Alam, and Paraguas 2011; Kumar, Dey, and Paraguas 2005) to provide policy advice and interventions in fisheries and aquaculture subsectors. Findings from these studies show that the income and expenditure elasticities of fish demand at the aggregate level in both developed and developing countries are positive and inelastic; however, disaggregated fish demand varies across fish species and countries. Furthermore, the literature also shows that own-price elasticities for aggregated and disaggregated fish groups are negative, while the magnitude of the price elasticity estimates of disaggregated fish species is mixed.

The findings of Liverpool-Tasie et al. (2021) show that in terms of income and price elasticities, imported fish groups have been strongly incorporated into Nigerian consumers' fish consumption habits. Bronnmann, Guettler, and Loy (2019) highlight that elastic expenditure and inelastic price elasticities of demand are found at the aggregated fish level, but elastic price demand elasticity at the disaggregated level indicates that most fish are highly substitutable. Dey, Alam, and Paraguas (2011) report that income and price elasticities of high-value fish species demand are elastic across income quartiles. Kumar, Dey, and Paraguas (2005) find elastic income

and inelastic price elasticities of demand for all disaggregated fish groups across the income quartile groups. The literature on calories and food expenditures elasticities with respect to income shows that the magnitude of income elasticity of food expenditures is larger than that of calories. The implication is that as income increases, poor consumers are keen to spend more income on food but they adjust their food choices (e.g., marginal food choices) in terms of their income level and low-level perception of calorie intake requirements. Therefore, their calorie intake does not substantially increase with increased income (Behrman and Deolalikar 1989).

This empirical evidence suggests that the quality of estimation results may depend on the statistical techniques, types of data, and assumptions adopted (Okrent and Alston 2011). The most common problems related to the demand system estimations are endogeneity and sample selection bias derived from zero observations (MacKay and Miller 2019). Furthermore, most studies have estimated fish demand at the aggregate household level, ignoring potential differences in consumption behavior across household categories and fish types. Toufique, Farook, and Belton (2017) have studied the differences in consumer demand by rigorously defined poverty groups; nonetheless, their estimation does not address the endogeneity and sample selection bias issues. In this study, we overcome these weaknesses by categorizing households into explicit poverty groups and controlling for both endogeneity and selection bias using a multistage budgeting approach combined with the quadratic almost ideal demand system (QUAIDS) model.

In this paper, we examine the household-level consumption behavior of different fish sources across household categories in Myanmar. Fish consumption is disaggregated into four groups (aquaculture, freshwater capture, marine capture, and dried fish). Among the groups, while the first three fish groups are categorized by their origin, the dried fish group represents a different product form that originates from both freshwater and marine captures. Our research is the first in Myanmar to use the available household-level survey data to estimate fish demand elasticities across the household categories (poverty groups and household location). The analysis raises the following research questions: What factors influence demand for aggregated and disaggregated fish groups and the substitution among the individual fish groups? How do the consumption patterns of disaggregated fish groups differ across the household categories? What is the extent of substitutability between fish from each of these categorized sources? Based on these questions, the following hypotheses are tested:

- Expenditure and income elasticities of aggregated and disaggregated fish demand are higher in poor and rural household groups than in nonpoor and urban household groups.
- The compensated own-price elasticity of demand for all fish groups is lower for poor and rural households than for nonpoor and urban households.
- Fish production from aquaculture can continue to compensate for the decline in the availability of fish from capture fisheries.

Elasticity estimates across household groups are essential to understanding fish demand responsiveness to changes in income and prices. This disaggregated information is needed to assess how economic policies and technological change influence fish distribution and households' food and nutrition security in developing countries. Moreover, information about demand parameters is useful for calibrating demand equations in fish foresight modeling studies (e.g., Tran et al. 2017; Tran et al. 2019; Chan et al. 2019) to inform policy and decision-making to support sustainable

fisheries and aquaculture development to positively contribute to sustainable development goals. Income and price demand elasticities could also help private stakeholders along the fish supply chain adapt to consumer preferences changes.

DATA DESCRIPTION

This study uses data from the Myanmar Poverty and Living Conditions Survey (MPLCS) of 2015, jointly conducted by the Ministry of Planning and Finance and the World Bank. The survey interviewed a stratified multistage sample of 3,648 households representing four agro-ecological zones and rural and urban areas in Myanmar. Of the total sampled households, 66 were dropped due to missing data, leaving 3,582 households for the analysis. Fish consumption data in the food consumption module of the survey comprises 37 fish species; however, based on the previous literature, we followed Belton et al. (2015) to group household fish consumption into four groups: aquaculture, freshwater, marine capture fisheries, and dried fish products. Details of fish product classification are reported in table A in the appendix. The purchase unit value method was used to obtain price per unit of the consumed food in this study. Because a given good may differ in quality by household, its calculated unit values may reflect these differences in quality by household. Using the national poverty line figure, which was MMK 1,241 per day[1] or MMK 452,965 per year in 2015, we categorized the study households as poor and nonpoor.[2]

Although it is common for Myanmar to export fish products from all sources to other countries, the majority of fish production goes to domestic markets. Exceptions are the high-value marine fishery products (such as hilsa, live mud crab, live swamp eel, and pink shrimp) and lower-value fish species of rohu, which are exported to many countries, mainly India, China, Singapore, and Thailand (Burcham et al. 2020; Soe et al. 2020 ; Johnstone et al. 2012). The proportion of households reporting zero fish consumption at the aggregated fish level in the past seven days was less than 10%, varying depending on the categorized household groups. At the disaggregated level, the proportion of the households consuming dried fish for the overall sample is the highest at 81.24% of total households, followed by aquaculture (43%), freshwater capture (40%), and marine capture (39%), respectively.

As reported in table 1, inequality of fish consumption between poor and nonpoor households is most considerable for aquaculture and freshwater fish; consumption from these sources is around 1.5 times higher for nonpoor households than for poor households. In addition, urban households consume more aquaculture fish than do rural households. The apparent tendency of urban households to consume larger quantities of aquaculture indicates a high degree of substitutability of aquaculture fish with capture fish (Belton et al. 2015). Overall, while dried and processed fish products are the most consumed, the smallest share of fish consumption is from aquaculture fish, irrespective of the household groups, except for the urban households. This finding implies that even though the importance of the aquaculture sector is growing, this sector is the least important source of fish in Myanmar by a quite large margin, especially when dried and processed fish products that originate mainly from capture fisheries are taken into account. Regarding the live weight equivalence using conversion factors from Hortle (2007), it takes 3–4 kg

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1. USD 1 in January 2015 at the market exchange rate was worth MMK 1,029.50 (US dollar to Myanmar kyat rates on January 5, 2015, from https://www.exchange-rates.org/Rate/USD/MMK/1-5-2015).
2. For more details, see World Bank and Ministry of Planning and Finance (2017).

