Global seafood demand growth differences across regions, income levels, and time

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Abstract

We used an index approach to calculate demand growth for seafood in 107 countries from 1984 to 2013. We used the results to calculate aggregate demand growth by income- level, regionally, and globally. While seafood production has more than doubled since the mid-1980s, we showed that global demand for seafood has been higher than the global seafood supply. Demand growth for seafood varies across time, countries, regions, and income groups. The average annual seafood demand growth across countries varies between -6 and 7.5%. Global demand growth for seafood has steadily declined since the 1980s, mainly caused by a slowdown of demand in Asia. South- America and Africa had the highest demand growth from 2004 to 2013, while both North America and Oceania had negative demand growth in this period. High-income countries have had consistently low seafood demand growth from 1984 to 2013, while demand growth in all other income levels has been substantially larger.

Keywords: Demand growth, seafood consumption, world

JEL codes: C20, D11, Q11, Q18,

Introduction

The consumption of food of animal origin has shown significant growth over recent decades (FAO 2016). Between 1961 and 2013, global fish consumption per capita more than doubled, with its rate of growth faster than that of any other animal-based food products[1]. Fish consumption per capita increased from 9 kg to 20 kg, milk and cream consumption increased from 76 kg to 90 kg, and meat consumption increased from 23 kg to 43kg (FAO 2016; World Cancer Research Fund 2018). Despite its growth, fish accounts for only roughly 17 % of all animal protein and 6.7 % of all protein consumed by humans (FAO 2018).

Changes in consumption in any market can in essence be attributed to two factors: a change in supply or a change in demand. Global fish production has more than doubled since the mid-1980s (Valderrama & Anderson 2010; FAO 2016). According to the FAO (2016), in 2013, the global supply of fish reached 141.5 million tonnes. The rapidly growing aquaculture sector has been the main contributor to this supply growth (Anderson 2002; Kobayashi et al. 2015)[2]. Productivity growth and increased control over the production process in the sector have played a significant role in reducing production costs and hence reducing fish prices (Asche, Roll, & Tveterås 2007). Besides the supply growth, the demand side of the sector has also played a significant role in global fish consumption and production expansion. Demand is a key determinant of aquaculture productions. In particular, the demand for specific species of seafood types is critical. In aquaculture production, species selection is determined by profit-maximizing firms subject to production costs and consumers' willingness to pay for various species. Without demand growth, any increase in consumption in the future needs to be caused

[1] We sometimes use fish instead of seafood. When we use fish we are particularly referring to fish, not seafood in general.

[2] While the supply from wild-capture production has remained stagnant, with an annual production of no more than 95 million tonnes since the 1990s, the contribution of the rapidly growing aquaculture sector to the global seafood supply has been growing. According to the FAO (2016), in 2014, the sector had a share of 44 % of the total seafood supply, with a production level of 74 million tonnes.

by further productivity and supply growth. Demand growth leads to higher prices that increase the quantity supplied (and consumed), even if there is no productivity growth.

Empirical studies on seafood demand growth are limited. However, existing studies highlight the importance of demand growth for the expansion of both production and consumption (e.g., Asche, Roll, & Tveterås 2007; Roheim, Gardiner, & Asche 2007; Dey et al. 2008; Asche, Roll, & Trollvik 2009; Brækkan et al. 2018). For instance, Asche, Roll, and Tveterås (2007) using salmon and shrimp, and Asche, Roll, and Trollvik (2009) using salmon and cod as examples, argued that if there is no demand growth for a species, the production growth will be limited, even if productivity growth for that species is substantial. Asche et al. (2011) and Brækkan and Thyholdt (2014) also emphasized the role that the demand side of the market has played in the success of salmon aquaculture.

The study of demand growth has not received the same attention in the literature as supply (or productivity) growth. This could be due to several factors, including the major issue of methodological complexity. According to Asche et al. (2011) and Brækkan et al. (2018), the methodological framework to investigate demand growth is not as established in the literature as that of supply (or productivity) growth. Demand growth or contraction may occur for various reasons, including changes in consumer income, prices of substitute and complementary products, population growth, demographics, and the appearance of new information about a product (Dey et al. 2008; Brækkan & Thyholdt 2014; Brækkan et al. 2018). The existence of a multitude of factors affecting demand makes the methodological framework for studying demand growth complex and challenging.

