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Demand Elasticities of Canned Tuna at Point of Sale of a Large Retail Chain in Southern Philippines: Implications for Sustainability Policy

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New variants of canned skipjack tuna have been developed by large manufacturers of canned tuna in the Philippines. This study analyzes the expenditure and price elasticities of canned tuna and determines the implications for sustainable fishery. An AIDS (almost ideal demand system) model incorporating an income group variable was used to estimate these elasticities. This study utilized a pooled time series data of 459 weekly point-of-sale observations from 2010–2012 of three store branches of a large supermarket chain in southern Philippines. The point-of-sale data suggest that canned tuna consumption is composed mostly of tuna in sauce with vegetables followed by tuna in oil and tuna in sauce without vegetables. For both high- and low-income groups, the expenditure elasticities have the expected positive signs – indicating that as the income of consumers' increases, the quantity demanded for canned tuna in three product mediums also increases. For high-income consumers, consumption of tuna in sauce with and without vegetables is more responsive to income changes. The own-price elasticities of the three product mediums across high- and low-income store branches have negative signs – suggesting that as their own price increases, the quantity demanded for these products decreases. The cross-price elasticities suggest that tuna in sauce with vegetables is a substitute for tuna in oil and in sauce without vegetables for both income groups. Thus, promoting more use of vegetables through product development may lead to a lower volume of tuna meat used in canned tuna products, which contributes to addressing tuna resource sustainability.

Keywords: canned tuna, demand estimation, point-of-sale, retail, sustainable fishery

INTRODUCTION

The increasing consumption of fishery products, including skipjack canned tuna, among Filipino consumers puts pressure on the sustainability of tuna resources. In 2015, a typical Filipino would consume 36.8 kg/yr of fish and fish products and 2.0 kg/yr of tuna (BFAR 2019). However, there is a significant depletion of domestic tuna stocks in the country, including skipjack tuna (Vera and Hipolito 2006). Skipjack tuna is normally caught *via* purse-seine fishing, either on fish aggregating devices (FADs) or free school. A majority of the purse seiners in the Philippines catch skipjack on FADs (Harley *et al.* 2014) that results in by-catch of juvenile yellowfin and bigeye tunas among other small fishes (Macusi *et al.* 2015, 2017). Juvenile tuna by-catch, which is a product of unsustainable fishing practices in tuna fishery such as the use of smaller than the standard 3-cm mesh size by commercial fishing vessels (Muallil *et al.* 2014), are widely sold and not regulated in the domestic market. As a consequence, the purse seine fishing activity puts more pressure on tuna stocks.

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Although the Philippine canned tuna industry is generally export-oriented, 10% of its total production is consumed by the domestic market (Yamashita 2008). The canned tuna industry is also booming as its production increases to cater to the demand of the expanding market (Aprieto 1995), mainly brought about by consumers favoring the healthier option (Yamashita 2008). The current body of literature focuses on the Philippine export-oriented tuna industry (Costales and Garcia 2002; Yamashita 2005; Castro *et al.* 2017) but little research highlights the impact of domestic tuna consumption on sustainability, particularly skipjack tuna, as predominantly used in the canning industry.

Fishery management and improvements in its governance are crucial in addressing issues on sustainability of marine resources. From 2012–2014, Asian tuna exporters such as the Philippines, Thailand, and South Korea were given a yellow card by the European Union – one of the major tuna markets – due to non-compliance to the international rule in minimizing IUU (illegal, unreported, and unregulated) fishing but were lifted after amendments were made in their policy governance framework on fisheries (Deringer 2019). Among the issues commonly observed in Philippine fisheries include underreporting of tuna catch – especially among the small fishers (Barut and Garvilles 2013; Lepardo *et al.* 2017) – by-catch of juvenile tuna species, and ineffective gear restrictions (Bailey *et al.* 2012). The rampant use of FADs is also a growing concern in the country (Macusi *et al.* 2015, 2017) since the juvenile tunas use these artificial devices as their habitat (Mitsunaga *et al.* 2012). Thus, public and private institutions have responded by raising sustainability awareness about the environmental effects of the commodity's production to complement supply-driven fishery management measures (Giacomarra *et al.* 2021). These measures shifted focus from supply-driven mechanisms to market-based approaches, which leads to wider environmental gains on fishing (Kirby *et al.* 2014).