Table 1. Annual Per Capita Fish Consumption in 2015 (kg/year)

	National	Poor	Nonpoor	Sig.	Rural	Urban	Sig.
Aquaculture	4.62	3.26	5.23	***	3.45	6.65	***
Freshwater capture	5.10	3.44	5.84	***	5.76	3.93	***
Marine capture	5.94	6.40	6.00		6.54	4.88	***
Dried fish[a]	7.58	6.40	8.11	***	8.18	6.55	***
All fish	23.24	19.21	25.05	***	23.94	22.02	***

Note: $N = 3,582$. [a] Dried fish includes pickled and fermented fish products. *** indicates statistical significance at the 1% level. Source: Own calculations from MPLCS dataset 2015.

of fresh fish to produce 1 kg of dried fish but only 1 kg or less of fresh fish to produce 1 kg of fermented fish products, as more water is retained in the fermentation process.

METHODOLOGY FOR ELASTICITY ESTIMATION

ANALYTICAL FRAMEWORK

Based on neoclassical demand theory, two popular econometric models are commonly used for demand and elasticity estimation: simultaneous demand systems and single-equation models. The main weakness of single-equation models is that the adding-up restriction of the demand theory is violated, and such demand models are inconsistent with standard utility maximization (Okrent and Alston 2011; Ecker and Qaim 2011). On the other hand, demand systems consisting of multiple simultaneous equations can reflect and incorporate the mutual interdependencies and substitution effects between several products of consumer demand when the price changes and allow for the estimation of the entire food demand system with the theoretical restrictions derived from economic theory (Ecker and Qaim 2011). However, the full demand system estimation is impractical if more than 100 food products are included in the dataset, as the parameters of the price elasticities increase with the square of the number of the food items (Deaton and Muellbauer 1980; Edgerton 1997; Gao, Wailes, and Cramer 1996). To solve this problem, a multistage budgeting framework is commonly used to analyze the household fish demand system. The usual assumption of this framework is that the consumer's decision on their total expenditure/income allocation to the commodity groups is based on price index information. In addition, allocation of expenditures within the commodity groups is independently performed, and then one can estimate the demand system independently at each stage and add up these elasticity estimations to total elasticities over the stages (Edgerton 1997).

In this study, we apply a three-stage budgeting process, in which a household allocates its total budget to food and nonfood expenditure in Stage I. Conditional on Stage I allocation, a portion of the total food expenditure is allocated to fish consumption in Stage II. In Stage III, conditional on the Stage II allocation, the total fish expenditure is further disaggregated into specified fish groups. In order to account for any measurement error problem, the predicted total food expenditure for each household derived from Stage I is used in the second stage, and the predicted total fish expenditure from Stage II is applied in the third stage instead of real expenditures. The purpose of using predicted expenditure is that the commodities' expenditure share is directly computed from the observed total food expenditures. Therefore, using the observed total food expenditures can be biased and inconsistent because of the probable correlation between the error term

and total expenditure in the expenditure share equation (Edgerton 1993; Zheng and Henneberry 2010). In addition, the expenditure function is a direct function of income and prices. The income variable is assumed to be exogenous in this function because the consumer's decision does not affect this variable, and then demand or expenditure cannot influence the income. A common assumption for treating price as exogenous in the household demand analysis is that consumers are price takers and have no impact on prices. The cross-sectional data are often complicated with censoring the dependent variable created by zero expenditure for the food products. The nonnegative value of observed budget shares means that the dependent variable is censored (Heien and Wessells 1990). Therefore, this censored data in the disaggregated level demand estimation must be accounted for to obtain consistent elasticity estimates and parameters (Shonkwiler and Yen 1999).

STAGE I: The total food expenditure function is estimated to be dependent on the Stone price index (SPI) for food, annual income, and other household characteristics. The SPI for food is calculated as the mean of the food price $\ln P_f^*$ as follows:

$$\ln P_f^* = \sum_{j-1}^m w_j \ln pfd_{j,} \tag{1}$$

where w_j and pfd_j are the budget share of the commodity j and price of food commodity j, respectively. The functional form used in the first stage through ordinary least squares (OLS) is specified as follows:

$$\ln(M) = \alpha_0 + \alpha_1 \ln P_f^* + \alpha_2 \ln I + \alpha_2(\ln I^2) + \sum_{i-1} \alpha_i Z, \tag{2}$$

where M denotes annual total food expenditure (MMK); I is annual income (MMK); and Z is a vector of demographic variables that include household size, household head's age, the dummy variable for the household's location in either an urban or a rural area, and the primary occupation of the household head. Both linear and quadratic forms of income variables are included in the model. The purpose of the quadratic form of income is to capture the nonlinearity of changes in total food expenditure across income.

STAGE II: Total food expenditure is allocated to aggregate fish spending as a portion by each household. The model for the aggregated fish expenditure through the OLS method is presented as follows:

$$\ln(F) = \alpha_0 + \alpha_1 \sum_{i-1}^k \ln pfd_i + \alpha_2 \ln M + \alpha_2(\ln M^2) + \sum_{i-1} \alpha_i Z, \tag{3}$$

where F denotes annual aggregated fish expenditure (MMK); pfd_j is the price of food commodities; M is the predicted annual total food expenditure obtained from equation 2; and Z is a vector of demographic variables, as mentioned in equation 2. In order to account for the sample selection bias derived from the zero consumption of aggregated fish groups, the two-step procedure is applied. In the first step, a probit model is used to estimate the probability that a given sampled household will consume the fish in question. Based on the probit regression results, cumulative density and probability density functions are calculated, and then we compute the inverse Mills ratio (IMR) for each household. In the second step, IMR is incorporated as an additional explanatory variable to censor the latent variables in the aggregated fish expenditure function.

STAGE III: The linear expenditure form of the AIDS model is well adapted for the econometric estimation of expenditure and price elasticities, but it has been criticized for producing inconsistent and biased parameter estimates in most cases (Asche and Wessells 1997). Banks, Blundell, and Lewbel (1997) show that Engel's curve requires the quadratic expenditure term because Engel's curve is not always linear. To deal with this issue, the QUAIDS model is developed by adding a quadratic expenditure term that can capture the nonlinearity of consumption in the budget shares (Blundell, Pashardes, and Weber 1993; Banks, Blundell, and Lewbel 1997). The QUAIDS model maintains all the relevant specifications of the AIDS model, which means that it is an arbitrary first-order approximation to any demand system and satisfies all the axioms of choice and exact aggregation over households proposed by Deaton and Muellbauer (1980). Moreover, it has several advantages over the other demand analysis approaches. First, beyond the price and income effects, it captures the impact of the socioeconomic characteristics on the budget share. Second, it considers econometric issues such as expenditure endogeneity and zero consumption (Obayelu, Okoruwa, and Oni 2009). Finally, it allows us to independently account for the household fish choices among the different fish groups.