Thus, most demand studies on seafood have focused on estimating demand elasticities for particular seafood species. The estimated demand elasticities can be used to evaluate issues such as the effects of changing prices, incomes, and the degree of substitutability between potentially competing seafood products (e.g., Dey et al. 2008; Gallet 2009; Bronnmann, Loy,

& Schroeder 2016). This can help reveal how consumers respond to an increase in income, prices, and the price of substitute products. It is worthwhile to note here that, on average, seafood demand is more inelastic in high-income countries than in middle- and low-income countries (Muhammad et al. 2011). While elasticities are useful, they must be used to enable an understanding of what has happened in the past and what may happen in the future.

The main objective of this study was to estimate seafood demand growth across countries from all over the world. We used the demand index approach developed by Marsh (2003) to estimate the demand growth. Based on data availability, demand growth across 107 countries is estimated using data from 1984 to 2013. To our knowledge, this paper is the first analysis of fish demand growth on a global scale.

The rest of this paper is organized as follows. The next section presents the trend of global seafood consumption and consumption differences across countries and regions. The method and data used are presented in the third and fourth sections, respectively. The fifth section present the empirical results and discussion, with concluding remarks in the last section.

Trend of global seafood consumption and consumption disparity across countries and regions

Significant seafood supply growth over the past few decades has enhanced the world's capacity to consume more seafood (FAO 2016). As illustrated in Figure 1(a), annual global seafood consumption increased from approximately 58.6 to 133 million tonnes between 1984 and 2013. This implies annual average consumption growth of 4.2 % over this period. Similarly, the average global seafood consumption per capita showed an increasing trend, rising from 12.4 kg in 1984 to 20 kg in 2013 (Figure 1(b)).

[Figure 1 here]

Despite the increase in global seafood consumption, the level of seafood consumption varies considerably among countries and regions. As shown in Figure 2, in 2013, seafood consumption per capita across countries varied from 1 kg to more than 161 kg. Table A2 in the Appendix also reported the per capita consumption in 2013.

[Figure 2 here]

Figure 3 shows the development of average seafood consumption per capita by region. From the figure, we can see that seafood consumption per capita grew most noticeably in East Asia and the Pacific (from approximately 28 kg to 37 kg) and South Asia (from 5.7 to 11.2 kg) from 1984 to 2013.

[Figure 3 here]

Over the same period, seafood consumption per capita remained static in Sub- Saharan Africa (at around 11.5 kg) and in North America (at 30 kg). Between 1984 and 2013, seafood consumption per capita increased in Europe and Central Asia from 18.6 to 24.5 kg, in the Middle East and North Africa from 8.5 to 13.5 kg, and in Latin America and the Caribbean from 11.9 to 14.5 kg.

Over recent decades, China has shown remarkable growth in seafood consumption per capita, increasing from 14.4 kg in 1993 to 38 kg in 2013. Total fish consumption in China is also far above that of all other countries. For instance, in 2013, the volume of seafood consumed in China was approximately 49 million tonnes. This number is higher than the volume of seafood consumed by the top nine fish consuming countries in the world (excluding China) combined in the same year (FAO 2016). It is worth mentioning here that China has also been responsible for most of the growth in the world per capita seafood supply in recent decades. This is owing to the drastic expansion in its seafood production, from aquaculture in particular, with a significant share of this production being exported (FAO 2016).

Various factors are cited in the literature as possible causes of the seafood consumption differences across countries and regions. Some of the main factors include food eating habits, culture, accessibility, income, population growth, and lifestyle changes (FAO 2016)

Method

In this study, we use an index approach developed by Marsh (2003) for measuring demand growth. The approach measures demand shifts in the price direction, where the demand shift can be interpreted as a shift in consumers' willingness to pay for a given quantity of a product. However, depending on whether a price variable or a quantity variable is exogenous, the demand shift can be measured either as a quantity shift or a price shift (Asche et al. 2011).