In the Philippines, a study was conducted to provide a comparison among the three private incentive mechanisms in Philippine tuna value chains – namely, the Marine Stewardship Council certification, the International Seafood Sustainability Foundation (ISSF) Proactive Vessel Register, and the World Wildlife Fund for Nature's fishery improvement project model (Tolentino-Zondervan *et al.* 2016). It showed that while these mechanisms encouraged sustainable fishing practices, challenges remained such as developing fishers' capabilities and providing incentives that compensate for the additional costs and risks of upgrading.

Although consumer awareness about their environmental footprints is increasing, it has yet to become a way of life (Szerényi *et al.* 2011). The largest manufacturer of canned tuna for domestic consumption, Century Pacific Food Inc. (CNPF), has claimed to comply with the conservation measures of both local and international organizations such as the British Retail Consortium, Bureau of Fisheries and Aquatic Resources (BFAR), Earth Island Institute/ Dolphin Safe Tuna, International Food Standard, ISSF, Regional Fisheries Management Organization, Western and Central Pacific Fisheries Commission, World Wildlife Fund, and Marine Stewardship Council, among others (CNPF 2019). Most domestically sold canned tuna brands under the CNPF only include the Dolphin Safe logo, for which its impact on sustainability of tuna fisheries has been disputed (Miller and Bush 2014). Compliance to sustainable fishery measures is very costly coupled with the lack of a governance system to strictly regulate fishing practices. Despite the efforts, producers have less incentive to employ sustainable fishing practices. However, there are now programs that use market incentives such as the Fishery Improvement Programs, which encourage less costly sustainability improvements (Sampson *et al.* 2015; Tolentino-Zondervan *et al.* 2016) to address consumers' negative response to higher prices (Sun *et al.* 2017).

The typology of market groups in the country includes high-income and health-conscious consumers, middle-income group, and the lower-income budget-conscious group (Bayogan and Lacap 2015). New tuna variants have been introduced due to the changing preferences and tastes of consumers. Most of these new flavors are usually sauced dishes that include vegetables in the ingredients. Commonly used vegetables in canned tuna in sauce are sweet pepper, carrots, and potatoes. These are found in *afritada*, *caldereta*¸ *mechado*, and *paella* – variants containing most vegetables. A regular can, weighing 100–180 g, contains about 22–31% vegetables (Bayogan and Lacap 2015). The addition of vegetables does not only add nutrition and value to the product but also reduces the amount of tuna meat per can. Hence, it has a potential to promote responsible consumption and a sustainable tuna value chain.

This paper estimates the expenditure and price elasticities for canned tuna using retail point-of-sale data. The use of scanner data (referred to as point-of-sale in the Philippines) has gained popularity because of its ability to provide a better picture of the behavior of retail consumption and prices for different goods such as meat products (Capps 1989), fish products (Wellman 1992), and canned tuna products (Teisl *et al.* 2002; Jaffry and Brown 2008). While this is popular in developed countries, the use of scanner data in emerging countries like the Philippines is limited mainly due to the difficulty of accessing these data from large retailers. While studies that obtained store-level elasticities aim to look at patterns between and among stores, this study looks at patterns of canned tuna

consumption among different product mediums across income groups. Applications on store-level analysis have provided fundamental information to retailing policies, which mainly include promotion designs and product pricing (Hoch *et al.* 1995).

The domestic market for canned skipjack tuna currently has little to no information about its sustainability measures, if any. This research posits that in the absence of a sustainability certification, consumers can play a role in addressing sustainability issues when they are introduced to product substitutes that can help ease pressure on the depleting skipjack tuna stock. While the literature focuses on the impact of ecolabels on sustainable seafood awareness and consumption (Reczkova *et al.* 2013; Jonell *et al.* 2016; Giacomarra *et al.* 2021), this research looks at how varied product mediums of canned skipjack tuna provides options to consumers, thereby presenting opportunities for improving consumer and producer benefits. Furthermore, this study highlights the importance of incorporating income groups. This research hypothesizes that consumers particularly in the low-income group are price sensitive compared to the high-income group. Also, in terms of expenditure, the low-income group are more likely to be more sensitive to income changes. However, this may vary depending on the product medium.