According to Banks, Blundell, and Lewbel (1997), the QUAIDS model has the indirect utility function of the form

$$\ln V(p, m) = \left[\left\{ \frac{\ln m - \ln a(p)}{b(p)} \right\}^{-1} + \lambda(p) \right]^{-1},$$ (4)

where $\frac{\ln m - \ln a(p)}{b(p)}$ is the indirect utility function of the price-independent generalized logarithmic (PLGLOG) preference demand system. Here, m denotes predicted household total fish expenditure, and $a(p)$, $b(p)$, and $\lambda(p)$ are the functions of the vector of price p.

The former function $\ln a(p)$ is defined as

$$\ln a(p) = \alpha_0 + \sum_{i=1}^{4} \alpha_i \ln p_i + \frac{1}{2} \sum_{i=1}^{4} \sum_{j=1}^{4} \gamma_{ij} \ln p_i \ln p_k,$$ (5)

while $b(p)$ is the Cobb-Douglas price aggregator:

$$b(p) = \prod_{(i=1)}^{4} p_i^{(\beta_i)}.$$ (6)

In addition, the price aggregator function is defined as the following:

$$\lambda(p) = \sum_{i=1}^{4} \lambda_i \ln p_i.$$ (7)

Applying Roy's identity to the indirect utility function, the budget share in the QUAIDS model can be expressed as the following:

$$w_i = \alpha_i + \sum_{j=1}^{4} \gamma_{ij} \ln p_j + \beta_i \ln \left\{ \frac{m}{a(p)} \right\} + \frac{\lambda_i}{b(p)} \left[\ln \left\{ \frac{m}{a(p)} \right\} \right]^2 \quad i = 1, \dots, k.$$ (8)

CENSORING

The two-step estimation procedure is applied to account for the zero expenditure in the categorized fish groups as Stage II. Based on the probit analysis results, IMR is incorporated in each

budget share equation of the QUAIDS model. The budget share expression in equation 8 is modified as follows:

$$w_i = \alpha_{i0} + \sum_k \delta_{ik} s_k + \sum_{j=1}^{4} \gamma_{ij} \ln p_j + \beta_i \ln\left\{\frac{m}{a(p)}\right\} + \frac{\lambda_i}{b(p)}\left[\ln\left\{\frac{m}{a(p)}\right\}\right]^2 \tag{9}$$
$$+ \pi_i IMR_i + \varepsilon_i, i = 1, \ldots, k.$$

In equation 9, w_i is the budget share of the categorized fish groups, where the parameters δ_{ik}, γ_{ij}, β_i and λ_i are estimated; δ_{ik} is the effects of k_{th} demographic factors; γ_{ij} measures the effects of a change in the price of commodity j on the expenditure share equation of commodity i; and β_i and λ_i measure the effect of the change in the total fish expenditure on the expenditure share of the categorized fish groups.

Economic theory imposes several restrictions on the parameters. For theoretical consistency, equation 9 is estimated under the following restrictions:

(a) Adding up condition:

$$\sum_{i=1}^{4} \alpha_{i0} = 1, \sum_{i=1}^{4} \delta_{ik} = 0, \sum_{i=1}^{4} \beta_i = 0, \sum_{i=1}^{4} \lambda_i = 0, \text{ and } \sum_{i=1}^{4} \gamma_{ij} = 0. \tag{10}$$

(b) Since demand functions have the homogeneous degree of zero,

$$\sum_{i=1}^{4} \gamma_{ij} = 0 \; \forall \; j. \tag{11}$$

(c) Slutsky symmetry imposes that

$$\gamma_{ij} = \gamma_{ji}. \tag{12}$$

In this study, the QUAIDS model is analyzed in Stata with the nonlinear seemingly unrelated regression (NLSUR) procedure developed by Poi (2012). During this procedure, dropping one expenditure equation is done to avoid an error in the covariance matrix due to a complete demand system, which is identically singular as the budget shares sum to 1 (Heien and Wessells 1990). Afterward, the parameters for the dropped equation are computed with the help of additivity (equation 10), homogeneity (equation 11), and symmetry (equation 12) restrictions.

DEMAND ELASTICITIES CALCULATION

The formulas to estimate the elasticities from the QUAIDS model follow those of Banks, Blundell, and Lewbel (1997). Equation 9 is differentiated concerning $\ln m$ and $\ln p_j$:

$$\mu_i \equiv \frac{\partial w_i}{\partial \ln m} = \beta_i + \frac{2\lambda_i}{b(p)}\left[\ln\left\{\frac{m}{a(p)}\right\}\right] \tag{13}$$

and

$$\mu_{ij} \equiv \frac{\partial w_i}{\partial \ln p_j} = \gamma_{ij} - \mu_i\left(\alpha_j + \sum_k \gamma_{jk} \ln p_k\right) - \frac{\lambda_i \beta_j}{b(p)}\left[\ln\left\{\frac{m}{a(p)}\right\}\right]^2, \tag{14}$$

where $\ln p_k$ is a price index calculated as the arithmetic mean of prices for k fish groups.

The expenditure elasticities for the fish category are given by

$$e_i = \frac{\mu_i}{w_i} + 1. \tag{15}$$

However, it is essential to note that the individual fish group's expenditure elasticity is computed based on total fish expenditure in the QUAIDS model and does not directly capture the consumer responses to total food expenditure or income.

The uncompensated (Marshallian) price elasticity takes both income and price effects into consideration and is derived as the following:

$$e_{ij}^{\mu} = \frac{\mu_{ij}}{w_i} - \delta_{ij}, \tag{16}$$

where δ_{ij} indicates Kronecker delta, which takes the value of 0 for cross-price elasticity ($i \neq j$) and the value of 1 for own-price elasticity ($i = j$).

From the Slutsky equation, compensated price elasticities (Hicksian) are obtained, which take only a price effect:

$$e_{ij}^{c} = e_{ij}^{\mu} + e_i w_j. \tag{17}$$

A caveat about the results is that using cross-sectional food consumption survey data at the household level for the demand analysis has limitations in terms of accuracy. First, recall of food consumption captures all food that has entered the household, but family members may not consume all of it: some food might be given to hired laborers or guests, fed to animals, or wasted. This can result in the overvaluation of food intake, particularly among wealthy households (Bouis 1994). Second, household-level food consumption surveys do not collect intra-household consumption data, so it is assumed that food is equally distributed among the household members. Third, there are issues with food commodity prices because many datasets do not include food prices directly. Those prices are obtained from the unit prices or average prices by dividing the expenditure on a product by the amount consumed. If the survey captures the market prices of individual food items at the community level, the estimation results will be more accurate. Although we are aware of the drawbacks mentioned above of the survey data, individual-level food consumption data are hardly available for developing countries. Our analysis can provide practical and vital information on the consumer demand situation, particularly fish demand. Moreover, there is mitigation to the shortcomings. Because of the short recall period (seven days) in this survey, respondents should be able to remember the precise amount consumed and expenditure, whereas they might not be able to do so with a longer recall period. Furthermore, this study focuses on the demand for four primary fishery sources in Myanmar instead of individual fish species. Therefore, potential problems in the results should be minimized, as long as there is no systematic bias in the reporting of prices between the four groups of fishery sources.