Brækkan and Thyholdt (2014) and Brækkan et al. (2018) argued that the choice to measure demand shifts in the quantity or price direction is simply a matter of preference. They stated that any shift in demand is a movement of the demand schedule between two periods and a demand shift measured using this approach is a local measure of the size of this movement. As a result, measuring this movement vertically or horizontally does not depend on price or quantity being exogenously given. For any shift in the quantity direction (horizontally), the corresponding shift in the price direction (vertically) can easily be computed (Sun & Kinnucan 2001; Brækkan & Thyholdt 2014).

Following Brækkan et al. (2018), the derivation of the approach is presented below. Figure 4 illustrates a demand shift in the quantity direction, (i.e., horizontally). In the figure, suppose that the demand schedule in period t is denoted by D_t and the demand schedule in period $t + 1$ is denoted by D_{t+1}. Moreover, let Q_t and P_t be the quantity and price in period t, and Q_{t+1} and P_{t+1} be the quantity and price in period $t + 1$.

[Figure 4 here]

If there is no shift in demand from period t to $t + 1$, the expected quantity demanded given the observed price P_{t+1} would be at point c. Denote this expected (or predicted) quantity demand at point c by $Q_{E|D=D_t}$. The horizontal distance between $Q_{E|D=D_t}$ and the actual quantity demanded Q_{t+1} is the absolute shift in demand. That is, the absolute demand shift is the horizontal distance between the demand schedules in periods t and $t + 1$. As it is customary to express demand shifts in relative (percentage) terms, we express the absolute shifts in demand here in relative terms.

Previous studies of demand shift using this approach express the shifts relative to the expected quantity (Asche et al. 2011; Marsh 2003). However, as argued in Brækkan and Thyholdt (2014), it is also possible to specify the shift in demand relative to the quantity in period t (i.e., Q_t). The latter implies that, for instance, a 10% increase in demand can be interpreted as a 10% increase in the quantity demanded relative to the quantity in period t, given the price in period t. As Brækkan and Thyholdt (2014) claimed, this calculation is consistent with the specification of horizontal shifts in demand in equilibrium displacement models (Muth 1964; Alston, Norton, & Pardey 1995). Following Brækkan and Thyholdt (2014), we specify the shift in demand relative to the quantity in period t. Therefore, the horizontal relative shift in demand from period *t* to period $t + 1$, denoted here by η, can be given by:

$$\eta = (Q_{t+1} - Q_{E|D=D_t})/Q_t \qquad (1)$$

Some adjustment of (1) yields:

$$\eta = (Q_{t+1} - Q_t)/Q_t \; - (Q_{E|D=D_t} - Q_t)/Q_t \; \equiv Q_t^* - Q_E^* \qquad (2)$$

Where $(Q_{t+1} - Q_t\,)/Q_t = Q_t^*$ is the relative change in quantity, and $(Q_{E|D=D_t} - Q_t)/Q_t = Q_E^*$ is the relative difference between the expected quantity in period $t+1$ and the observed quantity in period t. Given a demand elasticity, denoted by $\varepsilon,$ the expected quantity change Q_E^* can be obtained as:

$$Q_E^* = \varepsilon(P_{t+1} - P_t)/P_t \; \equiv \; \varepsilon P_t^* \qquad (3)$$

Now, by substituting (3) into (2), the relative horizontal shift in demand is given as follows:

$$\eta = Q_t^* - \varepsilon P_t^* \qquad (4)$$

The demand shift in the price direction can be obtained by dividing the horizontal shift in demand by the negative of the corresponding elasticity of demand (Sun & Kinnucan 2001; Brækkan & Thyholdt 2014). This vertical demand shift can be expressed as:

$$\eta^V = \frac{\alpha}{-\varepsilon} = -\frac{Q_t^*}{\varepsilon} + P_t^* \qquad (5)$$

For example, a vertical demand shift of, 5% would imply a 5% increase in consumers' willingness to pay for a given quantity of a product. The price and quantity direction measures of demand shift will be identical if the elasticity of demand is equal to -1. In this study, as explained above, following Brækkan and Thyholdt (2014), we measure the shifts in demand in the quantity direction.