In the Philippines, the use of the AIDS model and its other forms such as the LA AIDS (linear approximate almost ideal demand system) and the QUAIDS (quadratic almost ideal demand system) models have been employed in various studies to estimate demand elasticities in food products but not using the point-of-sale data (Garcia *et al.* 2005; Lantican *et al.* 2011; Castro *et al.* 2017). Thus, this study estimates the price and expenditure elasticities generated from the AIDS model using point-of-sale data from the three store branches of a large supermarket in Davao City, Philippines. It explores the possibility of addressing tuna resource sustainability issues by identifying demand patterns of consumers. Identifying consumer patterns will help gain insights not just on the implications to the demand side but to the production side as well. The study specifically looks at the market potential of canned tuna in sauce with vegetable ingredients which is a substitute for tuna ingredients. Increasing demand for canned tuna with vegetables implies lower demand for tuna and less pressure on supply, thereby contributing to sustainability of tuna resources.

MATERIALS AND METHODS

AIDS Model

This study used the AIDS model of Deaton and Muellbauer (1980) in estimating the nature of demand for three product mediums – namely, tuna in oil, tuna in sauce with vegetable, and tuna in sauce without vegetable. The AIDS model is estimated using the *quaids* command in Stata developed by Poi (2012), which incorporates demographics using scaling techniques introduced by Ray (1983). Following Ray (1983), the expenditure function form is expressed as:

$$e\ (p.z.u) = m_0(p,z,u) \times e^R(p,u) \tag{1}$$

In this study, z is a binary model representing an income level group (*i.e.* 1 for higher-income and 0 for lower income store branches). The expression $m_0(p,z,u)$ measures the expenditure function to consider the effects of the income level group. This is further decomposed as $m_0 = (p,z,u) = m_0(z) \times \phi(p,z,u)$. The first term measures change in the actual expenditure level without accounting for the changes in consumption, while the change in actual goods consumed and relative prices is accounted for by the second term (Poi 2012). Following Poi's (2012) specification, the demand model is expressed as:

$$\Delta w_{i,t} = a_i + \sum_{j=1}^{n} \gamma_{ij} \Delta \ln \ln p_{j,t} + \beta_i \left(\Delta \ln \ln X_t - \sum_{j=1}^{n} w_{j,t-1} \Delta \ln \ln p_{j,t} \right) + \varepsilon_{i,t}$$

$$w_{it} = \alpha_i + \sum_{j}^{n} \gamma_{ij} ln p_{jt} + (\beta + \eta_i z)\, ln\acute{n} \left\{ \frac{m_t}{m_0(z)\alpha(p)} \right\} + \frac{\lambda_i}{b(p)c(p,z)} \left[ln \left\{ \frac{m_t}{m_0(z)\alpha(p)} \right\} \right]^2 + u_{it} \tag{2}$$

where $\Delta w_{i,t}$ and p_{it} represent at time t, the share of the total expenditure of the i^{th} product medium, and price of the j^{th} product medium, respectively. Moreover, m_t is the total expenditure of three product mediums. On the other hand, lnP_t and $c(p,z)$ are respectively defined as:

$$e\ (p.z.u) = m_0(p,z,u) \times e^R(p,u) \tag{3}$$

$$c(p,z) = \prod_{j=1}^{k} p_j{}^{\eta_{jz}} \tag{4}$$

Several studies including those of Deaton and Muellbauer (1980), Alston and Chalfant (1993), and Eales and Unnevehr (1994) have observed that the AIDS model has a functional form that is flexible, and it can be obtained from maximizing utility function and, under certain restrictions, allows aggregations and is also compatible with disaggregated data. In this paper, Stata version 12.1 was used to estimate the above AIDS specification.

Likewise, we imposed the classical triad restrictions to the AIDS model – which are the adding up, homogeneity, and symmetry restrictions, respectively:

$$\sum_{i=1}^{n} \alpha_i = 1 \sum_{i=1}^{n} \gamma_{ij} = 0 \sum_{i=0}^{n} \beta_i = 0 \tag{5}$$

$$\Sigma_j \gamma_{ij} = 0 \tag{6}$$

$$\gamma_{ij} = \gamma_{ji} \tag{7}$$

Following Green and Alston (1990), the expenditure, uncompensated (Marshallian), and compensated (Hicksian) elasticities are calculated. The expenditure elasticity is estimated by $\eta_i = 1 + \frac{\beta_i}{w_i}$ while the uncompensated (Marshallian) price elasticities are given by $e_{ij}^u = \frac{\gamma_{ij} - \beta_i w_j}{w_i}$. Finally, the compensated (Hicksian) price elasticities are derived using the Slutsky equation:

$$e_{ij}^c = e_{ij}^u + \eta_i w_j \tag{8}$$

where e_{ij}^u is the uncompensated (Marshallian) price elasticities of product medium i with respect to medium j, η_i is the expenditure elasticity for product medium i, and w_i is the average budget share of product medium j.