RESULTS AND DISCUSSION

Descriptive statistics of the variables included in the three stages of estimation are presented in table 2. The average income per year of the sampled households was MMK 3,689,440 (USD 3,584), of which MMK 2,409,627 (USD 2,341) was spent on food expenditure. On average, sampled households in the study spent 65% of their total income on food, of which the most substantial part (32.56%) was on rice (annual per capita rice consumption nationally is 168 kg (Scott, Mahrt,

Table 2. Summary Statistics of Variables Used at Various Stages

Variable	Mean	Std. Dev.
Total household income (MMK/year)	3,689,440	6,148,347
Total food expenditure (MMK/year)	2,409,627	1,659,690
Total fish expenditure (MMK/year)	263,736	319,422
Aquaculture fish expenditure (MMK/year)	41,577	74,659
Freshwater capture fish expenditure (MMK/year)	49,509	105,255
Marine capture fish expenditure (MMK/year)	42,230	92,283
Dried fish expenditure (MMK/year)	130,421	232,112
Prices of food products (MMK/kg)		
Rice	546	291
Pulses	1,420	1,105
Roots and tubers	597	225
Meat	4,916	23,131
Vegetables	771	255
Fruits	1,191	706
Fish	3,956	1,408
Aquaculture fish	2,794	1,847
Freshwater capture fish	2,910	2,203
Marine capture fish	3,649	2,023
Dried fish	7,059	2,046
Demographic variables		
Household size (no.)	5	2.14
Household head's age (year)	51	14
Dummy = 1 if households live in urban area, 0 if otherwise	0.37	0.48
Dummy = 1 if any household is above this poverty line, 0 if otherwise	0.69	0.46
Dummy = 1 if sampled households are engaged in agriculture, 0 if otherwise	0.42	0.49
Dummy = 1 if household head's occupation is agriculture, 0 if otherwise	0.20	0.39

Budget share of fish groups	Percentage	
Share of aquaculture	0.19	–
Share of freshwater capture	0.18	–
Share of marine capture	0.16	–
Share of dried fish	0.47	–

Source: Own calculations from MPLCS dataset 2015.

and Thilsted 2020) followed by fish and fishery products (11.72%) and meat (10.58%). Among the fishery products, the proportion of dried fish products accounts for the largest share of total fish expenditure (47%). However, the unit price of dried fish is more than double that of freshwater fish. This price gap reflects water loss during the drying process, making it a concentrated source of nutrients (Belton et al. 2015). Moreover, total fish expenditure accounts for more than 50% of total animal-protein sources. Fish represents a cheaper source of micronutrients than other animal sources of food, and freshwater fish prices are 20% lower on average than those of meat (cf. table 2).

For demographic variables, the average family size in Myanmar was five persons, and the average age of the household head was 51 years old. The average life expectancy in 2017 was 66 years old. From the study sample, it is estimated that 37% and 63% of the sampled households lived in urban and rural areas, respectively. Regarding the poverty status of the sampled households, 31% were below the poverty line. The survey data show that 42% of sampled households worked in agriculture, including farming, aquaculture and fishing, livestock rearing, agricultural labor, and remittances related to agricultural activities conducted elsewhere. Regarding the main

occupation of the household head, 20% of the sampled household heads engaged in agriculture. These findings imply that Myanmar is characterized by a higher level of landlessness (Boutry et al. 2017).

STAGE I: PARAMETER ESTIMATES OF THE FOOD EXPENDITURE FUNCTION

The results of the first-stage estimation are presented in table 3. In this function, the price index of the food is negatively and statistically significantly related to total food expenditure, which means that higher food prices lead to declining expenditure on food items. The annual income and its square term are significant variables, with the former having a positive sign and the latter a negative sign. This indicates that the response of total food expenditure to changes in income is nonlinear with respect to the budget. As income goes up, the expenditure on food also tends to increase. However, the negative sign of squared income indicates that the rate of increase in food expenditure becomes smaller. This implicitly represents the behavior of the consumers with respect to food consumption. Once consumers have reached a certain level of food consumption, any further increase in income does not induce the consumers to spend more on food. These findings follow Engel's law and are consistent with studies by Garcia, Dey, and Navarez (2005) and Dey, Alam, and Paraguas (2011). The positive and significant sign of the household size implies that an increase in the family size increases the total household food expenditure.

Additionally, the household head's age is significant with a positive sign, indicating that households with older heads consume more food products than households with younger heads. The coefficient of the location dummy variable is significant with a negative sign, indicating that rural households' food expenditure is higher than that of urban households, the reasons of which are unknown. The household head who worked in agriculture is positively and significantly associated with greater food consumption.

STAGE II: PARAMETER ESTIMATES OF THE FISH EXPENDITURE FUNCTION

The estimation results of this stage are shown in table 4. The coefficient of the total food expenditure and its square terms are insignificant. We expected that if the total food expenditure increases, the respective expenditure on fish also tends to increase, but total fish expenditure does not significantly respond to changes in total food expenditure in this stage. The positive own-price parameter of fish indicates that an increase in average fish price may slightly decrease the

Table 3. Estimation Results of the Total Food Expenditure Function in Stage I

Variable	Coefficient	Robust Std. Err.
Log household annual income	4.893***	0.378
Log household annual income squared	−0.134***	0.013
Ln Stone price index	−0.074***	0.021
Household head's age	0.002***	0.000
Household head's occupation (1 = agriculture, 0 = other)	0.034***	0.011
Household size	0.006***	0.002
Household location (1 = urban, 0 = rural)	−0.078***	0.009
Constant	−28.531***	2.760
N	3,582	
R^2	0.87	

Note: Log of total food expenditure is the dependent variable. *** indicates statistical significance at the 1% level. Source: Own calculations from MPLCS dataset 2015.

Table 4. Estimation Results of the Total Fish Expenditure Function in Stage II

Variable	Coefficient	Robust Std. Err.
Ln total food expenditure[a]	1.295	0.821
Ln total food expenditure squared[a]	−0.027	0.029
Ln price of fish	0.212***	0.056
Ln price of cereals	0.454***	0.086
Ln price of pulses	0.210***	0.042
Ln price of roots and tubers	0.167***	0.054
Ln price of fruits	0.095**	0.039
Ln price of vegetables	−0.021	0.060
Ln price of meat	−0.022	0.041
Inverse Mill's ratio	−6.794***	0.059
Household head's age	0.006***	0.001
Household head's occupation (1 = agriculture, 0 = other)	0.182***	0.048
Household size	0.030***	0.008
Household location (1 = urban, 0 = rural)	−0.185***	0.041
Constant	−8.055	5.965
N		3,582
R^2		0.90

Note: Log of total fish expenditure is the dependent variable. [a] Estimated values obtained from Stage I are used in this model. *** and ** indicate statistical significance at the 1% and 5% levels, respectively. Source: Own calculations from MPLCS dataset 2015.

household's quantity of fish consumption, but it would not lead to a decrease in fish expenditure, as it seems to be a staple food for the fish-eating population. The coefficient of the price of major food commodities, such as rice, pulses, roots and tubers, and fruits, are significant variables with a positive sign, indicating that when the prices of those commodities go up, household will consume more fish with less of those commodities. The coefficient of the IMR is significant and negative in this stage, suggesting that correcting for selection bias created by the presence of zero consumption data is essential.The sign of the urban household's dummy variable is negative and statistically significant, showing that rural households consume more fish than do urban households. The common assumption that urbanization and rising incomes are associated with higher fish consumption is true for aquaculture fish. However, we observe the opposite for freshwater and dried fish. These findings support the study of Belton et al. (2015), who show that there is higher per capita fish consumption of freshwater and dried fish in rural areas and aquaculture fish in urban areas. The sign and significance level of these variables (household head's age and occupation, household size and location) are the same as in Stage I.