The above model has some advantages. First, the model is suitable for measuring the shift in demand between two different periods (Brækkan et al. 2018). Moreover, the model measures aggregated demand shifts caused by various factors (e.g., logistics, increased variety of products, income growth, changes in tastes and preferences), which are impossible or at least difficult to measure using other econometric demand models, because of limited data accessibility or model specification issues. Furthermore, the approach has been used extensively in the literature on demand growth (e.g., Sun & Kinnucan 2001; Marsh 2003; Asche et al. 2011).

Despite the above strengths, like any model, it has shortcomings. The results are highly dependent on the value of the demand elasticity. For instance, the true demand elasticity might not be constant over time. We perform sensitivity analysis using different elasticity values to check the robustness of the estimated results in this study.

Data and demand elasticity

The data required for the analysis are price and per capita seafood consumption. This means that the estimated demand growth should be interpreted as changes in per capita seafood demand.

The annual aggregate seafood consumption for each country; over the period from 1984 to 2013; is obtained from FAOSTAT (FAO database). The consumption data reported by the FAO is apparent consumption of fish and fishery products. It is measured as the total quantity of FAO reported fish and fishery products produced in a country added to the total quantity imported and adjusted to any change in stocks minus exports and non-food uses[3]. Then per

[3] The FAO apparent consumption data is compiled from various sectors (e.g., production and trade). As a result, due to problems associated with variable or uncertain conversion factors and inadequate knowledge on stock changes, some uncertainties are more likely that apparent consumption might not reflect changes in

capita consumption is calculated by dividing the aggregate consumption by the total population in each country. The population data are obtained from the World Bank database (World Bank 2016). Considering that seafood products are highly diversified in quality and price, using aggregate data has some drawbacks. However, given the lack of more detailed data, this is probably the best way to proxy country- level seafood consumption. Moreover, other studies (e.g., Muhammad et al. 2011; Nguyen & Kinnucan 2018) have followed a similar approach.

The data available to compute the consumer-level seafood prices in each country are aggregate import quantities and values, which are obtained from the FAOSTAT database (FAO, 2015). In this study, we used import prices for three reasons. First, most previous demand studies have been carried out using trade data. As a result, many of the estimated demand elasticities in the literature are based on trade data (Asche et al. 2011). Second, it is relatively easy to get several years' worth of trade data for most countries. Third, at least at present, there is no better alternative to import price to proxy the domestic fish price in most countries.

Using import price to proxy consumer-level price obviously has some drawbacks. First, domestic consumption in most developing countries is mostly supplied by local production, not imports. Second, developing countries, particularly countries in East and Southeast Asia, are mainly exporters of seafood. However, it is also true that developing countries export high-value seafood to developed countries, while retaining and importing lower-value seafood products for their domestic supply (Tran et al. 2019). Nonetheless, because of rising consumer incomes, consumers in developing countries are diversifying the types of seafood they consume through import. This has caused a surge in seafood imports to

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consumption habits in a country. For more detail, please refer to the link http://www.fao.org/cwp-on-fishery-statistics/handbook/socio-economic-data/food-balance-sheets/en/.

develop countries (FAO 2016). For developed countries, a sizable and growing share of the seafood consumed is supplied through imports; using import prices in these countries therefore seems reasonable. Thus, while interpreting the results, especially those from developing countries, we must keep in mind the uncertainty regarding the use of import prices as a proxy for consumer seafood prices.

For each country, the unit price is expressed in the local currency, with exchange rate data obtained from the World Bank database (World Bank 2016). The prices are deflated using the respective country's consumer price indices (CPI), which is also extracted from the World Bank database.

To compute the shifts in demand, we must have appropriate demand elasticity estimates for each country considered in this study. Muhammad et al. (2011) estimated demand elasticities for seafood and fishery products for most countries in the world using a consistent methodology and data. Although there are several other studies estimating demand elasticities, they are often limited to a specific species or country. Muhammad et al.'s (2011) elasticities of demand estimates for most countries of the world are appropriate to use in this study. They estimated price and income elasticity of demand for broad food categories, including seafood, based on cross-country demand analyses conducted using International Comparison Program data from 2005. The study used a two-stage demand system to estimate the elasticities for 144 countries. Three types of own-price elasticities are reported in the paper: the Frisch deflated own-price elasticity, the Slutsky (compensated) own-price elasticity, and the Cournot (uncompensated) own-price elasticity.