Expenditure and price elasticities show the responsiveness of consumers to income and price changes, respectively. Uncompensated elasticity (Marshallian) assumes constant income while compensated elasticity (Hicksian) considers the income effect. Thus, in understanding consumer responsiveness to price changes, this study used the Hicksian (compensated) elasticities to interpret price elasticities following Singh *et al.* (2014). Compensated elasticity was used in interpreting the results as it provides information on the substitution of product mediums, taking into account income changes. Price sensitivity of consumers to tuna products, particularly skipjack canned tuna, would be interesting to policymakers as it will guide them with regards to crafting market-driven sustainability policies. In particular, the substitutability of tuna in sauce with vegetables to tuna in oil and tuna in sauce without vegetables is an interesting insight for reducing tuna meat consumption.

Data Source

A time series composed of weekly point-of-sale data from January 2010 to December 2012 pooled from the three store branches was obtained from a large supermarket chain in Davao City. These store branches were classified according to income levels tagged by the supermarket chain as the "high-income level group" and the "low-income level group" in selected urban areas in Davao City based on the demographic profiles of its frequent buyers. In the absence of the actual household income data, the study made use of the supermarket chain's classification of their frequent buyers in terms of their purchasing behavior such as volume and frequency of purchase. While the frequent buyer information was not given to the authors, the supermarket chain gave their own classification of the income level groups.

The data had various brands but to protect the identity of the brands, they were grouped together according to product mediums. The raw data included volume, value sales, and the price for every start of the week. The data did not include price discounts by the manufacturers as well as other promotional activities carried out by the retail firm. The final data set used was composed of 459 valid observations.

Definition of Variables and Data Analysis

There were several product forms present in the data. These were identified as flake, chunk, solid, corned, meatloaf, and fillet. The data set was further categorized according to the product mediums – which are tuna in oil, tuna in sauce with vegetable ingredients, and tuna in sauce without vegetable ingredients (Table 1). In this study, there was no variation as to the product forms of tuna in sauce with vegetables as they all are in flake form. Flakes, corned, and meatloaf forms were present in tuna in sauce without vegetables. Both the groups tuna in sauce with and without vegetable ingredients included a different range of product mediums, which include tomato sauces and coconut milk and other vegetable mixes.

Table 1. Canned tuna variants and product mediums.

Variants	Product medium	Vegetables present
Vegetable oil	Oil	
Oil		
Oil lite		
Afritada	Sauce with vegetables	Bell pepper, potatoes, green peas
Caldereta		Potatoes, carrots, green peas
Sweet and spicy sauce		Chili
Hot and spicy sauce		Chili, peppercorns, carrots
Mechado		Green peas, potatoes, carrots
Bicol express		Chili
Sisig		Onion
Laing		Taro leaves
Corned tuna		Onion, garlic
Chili corned tuna		Onion, garlic, chili
Adobo	Sauce without vegetables	
Barbecue		
Asado		
Lechon paksiw		
With *calamansi*		
Meatloaf		

The products were grouped based on how they can be utilized. Most of the tuna in sauce with and without vegetable ingredients are value-added products and are usually consumed on their own while tuna in oil, although they can be eaten as opened, are often utilized in sandwich and salad mixes (Jaffry and Brown 2008) and are considered substitutes to fresh tuna in most fish dishes. This study followed Jaffry and Brown's (2008) study, which explains the choice of analyzing the data with respect to the type of medium.

Further, the data was analyzed on a per can unit of measure as the net weight in grams (g) is also a factor in consumer decision-making. The net weight of a can normally ranges from 80–420 g. However, for simplicity of analysis, only the regular can sizes of 95–184 g were considered in the study. Canned tuna products in oil and in sauce are sold in 95–184 g cans. Finally, the study made use of a discrete demographic variable, income group variable, where 1 means being in the high-income level group and 0 being in the low-income level group.