STAGE III: PARAMETER ESTIMATES OF THE FISH DEMAND SYSTEM EQUATIONS

The QUAIDS model parameters estimation of the four fish groups by household categories are presented in table B in the appendix. In the demand analysis at the household level, some households may pay the same prices for the food products and have the same income but have different food preferences and demographic characteristics. The coefficients of the square terms of total fish expenditure are statistically significant for all equations in almost all cases. These results imply that the response of categorized fish groups' expenditure share to changes in total fish expenditure is nonlinear. Household size coefficients are significant for almost all equations

across the household groups, but the sign of this variable varies across the species and household groups, indicating different consumer preferences in fish consumption patterns. Although the sign of the variable for the household head's occupation varies across fish groups and households, the household head working in the agriculture sector is significantly associated with the consumption of specific fish groups. The IMRs are significant for all the equations across household groups. It implies that including this variable in the QUAIDS model to correct selection bias created by zero observations for categorized fish groups proved appropriate.

Regarding the findings mentioned above, the model yields results that are as expected and in line with the theory for the different household groups and that provide mostly statistically significant coefficient estimates at the 5% level or less. For the budget share type model estimated with cross-sectional data, low R^2 values (ranging from 0.37 to 0.65) are not unusual because of the large degree of stochastic variation in the survey data. The model also provides the root mean square error as the measurement of the predictive accuracy of the regression model (ranging from 0.1 to 0.3). These values are reasonable when compared with other AIDS or QUAIDS model estimation by Akbay, Boz, and Chern (2007); Bronnmann, Guettler, and Loy (2019); Ecker and Qaim (2011); and Mergenthaler, Weinberger, and Qaim (2009).

EXPENDITURE AND INCOME ELASTICITY ESTIMATIONS AT VARIOUS STAGES

Expenditure and income elasticities calculated at different stages are shown in table 5. In Stage I, the average income elasticity for total food expenditure at the national level is 0.73. In line with theory, this income elasticity in rural households (0.75) is higher than that in urban households (0.70). It indicates that rural households allocate proportionately more of their budget to food than do urban households with a similar rise in income. A result that is in line with the theory is achieved for the poverty groups. Poor households are found to have a higher income elasticity (0.89) than nonpoor households (0.66). Regarding the elasticities results in Stage II, the food expenditure and income elasticities of total fish expenditure show the same pattern as in Stage I in household categories. All values are inelastic; that is, they range between 0 and 1, indicating that fish is a normal good among households in Myanmar. To calculate the income elasticity of aggregated fish expenditure in Stage II, we must multiply the food expenditure elasticity of aggregated fish demand with the income elasticity of food demand. If the income elasticity of food demand and the food expenditure elasticity of aggregated fish demand are 0.73 and 0.42, respectively, the income elasticity of demand for aggregated fish is 0.31.

Table 5. Estimated Expenditure and Income Elasticities in Various Stages

Elasticities in Various Stages	National	Poor	Nonpoor	Rural	Urban
Income elasticity of food expenditure (Stage I)	0.73	0.89	0.66	0.75	0.70
Food expenditure elasticity of fish expenditure (Stage II)	0.42	0.45	0.40	0.42	0.41
Income elasticity of fish expenditure (Stage II)	0.31	0.40	0.26	0.32	0.29
Income elasticity of demand for the specified fish groups (Stage III)					
Aquaculture	0.57***	0.76***	0.54***	0.72***	0.46***
Freshwater capture fish	0.48***	0.63***	0.38***	0.44***	0.45***
Marine capture fish	0.21***	0.30***	0.17***	0.30***	0.10***
Dried fish	0.19***	0.24***	0.15***	0.19***	0.17***

Note: *** indicates statistical significance at the 1% level. Source: Own calculations from MPLCS dataset 2015.

Regarding the positive and higher income and expenditure elasticities of demand of poor and rural households, the proportion of income spent on food is higher for those households, compared with the urban and nonpoor households. This is consistent with Engel's law, which states that a larger proportion of the budget of a poor family goes to food consumption, while the rich family tends to spend a greater proportion of its income on nonfood items. For all specified fish groups in Stage III, income elasticities show the same pattern across the household categories as in Stages I and II; that is, they are less than 1, indicating that they are normal goods. In that case, the income elasticity of demand for categorized fish groups was calculated as the income elasticity of aggregated fish demand. In order to save space, we did not present the fish expenditure elasticities of disaggregated fish groups in table 6.

Among the different fish consumption sources, aquaculture fish is the most income-responsive across household categories, followed by freshwater capture fish. It means that if income increases in Myanmar, aquaculture fish consumption will grow faster than the consumption of fish from other sources. This significant result suggests that increasing aquaculture fish supply will somewhat compensate for stagnant and declining capture fish production to fulfill the required demand with the changing income growth. Likewise, reducing the costs of aquaculture fish production with a corresponding decrease in market price is a development strategy that benefits poor and rural households. In other words, investment in aquaculture to increase supply, thereby reducing prices of aquaculture fish and contributing to growth in total fish consumption, will be pro-poor growth.

Assuming that the real per capita income in Myanmar continues to increase through economic growth in the absence of COVID-19 and the military coup, a large share of future fish demand for all fish groups will come from poor and rural households. In this situation, the hypothesis that poor and rural households have higher food expenditure and income elasticities than nonpoor and urban households is true for both aggregated and disaggregated fish groups. However, the COVID-19 pandemic and sociopolitical crisis on February 1 have created a significant impact on the economic slowdown and food insecurity with jobs and income loss, particularly for poor and vulnerable people in both urban and rural areas, increasing food and input prices, limiting access to credit, and hampering exports. These shocks have large potential to jeopardize much of the development progress that has been made over the past years and could have long-term impacts on the food system (Reliefweb 2021). Given the importance of fish to overall dietary patterns in Myanmar, continued income contraction and increasing food prices will likely impact the future food and nutrition security of households, making it harder for poor and vulnerable households to afford fish products.