The Frisch deflated own-price elasticity of a good is computed when price changes and income are compensated for to keep the marginal utility of income constant. The Slutsky (compensated) own-price elasticity measures the change in demand for a good when the price of that good changes, while real income remains unchanged. The Cournot (uncompensated) own-price elasticity refers to the situation where own-price changes, nominal income remains constant, and real income changes. The use of each measure of elasticity depends on the needs of the researcher. Since there is no compensation to keep the marginal utility of income constant in real life, Cournot (uncompensated) own-price elasticity is appropriate to use in this study. However, since only Frisch own-price elasticity is reported in the food subcategories in Muhammad et al's (2011) paper, we use Frisch own-price elasticity in this study. The Cournot and Frisch elasticities are relatively close for high-income countries, but can be different for low- and middle-income countries. Thus, using Frisch own-price elasticity in low- and middle-income countries might affect the results. Table 1 in the Appendix reports these price elasticities.

As one can observe from Table 1 in the Appendix, there are variations in the price elasticities across countries, ranging from 0.19 to 0.55 in absolute value. The elasticity of demand computed based on income level is also reported in Muhammad et al.'s (2011) paper. The reported elasticity estimates show that demand is more inelastic in high-income countries than in low- and middle-income countries. As we included some countries in this study whose own-price-elasticities are not reported in Muhammad et al.'s (2011) paper, we use the own-price elasticity for these countries' income level. This permits us to estimate demand growth for seafood in 107 countries in the period from 1984 to 2013.

Results and discussion

Figure 5 reports the annual average seafood demand growth across countries over the study period[4]. As shown in Figure 5, it ranges from - 6 to 7.5 %.

[4] The reported demand growth should be interpreted as per capita seafood demand growth, as it is calculated using per capita seafood consumption.

[Figure 5 here]

The estimated average seafood demand growth in China, which is by far the largest seafood consuming country in the world, is 6.3 %. In general, our results show that there are substantial differences in demand growth across countries.

Next, we calculated aggregate demand growth based on the income categories of countries (high income, upper middle income, low-middle income, and low income), to see whether there are differences in seafood demand growth based on income category. To calculate the aggregate demand per income category, we used the total population in every country as weights [5]. Figure 6 reports the results.

[Figure 6 here]

As shown in the figure, the aggregate demand growth for the upper-middle-income category was higher than that of the other income categories. This result seems reasonable for at least two reasons. First, as we discussed in the theoretical section, income is among the main driving factors of demand growth. High- income growth over recent decades has mainly been observed in developing countries, particularly in Asia. Furthermore, the presence of China in the upper-middle income category is a major contributor to the substantial growth.

Despite the effect of income on demand growth, it is slightly surprising to observe that the aggregate seafood demand index in countries in the low-income category was higher than in the lower-middle-income and higher-income categories. Since there are factors other than

[5] Since our demand growth calculation was based on per capita seafood consumption, it is reasonable to use the total population in every country as the weights. Here and in the subsequent section, demand indices are calculated relative to the base year 1984 (i.e., 1984 = 100).

income that can affect seafood demand growth, this result might still hold. However, it is quite surprising to see the slow growth of the aggregate seafood demand index for the high-income category. This might be an indication that consumers in high-income countries have diverse sources of protein other than seafood, or that seafood demand in higher-income countries is reaching a point of saturation. Nevertheless, due to the relative sizes of different markets, 1% growth in demand from the high-income countries translates to a much larger increase in quantity demanded than 1 % growth in demand from low- and middle-income countries.

Next, we calculated the aggregate seafood demand growth based on the countries regional classification and continents. Figure 7 and Figure 8 show the trends of the aggregate seafood demand indices based on regions and continents, respectively. As shown in Figure 7, the aggregate seafood demand index in East Asia increased continuously over the study period, and the growth was far higher than in the other regions.