RESULTS

The summary statistics of the variables used in the demand analysis is shown in Table 2. The mean consumption was highest for canned tuna in sauce with vegetables (5,705 cans/wk/store), followed by tuna in oil (1,698 cans/wk/store) and tuna in sauce without vegetables (1,229 cans/wk/store). In terms of prices, the most expensive was the tuna in oil with an average price of PHP 24.82/can, followed by tuna in sauce with vegetables (PHP 19.73/can) and tuna in sauce without vegetables (PHP 17.74/can). Regarding budget share, tuna in sauce with vegetables comprised 63% share, followed by tuna in oil (24%), and tuna in sauce without vegetables (13%). This totals to PHP 180,385/wk/store budget for canned tuna. Concerning demographics, one store branch was identified as a high-income group while the two store branches were considered a low-income group.

The parameter estimates of the AIDS model satisfied the triad restrictions (Table 3). The triad restrictions are imposed in the AIDS model. The sum of alpha coefficients is equal to 1, the sum of the beta coefficients is equal to 0, and the sum of the gamma coefficients is equal to 0 for *i*th variable (tuna in oil, tuna and sauce with vegetable, and tuna in sauce without vegetable), which means satisfying

Table 2. Summary statistics of the variables used in the AIDS model.

Variable	Obs	Mean	Std. dev.	Min	Max
Consumption (cans per week)					
Oil	459	1698.05	797.74	550.00	3532.00
Sauce with vegetables	459	5704.90	2244.34	1644.00	9767.00
Sauce without vegetables	459	1229.30	433.60	447.00	4515.00
Prices (PHP/can)					
Oil	459	24.82	2.94	19.21	29.46
Sauce with vegetables	459	19.73	1.68	17.25	22.98
Sauce without vegetables	459	17.74	1.48	15.67	21.68
Budget shares (proportion to total expenditure)					
Oil	459	0.24	0.06	0.08	0.35
Sauce with vegetables	459	0.63	0.05	0.53	0.78
Sauce without vegetables	459	0.13	0.02	0.07	0.30
Total expenditure (PHP)	459	180384.50	74204.53	48377.42	362308.20
Demographics (1 = high income; 0 = low income)	459	0.33	0.47	0.00	1.00

Table 3. Parameter estimates of the AIDS model.

	Coeff.	R.S.E.	z	P > |z|	[95% conf. interval]		
Alpha							
Oil	0.383	0.020	19.530	0.000	0.344	0.421	***
Sauce with vegetables	0.453	0.018	25.230	0.000	0.417	0.488	***
Sauce without vegetables	0.165	0.008	20.320	0.000	0.149	0.181	***
Beta							
Oil	0.030	0.008	3.980	0.000	0.015	0.045	***
Sauce with vegetables	–0.026	–0.007	–3.790	0.000	–0.040	–0.013	***
Sauce without vegetables	–0.004	–0.004	–1.100	0.270	–0.012	0.003	
Gamma							
Oil_Oil	–0.623	0.049	–12.680	0.000	–0.719	–0.526	***
Sauce with veg_Oil	0.709	0.047	15.120	0.000	0.617	0.801	***
Sauce w/o veg_Oil	–0.087	–0.016	–5.480	0.000	–0.118	–0.056	***
Sauce with veg_Sauce with veg	–0.714	0.050	–14.370	0.000	–0.812	–0.617	***
Sauce w/o veg_Sauce with veg	0.005	0.022	0.240	0.811	–0.037	0.048	
Sauce w/o veg_Sauce w/o veg	0.081	0.016	4.940	0.000	0.049	0.114	***
Eta							
Income group_Oil	–0.094	–0.015	–6.080	0.000	–0.124	–0.064	***
Income group_Sauce with veg	0.037	0.008	4.550	0.000	0.021	0.053	***
Income group_Sauce w/o veg	0.057	0.011	5.080	0.000	0.035	0.079	***
Rho							
Income group	–0.091	0.151	–0.600	0.545	–0.386	0.204	

Significant code: ***0.001; number of observations = 459; number of demographics = 1; fit using $\alpha_0 = 10$; log-likelihood = 2282.4417; Coeff. – coefficient; R.S.E. – robust standard error; test for income group variable: Wald chi-squared (3) = 223.55, prob > Wald chi-squared = 0.000.

the adding-up condition. The sum of the gamma coefficients is equal to 0 for *j*th variable (tuna in oil, tuna in sauce with vegetable, and tuna in sauce without vegetable), which indicates satisfying the homogeneity condition. The Slutsky symmetry condition is also satisfied (not shown in the table). The use of Poi's *quaids* command in Stata automatically imposes the three restrictions.