Table 6. Uncompensated Price Elasticities of Demand for Fish Groups

Fish Group	National	Poor	Nonpoor	Rural	Urban
Aquaculture	−1.41***	−1.53***	−1.61***	−1.54***	−0.59***
Freshwater capture fish	−1.20***	−1.22***	−1.08***	−1.01***	−1.08***
Marine capture fish	−1.79***	−1.57***	−1.96***	−1.65***	−1.77**
Dried fish	−2.48***	−2.59***	−2.61***	−2.55***	−1.88***

Note: *** and ** indicate statistical significance at the 1% and 5% levels, respectively. Source: Own calculations from MPLCS dataset 2015.

UNCOMPENSATED/COMPENSATED OWN-PRICE
ELASTICITIES OF FISH DEMAND

Tables 6 and 7 represent uncompensated and compensated own-price elasticity estimates, respectively, for four fish groups by poverty groups and household location. As theoretically expected, all own-price elasticities (uncompensated and compensated) for all groups are found to be negative. The uncompensated elasticities account for both income and price effects, while the compensated price elasticities reflect the price effect only. Therefore, the substantial difference between uncompensated and compensated own-price elasticities indicates a substantial income effect.

Uncompensated own-price elasticities of fish demand. The uncompensated own-price elasticities presented in table 6 are found to vary across the fish groups, ranging from 0.59 to 2.59, indicating that the demand for all fish groups tends to be elastic. The discussion of results in the following section focuses on the compensated own-price elasticities estimation because they capture only the price effect on consumption and keep the utility constant.

Compensated own-price elasticities of fish demand. Table 7 represents the compensated own-price elasticities estimation for the categorized fish groups by household categories. The compensated own-price elasticity of demand for all fish groups, except freshwater capture fish, at the national level is elastic and in the range of 1.07 to 2.22. The compensated own-price elasticity of freshwater capture fish is close to 1. Elastic demand indicates that as fish prices rise, demand for fish will decline at a higher rate. Therefore, households at the national level will reduce their fish consumption, except for freshwater capture fish, by a disproportionately large amount in response to price increases.

Regarding the poverty group, the compensated own-price elasticity of fish sources, except for the freshwater capture fish, is lower for poor households than for nonpoor households. It implies that although nonpoor households can afford to pay a higher price for fish, they tend to respond quickly to higher price changes. This is because they have more substitutes available to them because of their ability to pay more. It is important to note here that the poor's lower responsiveness to increases in fish prices indicates that fish, except high-value species, is the cheapest form of animal protein and that the number of animal protein substitutes for fish at that price range is limited. We observe that the hypothesis that the own-price elasticities of fish demand for poor households are lower than those for nonpoor households is validated for aquaculture and marine capture fish sources.

Table 7. Compensated Price Elasticities of Demand for Fish Groups

Fish Group	National	Poor	Nonpoor	Rural	Urban
Aquaculture	−1.07***	−1.19***	−1.24***	−1.26***	−0.14
Freshwater capture fish	−0.93***	−0.96***	−0.82***	−0.75***	−0.86***
Marine capture fish	−1.69***	−1.43***	−1.88***	−1.51***	−1.73**
Dried fish	−2.22***	−2.35***	−2.35***	−2.27***	−1.65***

Note: *** and ** indicate statistical significance at the 1% and 5% levels, respectively. Source: Own calculations from MPLCS dataset 2015.

In terms of compensated own-price elasticities by household location, the gap between rural and urban households is relatively small for the capture fish groups. This is not the case for aquaculture fish, for which the price elasticity of demand is much higher in rural areas than in urban areas. The hypothesis that fish demand is more responsive to changes in its own price in urban areas than in rural areas is rejected for aquaculture. It implies that as urbanization proceeds and incomes grow, urban areas will increase the aquaculture fish market share because of the declining share of fish capture from rivers, lakes, and the sea (Tezzo et al. 2021).

COMPENSATED CROSS-PRICE ELASTICITIES

Compensated cross-price elasticity measures the change in the demand for one product as a result of changes in the price of another product. Table 8 presents the compensated cross-price elasticities for the four fish groups. The results show that the demand for aquaculture fish is significantly influenced by price changes in marine capture and dried fish. The positive and above unity compensated cross-price elasticities indicate that an increase in the price of marine capture and dried fish products will result in a higher-than-proportionate increase in the quantity of aquaculture fish demand for all household groups, except for the urban households concerning the marine capture fish price. These findings reveal that households in Myanmar would turn towards purchasing more farmed fish in the face of higher marine capture and dried fish prices. This finding is similar to the observation in Bangladesh, where Toufique, Farook, and Belton (2017) find that aquaculture fish demand is substantially affected by the price of marine capture fish. In contrast, the significant and negative compensated cross-price elasticities of demand for all household groups are found in the dried fish group, but its elasticity values are below unity, showing weak complementary effects with the marine capture fish source. An increase in the price of marine capture fish will cause a less-than-proportionate decline in the quantity of dried fish products.

Table 8. Compensated Cross-Price Elasticities of Demand for Fish Groups

Category	National	Poor	Nonpoor	Rural	Urban
Aquaculture					
Freshwater capture fish	0.12	0.13	0.25	−0.08	0.02
Marine capture fish	1.34***	1.42**	1.58***	1.40***	0.87*
Dried fish	3.70***	3.83***	4.27***	5.22***	1.95**
Freshwater capture fish					
Aquaculture	0.26**	0.32	0.11	0.12	0.69
Marine capture fish	1.03***	1.09***	0.89***	0.98***	0.94
Dried fish	2.42***	2.48**	2.07**	1.79***	1.91
Marine capture fish					
Aquaculture	0.47***	0.45***	0.42**	−0.04	−0.06
Dried fish	−0.90	−0.56	−0.93	0.26	−1.38
Freshwater capture fish	0.46***	0.40***	0.29**	0.42***	0.34
Dried fish					
Aquaculture	0.18	0.17	0.33*	0.29**	−0.15
Freshwater capture fish	0.16	0.13	0.13	0.18	0.17
Marine capture fish	−0.41***	−0.38	−0.48***	−0.28***	−0.39***

Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Source: Own calculations from MPLCS dataset 2015.

Regarding household location, the extent of substitution among the fish groups is greater in most cases for rural households than urban households, showing that the range for substituting fish from many different sources is higher for rural households. There is a higher diversity of individual species from capture fisheries in rural markets, as they are nearer to the point of production. A study by Belton et al. (2015) highlights that the rural fresh fish supply chain is typically served by capture fisheries that are characterized by much higher diversity of fish species. The fast-growing urban fresh fish supply chain is dominated by aquaculture production with a low diversity of species, owing to the nature of inland fishery and the predominance of fish ponds in rural and peri-urban areas. Traditionally, fresh fish available to the population in the eight landlocked states/regions and the inner areas of the six coastal states/regions came from the once abundant inland capture fisheries, where subsistence fishing is common. With the diversified and more widespread adoption of diversified small-scale aquaculture in all states/regions, the supply of freshwater fish at the homestead level is increasing. In addition, the move towards rice-fish production with a concomitant reduction in pesticide use is helping small indigenous fish species return to these landscapes. The practice of catching wild fish in and around rice fields is also widespread and helps to increase the choices available for consumption in rural areas.