The computation of Marshallian and Hicksian expenditure and price elasticities were made separately according to income group levels – namely, the high-income and low-income level store branches. The elasticities were calculated at their means. The significance of the income group variable was tested using Wald chi-squared test, with the value of 223.55 and *p*-value of 0.000 (Table 3). Thus, the null hypothesis that the income group variable has no significant effect in determining the expenditure pattern is rejected.

Expenditure elasticities are used as a proxy for income elasticities. They show how the consumption of a product changes in response to a change in the consumer's total expenditure. For both groups, expenditure elasticities had the expected positive signs, which indicate that the considered product mediums are normal goods (Figure 1). This may imply that as the income of Davao City consumers increases, the quantity demanded for canned tuna in three product mediums increases accordingly. For the high-income level group, the most responsive to expenditure changes is the tuna in sauce without vegetable ingredients (1.519) followed by tuna in sauce with vegetables (1.018), with the least responsive product medium being tuna in oil (0.785) (Table 4). On the other hand, the behavior of consumers is opposite for the low-income group, with tuna in oil being the most responsive to expenditure changes (1.143), followed by tuna in sauce without vegetables (0.971) and with vegetables (0.959) (Table 5).

The uncompensated and compensated own-price elasticities of all product mediums across group levels have negative signs (Figure 1). This means that when the own price of the product increases, the consumption for that good decreases. In contrast, if the own price of the product decreases, the consumption for the product increases. For the high-income level group, tuna in oil is the most responsive to own price changes with an elasticity of –2.811 (standard error of 0.163), which means that for every 1% increase in the price of canned tuna in oil, the quantity demanded of the product decreases by 2.81% (Table 4). The same behavior is observed for the low-income level group with a compensated own-price elasticity of –3.727 with a standard error of 0.234 (Table 5). Tuna in oil is followed by tuna in sauce with vegetables (–1.586 for high income and –1.463 for low income) and the least responsive is tuna in sauce without vegetables (–0.115 for high income and –0.286 for low income)..

Compensated and uncompensated cross-price elasticities of product mediums across group levels are also shown in Tables 4 and 5. For both groups, the compensated cross-price elasticities of tuna in oil and tuna in sauce with vegetables are 1.476 for the high-income group and 1.313 for the low-income group. This means that these product mediums are substitutes. To interpret, a 1% increase in the price of tuna in oil would increase the consumption of tuna in sauce with vegetables by 1.476% for the high-income group and 1.313% for the low-income group. In addition, the compensated cross-price elasticities of tuna in sauce without vegetables and tuna in sauce with vegetables are 0.110 for the high-income group and 0.150 for the low-

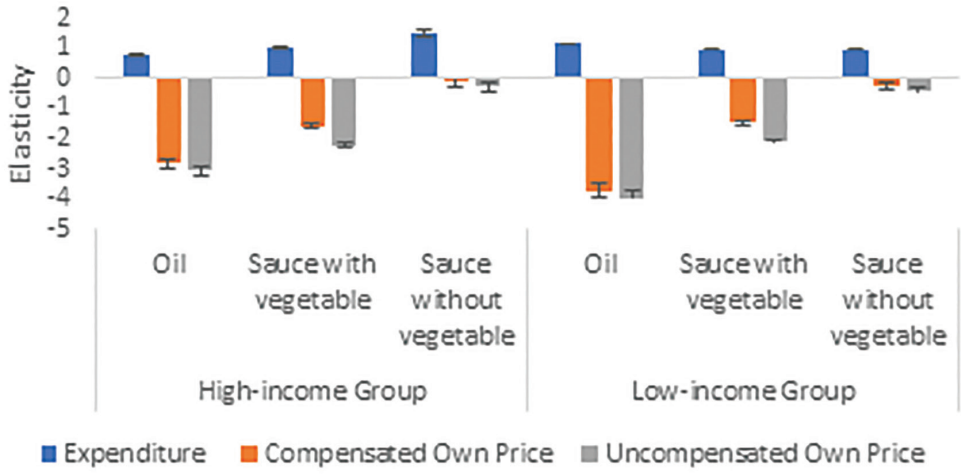

Figure 1. Expenditure and own-price elasticities of canned tuna product mediums.

Table 4. Elasticity estimates for high-income level group.

	Oil	Sauce with vegetable	Sauce without vegetable
Expenditure	0.785	1.018	1.519
	(0.060)	(0.023)	(0.104)
Compensated/ Hicksian			
Oil	–2.811	2.994	–0.183
	(0.163)	(0.157)	(0.053)
Sauce with vegetable	1.476	–1.586	0.110
	(0.077)	(0.082)	(0.036)
Sauce without vegetable	–0.533	0.649	–0.115
	(0.154)	(0.212)	(0.162)
Uncompensated/ Marshallian			
Oil	–3.044	2.522	–0.263
	(0.171)	(0.142)	(0.054)
Sauce with vegetable	1.175	–2.199	0.006
	(0.082)	(0.073)	(0.036)
Sauce without vegetable	–0.984	–0.265	–0.270
	(0.157)	(0.231)	(0.160)

Values in parentheses are standard errors.

Table 5. Elasticity estimates for low-income level group.

	Oil	Sauce with vegetable	Sauce without vegetable
Expenditure	1.143	0.959	0.971
	(0.036)	(0.011)	(0.027)
Compensated/ Hicksian			
Oil	–3.727	3.992	–0.265
	(0.234)	(0.223)	(0.075)
Sauce with vegetable	1.313	–1.463	0.150
	(0.073)	(0.078)	(0.034)
Sauce without vegetable	–0.395	0.681	–0.286
	(0.112)	(0.152)	(0.116)
Uncompensated/ Marshallian			
Oil	–3.970	3.255	–0.428
	(0.240)	(0.205)	(0.074)
Sauce with vegetable	1.109	–2.082	0.014
	(0.075)	(0.072)	(0.034)
Sauce without vegetable	–0.601	0.054	–0.424
	(0.116)	(0.142)	(0.116)

Values in parentheses are standard errors.

income group. Hence, tuna in sauce with vegetables is a substitute for both tuna in oil and tuna in sauce without vegetables and there is high substitutability to the former compared to the latter. In contrast, the compensated cross-price elasticities of tuna in oil and tuna in sauce without vegetables are –0.533 for the high-income group and –0.395 for the low-income group. This means that these product mediums have a complementary nature, which indicates that a price increase in tuna in oil would lead to a decrease in the consumption of tuna in sauce without vegetables.

DISCUSSION

The results suggest that there is a significant difference in the expenditure patterns for the three product mediums between the low- and high-income groups. In general, expenditure elasticities for all product mediums are positive across income groups, implying increased pressure on tuna stocks with increasing income of consumers. For high-income level groups, tuna in oil has the lowest expenditure elasticity of less than 1. Tuna in oil is commonly used as a meat ingredient in salads, sandwiches, and other viands. This may mean that the high-income households are less responsive to income changes since they are already consuming more of this product medium. The high-income responsiveness for tuna in sauce with and without vegetables may imply that the high-income households are looking for a variety of viand, which is offered particularly in tuna in sauce product medium or preference for consuming vegetables, which they could buy regardless of price due to high income.

However, an opposite behavior is exhibited in the low-income group. Canned tuna in sauce with vegetables has the lowest expenditure elasticity followed by tuna in sauce without vegetables, both having expenditure elasticities of less than 1. Thus, as income increases, expenditure shares for tuna in sauce with and without vegetables increase but less responsive to income changes, while expenditure share for tuna in oil increases as well and more responsive to income. The popularity of tuna in sauce with vegetables among low-income households can be attributed to its product variety offering common Filipino dishes, relative affordability considering the inclusion of vegetables, and complete ready-to-eat meal, which explains why low-income consumers are less responsive to income changes for this product medium.

It is interesting to note that consumption of tuna in sauce with and without vegetables by the high-income group is more responsive to income changes while for the low-income group, tuna in oil consumption is more responsive to changes in income. Hence, strategies on consumer awareness regarding the sustainability of skipjack tuna should be more focused on the low-income group as they tend to increase consumption of pure tuna meat as their income improves.