Regarding the cross-price elasticities by poverty groups, the extent of substitutability for all categorized fish groups, except for the aquaculture fish group, of poor households is higher than that of nonpoor households, indicating that there is a broad range of scope for altering consumption of fish from capture fisheries sources for those households. This implies that higher diversity of capture fish species can offer cheaper options for poor households, although the average prices of fish from these sources is higher than that of aquaculture fish.

SIMULATION ANALYSIS

According to the fish price data at the national level, the real price of capture fishery increased by around 20% on average between 2015 and 2019 (CSO 2019). The simulation results are shown in table 9. The results reveal that if household income and price of non-aquaculture fishery

Table 9. Simulation Results for Fish Prices and Income Changes

Fish Price and Income Changes	Aquaculture
Base: Annual aquaculture fish consumption per capita (kg/year)	4.62
Fish price and household income increase by 20%	
Scenario I: Freshwater capture fish price increases	5.69
Scenario II: Marine capture fish price increases	5.47
Scenario III: Dried fish price increases	4.65
Scenario IV: Freshwater and marine capture and dried fish prices increase	6.51
Scenario V: Income increases	9.02
Fish price and household income increase by 40%	
Scenario I: Freshwater capture fish price increases	6.72
Scenario II: Marine capture fish price increases	6.29
Scenario III: Dried fish price increases	4.65
Scenario IV: Freshwater and marine capture and dried fish prices increase	8.37
Scenario V: Income increases	13.38
Fishery production income of households decreases by 5.1%	3.56
Average agricultural income of households decreases by 7.4%	3.05

Source: Own calculations from MPLCS dataset 2015.

sources increase by 20%, annual aquaculture fish consumption per capita would rise from the base level of 4.62 kg to 5.69 kg, 5.47 kg, 4.65 kg, 6.51 kg, and 9.02 kg, respectively. When the household's income and prices of capture and dried fish increase by 40%, the quantity of aquaculture fish consumption per capita per year will increase to between 4.65 kg and 13.38 kg. With a decrease in fishery production income (by 5.1%) and average agricultural income (by 7.4%) of households during the COVID-19 lockdown period, according to the study by Diao and Mahrt (2020), per capita aquaculture fish consumption would decrease to up to 3.5 kg. Apart from the income contractions, domestic lockdown policies directly affected the fishery sector, with falling demand in both domestic and international markets for fish products (Htwe 2020; Kyaw 2020).

CONCLUSIONS AND POLICY RECOMMENDATIONS

The rapidly growing aquaculture sector and concurrent stagnation of capture fishery production are observed globally. Myanmar is one of the major consumers of fish worldwide, and its fish demand system has been increasing rapidly over the years, but no study has investigated demand parameters at the household level in particular. In this paper, a multistage budgeting framework combined with the QUAIDS model is applied to provide the micro-level evidence of fish demand in Myanmar using household survey data from 2015. The methodological issues of conducting demand analysis using cross-sectional household survey data, such as endogeneity and sample selection bias, are addressed in this study.

Income elasticity of demand for aggregated and disaggregated fish groups is positive and less than unity in all cases, indicating that all fish groups in Myanmar are normal goods. This trend is a reflection of the fact that all consumers in Myanmar frequently consume different fish species. A significant share of fish consumption is likely to come from poor and rural households (assuming that real income continues to rise) because of their higher income elasticity of demand. In the context of increasing household incomes, there will be a substantial increase in aquaculture fish demand in Myanmar, indicating that aquaculture production pressure will grow. If the fish supply from aquaculture does not respond to income increases, the fish price will increase, which will affect household food security to a greater extent. Poverty alleviation programs that increase household income are more likely to impact households' food and nutrition security by increasing fish consumption.

Compensated own-price elasticities by all household groups reveal a downward-sloping demand curve for all fish groups. Aquaculture and marine capture fish groups support the hypothesis that poor households are less responsive to changes in its own price than are nonpoor households. It reflects that those households have less animal protein substitutes for fish that are available and accessible to them because fish, except high-value fish species, is the cheapest source of animal protein. We observe the growing farmed-fish market in urban areas because aquaculture fish demand is the least responsive to changes in its own price in urban areas. Furthermore, a price-elastic fishery market indicates that those fishery sectors have the potential to increase the revenue of the producers if production increases accompany the falling price (Dey, Alam, and Paraguas 2011; Bronnmann, Loy, and Schroeder 2016; Toufique, Farook, and Belton 2017). We also observe a strong significant substitution of aquaculture for marine capture and dried fish products. As there is evidence of a declining trend in capture fishery production, the aquaculture sector can fulfill consumer demand through its rapidly growing production.

In order to sustainably increase farmed-fish production to secure food and nutrition security over the long run, the subsector needs to be more competitive and smallholder inclusive with

accompanying land-use regulatory reforms. In addition, there is a need to diversify fish species under aquaculture with improved extension services and new production technologies for small-scale farmers to adopt. Moreover, the development and improvement of input supply, mainly fish seed and feed, by collaboration with government and private sector actors should be a major priority. Sustainable production from capture fishery sources can be achieved through improved monitoring, control, and surveillance (MCS) that help reduce illegal, unreported, and unregulated (IUU) fishing and reinforce better capture fishery management and governance. Toufique and Belton (2014) report that viable capture fisheries can complement pro-poor aquaculture growth from the production side. In order to generate pro-poor outcomes through global transition in fisheries, there would be much greater impact if policies and intervention programs were implemented to sustain the contributions from both sectors, rather than relying on the aquaculture sector alone to meet the future fish demand.

A potential field of future research is to disaggregate the consumption data in the four groups of fishery sources into smaller subgroups based on main species (e.g., rohu, hilsa, and low-value species) within each group and its nutrient contribution (e.g., vitamins, minerals, and essential fatty acids). Panel or longitudinal data can also be used to track the change in demand elasticities over time. Considering that food insecurity and malnutrition remain considerable problems in Myanmar, in addition to the fishery sector, it is also vital to examine the complete food and nutrient demand system. The empirical results could be fed into a multimarket partial equilibrium simulation model for further policy analysis. In addition, the information can also be applied in policy analysis to evaluate the food and nutrition security situation and implement appropriate intervention programs for economic development and reduction of undernutrition.

APPENDIX

Table A. Classification of Fish Products Listed in the MPLCS by Source

	Fish Species	
Source	Burmese	English
Aquaculture	Nga myit chin	Rohu
	Nga gyin	Mrigal
	Nga ton	Pangasius
	Nga moke	Pacu
Freshwater capture	Nga yant	Snakehead
	Nga khu	Walking catfish
	Nga gyee	Stinging catfish
	Nga pyayma	Climbing perch
	Other small river fish	–
	Other medium river fish	
	Other large river fish	
	Pazun doke	Giant freshwater prawn
Marine capture	Nga shwe	Pike conger eel
	Nga pokethin	Croaker
	Sardines (all kinds)	–
	Squid/octopus	Squid/octopus
	Pazun kyawt	Shrimp
	Other small seawater fish	–

Table A. (*Continued*)

Source	Fish Species		
		Burmese	English
Dried, fermented, and other processed products	Other medium seawater fish		
	Other large seawater fish		
	Nga thalauk		Hilsa
	Kakatit		Sea bass
	Fish meat[a]		–
	Dried products (freshwater)		
	Ngayant chauk		Snakehead
	Other dried small river fish		–
	Other dried medium river fish		
	Other dried large river fish		
	Dried products (marine)		
	Nga kunshut chauk		Seer fish
	Ar bye chauk		Bombay duck
	Other dried small seawater fish		–
	Other dried medium seawater fish		
	Other dried large seawater fish		
	Dried prawns and powder		–
	Fermented products		
	Shrimp paste		–
	Fish and shrimp sauce		
	Nga pi yae		
	Nga pi kaung/salted fish		

Note: [a] Minced fresh fish (*nga chit*), used in fish cakes, can be made of fish originating from freshwater/marine capture or aquaculture. Source: Adapted from Belton et al. (2015).

Table B. Estimation Results of the QUAIDS Model

Variable		National		Poor		Nonpoor		Rural		Urban	
		Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.
Constant	a1	−0.343***	0.102	−0.371**	0.172	−0.428***	0.126	−0.490***	0.093	0.392	0.210
	a2	−0.506***	0.093	−0.548***	0.139	−0.414***	0.126	−0.493***	0.116	−0.445**	0.179
	a3	0.108	0.084	0.089	0.160	0.177*	0.099	0.139	0.097	0.096	0.174
	a4	1.741***	0.067	1.829***	0.109	1.664***	0.089	1.844***	0.084	0.956***	0.169
Ln total fish expenditure	b1	−0.107***	0.022	−0.106***	0.037	−0.129***	0.028	−0.087***	0.021	−0.101**	0.046
	b2	−0.073***	0.020	−0.072**	0.030	−0.061**	0.028	−0.066***	0.025	−0.054	0.040
	b3	0.034*	0.018	0.028	0.034	0.041*	0.022	0.025	0.021	0.048	0.038
	b4	0.146***	0.013	0.149***	0.019	0.149***	0.018	0.128***	0.016	0.107***	0.036
Ln total fish expenditure squared	l1	−0.006***	0.001	−0.006***	0.002	−0.007***	0.002	−0.006***	0.001	−0.007***	0.003
	l2	−0.004***	0.001	−0.004**	0.002	−0.003**	0.002	−0.003**	0.001	−0.003	0.002
	l3	0.002*	0.001	0.002	0.002	0.002	0.001	0.000	0.001	0.003	0.002
	l4	0.008***	0.001	0.008***	0.001	0.009***	0.001	0.008***	0.001	0.007***	0.002
Ln prices	g11	0.038	0.025	0.015	0.040	0.085**	0.038	0.048**	0.019	0.105**	0.048
	g12	0.056***	0.010	0.062***	0.015	0.054***	0.016	0.026**	0.010	0.021	0.019
	g13	0.020	0.012	0.026	0.021	0.003	0.018	−0.015	0.010	−0.015	0.026
	g14	−0.114***	0.020	−0.103***	0.032	−0.141***	0.028	−0.059***	0.017	−0.111***	0.035
	g21	0.056***	0.010	0.062***	0.015	0.054***	0.016	0.026**	0.010	0.021	0.019
	g22	0.014	0.016	0.011	0.022	0.012	0.020	0.023	0.019	0.014	0.023
	g23	0.024***	0.009	0.023	0.015	0.016	0.011	0.048***	0.010	0.005	0.017
	g24	−0.094***	0.017	−0.097***	0.023	−0.082***	0.024	−0.097***	0.020	−0.040*	0.024
	g31	0.020	0.012	0.026	0.021	0.003	0.018	−0.015	0.010	−0.015	0.026

Table B. (*Continued*)

Variable		National		Poor		Nonpoor		Rural		Urban	
		Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.
	g32	0.024***	0.009	0.023	0.015	0.016	0.011	0.048***	0.010	0.005	0.017
	g33	−0.062***	0.008	−0.067***	0.013	−0.055***	0.011	−0.072***	0.008	−0.009	0.021
	g34	0.018	0.014	0.017	0.025	0.036**	0.017	0.039***	0.014	0.019	0.019
	g41	−0.114***	0.020	−0.103***	0.032	−0.141***	0.028	−0.059***	0.017	−0.111***	0.035
	g42	−0.094***	0.017	−0.097***	0.023	−0.082***	0.024	−0.097***	0.020	−0.040*	0.024
	g43	0.018	0.014	0.017	0.025	0.036**	0.017	0.039***	0.014	0.019	0.019
	g44	0.190***	0.021	0.182***	0.033	0.187***	0.030	0.117***	0.024	0.133***	0.039
Household size	eta11	−0.001	0.002	−0.007*	0.004	0.005*	0.003	0.000	0.002	−0.006*	0.003
	eta12	0.002	0.002	0.000	0.003	0.002	0.003	0.007**	0.003	−0.002	0.003
	eta13	0.005***	0.002	0.006	0.004	0.000	0.002	0.005**	0.003	0.007**	0.003
	eta14	−0.006**	0.003	0.001	0.004	−0.007**	0.003	−0.012***	0.004	0.002	0.004
Household head's occupation	eta21	−0.080***	0.012	−0.078***	0.024	−0.080***	0.014	−0.008	0.009	−0.110***	0.036
	eta22	0.045***	0.011	0.056***	0.019	0.042**	0.014	0.025*	0.013	0.050*	0.028
	eta23	0.017	0.010	0.043*	0.024	0.012	0.011	−0.010	0.012	0.013	0.029
	eta24	0.018	0.014	−0.020	0.030	0.027	0.017	−0.007	0.017	0.047	0.042
IMR	d1	0.151***	0.014	0.221***	0.024	0.117***	0.017	0.482***	0.012	−0.525***	0.027
	d2	0.448***	0.017	0.527***	0.023	0.407***	0.024	0.430***	0.024	0.512***	0.021
	d3	0.278***	0.012	0.277***	0.024	0.288***	0.013	0.319***	0.015	0.262***	0.019
	d4	−0.877***	0.024	−1.025***	0.040	−0.811***	0.031	−1.231***	0.031	−0.250***	0.039
R^2		0.381***		0.416***		0.376***		0.598***		0.648***	
		0.464***		0.577***		0.419***		0.449***		0.533***	
		0.423***		0.462***		0.407***		0.441***		0.402***	
Root mean square		0.273		0.264		0.275		0.181		0.256	
		0.249		0.216		0.262		0.274		0.195	
		0.232		0.265		0.212		0.246		0.201	

Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Source: Own calculations from MPLCS dataset 2015.

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