All three product mediums are own-price elastic which suggests that consumption increases with a price decrease. For both income groups, consumption of tuna in oil is the most responsive to own price changes, implying that future increases in tuna in oil prices will result in reduction of consumption level. Thus, it will reduce the use of skipjack tuna, which contributes to sustainability measures.

Moreover, for both income groups, tuna in sauce with vegetables is a substitute medium for tuna in oil and tuna in sauce without vegetables. Thus, future price increases in tuna in oil and tuna in sauce without vegetables would lead to an increase in consumption of tuna in sauce with vegetables. This opens for a potential to address the depletion of skipjack tuna stocks as a portion of tuna meat in a can is substituted with vegetables, thereby reducing tuna meat volume.

Tuna in sauce with and without vegetables are getting higher attention compared to tuna in oil for the high-income level group. These two introduced variants are value-added products but are sold at relatively cheaper prices compared to tuna in oil since vegetable raw materials are cheaper compared to tuna meat. Also, unlike tuna in oil, different variants are present within these product mediums. Moreover, there is a possibility that consumers may have faced trade-off among flavors within product categories with the occasional introduction of new flavors. The popularity of tuna in sauce (*e.g. adobo*, *kalderata*, *afritada*, and *menudo* canned tuna) can be traced to the typical diet of Filipinos (Lipoeto *et al.* 2012) and the affordability of canned fish products as substitutes for fresh fish products (Joquiño *et al.* 2021).

Consumers turning into healthy and convenient food products may have contributed to the growing attention on value added canned tuna, which is the addition of vegetables in the ingredients. Moreover, the importance of convenience in food preparation is still increasing and the changing demographics, particularly the westernization of Asian diets, is the major driver for this trend (Pingali 2007; Kearney 2010). Hence, consumption of processed food – particularly canned products – is expected to rise.

The substitutability of tuna in sauce with vegetables to tuna in oil and tuna in sauce without vegetables opens opportunities for more advanced sustainability strategies such as eco-labeling in the tuna industry. As people's income increases, consumers become more willing to pay for convenience and to some extent sustainable approach in tuna fishing. This is indicative of a growing convenience food market and awareness in eco-labeling (Castro *et al.* 2016). The growing demand for eco-friendly labelled

canned tuna products (Guillotreau *et al.* 2017; Sun *et al.* 2017), the state mechanisms enforcing certification (Adolf *et al.* 2016) and the non-government and people's organization active involvement in the sustainable seafood movement (Leadbitter and Benguerel 2014) can contribute to the sustainable development goal of responsible consumption and production of tuna products.

This study is limited to the actual purchases of consumers in southern Philippines. The frequent buyer information could be integrated into the analysis to provide more insights about the role of socio-demographics to the actual purchases of consumers. This can be a good future research direction if this information is available.

CONCLUSION

Canned skipjack tuna in sauce with vegetables being a normal good for the low-income group and having responsive expenditure elasticity for the high-income level group is promising to the tuna industry. Tuna in sauce with vegetables has the potential to be accepted as a substitute for tuna meat by both low- and high-income consumers based on the outcome of expenditure and price elasticity analyses. Moreover, high-income consumers have more interest in tuna in sauce with or without vegetables as income improves. Canned skipjack tuna in sauce with vegetables is a promising alternative for tuna in oil and tuna in sauce without vegetables, potentially helping to ease supply pressure to the already depleting skipjack tuna stocks. To some extent, it could address sustainability issues in the tuna industry – particularly skipjack tuna – which is predominantly used in affordable canned tuna brands.

Adapting eco-labeling and other sustainability certification may incur additional costs – leading to increase in prices and, consequently, lower consumption. However, the production cost can be reduced through a more efficient use of inputs, economies of scale, and product development such as adding more vegetables and less tuna meat in the mix. If the overall price will reduce due to these strategies, the consumption of tuna in sauce with vegetables, being price elastic, will increase for both high- and low-income groups. This will be beneficial for both consumers and producers as the fall in prices can be offset by a larger increase in demand. Lastly, it will also benefit the other actors in the supply chain such as the vegetable farmers due to the sustained demand for vegetables used in canned tuna.

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