[Figure 7 here]

As shown in Figure 8, the aggregate seafood demand index grew much faster in Asia than on any other continents. The trends of the aggregate seafood demand indices on other continents (except for North America) were similar. In North America, a downward trend has been observed, particularly after 2005.

[Figure 8 here]

Finally, we calculated the aggregate global demand growth. For the sake of clarity and for illustration purposes, we illustrate the ratio of the global demand index and quantity index (hereafter, global demand-quantity index). For the purpose of comparison, we also calculated a global seafood price index, where each country is weighted by population. In Figure 9, the top graph is the global demand-quantity index, while the bottom graph is the price index.

[Figure 9 here]

As clearly shown in the figure, the global demand-quantity index increased over the study period. This indicates that seafood demand grew more than quantity supplied, since the global demand-quantity index could only increase if there had been higher growth in demand than in quantity supplied. Larger growth in demand than in quantity supplied necessitates an increase in price, as illustrated by the increase on our global seafood price index. In other words, the substantial global growth in seafood supply over recent decades has coincided with even larger growth in global seafood demand.

It might be interesting to observe the demand growth across continents and globally over different periods. Table 1 reports the average annual demand growth for each continent and globally over different periods.

[Table 1 here]

As can be seen from the table, the global average seafood demand growth varied between periods, with the rate of growth decreasing over time. Specifically, the global annual average demand growth was 4.28 %, 2.69 %, and 2.27 % over the periods 1984 - 1993, 1994 - 2003, and 2004 - 2013, respectively. Over the whole study period, the global annual average demand growth was approximately 3.5 %. Likewise, the average demand growth across continents also varied over different periods. The average demand growth in Asia, which is historically the largest seafood producing and consuming continent, decreased over time.

Another interesting point to observe from the table is the rate of average growth in Africa. The average growth rate in Africa was very low over the period from 1984 - 1993 compared to the other continents, but the rate of growth increased over time. The annual average demand growth in Africa in the period 2004 - 2013 was 2.96 %. The average growth rate in South America was comparably higher in recent years than on the other continents. This result is consistent with Garlock et al.'s (2020) finding that aquaculture production in some non-Asian countries has been growing more rapidly than in the major Asian producers in recent years. This may have facilitated growth in demand in these countries. However, over the entire period from 1984 to 2013, only the average growth rate in Asia (4.22 %) was higher than the global annual growth rate (3.50 %).

In general, the above results show that there are substantial differences in demand growth across countries, income groups, regions, continents, and over time.

Sensitivity analysis

It may not be likely that the elasticity of demand for a commodity is constant over time. Therefore, checking the robustness of the above results using different elasticity values is necessary. We re-computed the shift in demand in every country by varying the elasticities by - 0.2 and 0.2, where - 0.2 is the difference between the average demand elasticity for seafood in low-income and high-income countries as reported in Muhammad et al. (2011). The argument for using this number is based on the assumption that, over time, seafood demand in developing countries may have become more inelastic as income increased.

Figure 10 shows the global demand index for each elasticity value. In the figure, the elasticity obtained from Muhammad et al. (2011) is referred to as the baseline elasticity, while the baseline elasticity minus and plus 0.2 are referred to as more elastic and less elastic demand, respectively. As shown in the figure, the estimated global demand indices are similar regardless of the elasticities used in the estimation. This indicates that the results are not sensitive to the choice of elasticity values[6].

[Figure 10 here]

Conclusion and implications

Any growth in seafood consumption necessitates a growth in quantity produced (and/or caught). However, growth in quantity produced can be caused by both an increase in supply and an increase in demand. While the growth in seafood production in recent decades is well-documented, the demand side of seafood consumption has received less attention. In this paper we show that global demand growth between 1984 and 2013 was higher than the global growth in supply. This implies that demand growth has been a vital contributor to increased global seafood consumption in recent decades.

While global demand growth for seafood has been substantial, it has also lost pace from average annual global demand growth of 4.28 % between 1984 and 1993, to annual growth of 2.27 % between 2004 and 2013. The slowdown of demand growth in Asia has been the main contributor to slower growth in global demand for seafood. South America and Africa, while still miniscule compared to Asia in terms of seafood consumption, had the largest demand growth between 2004 and 2013.

[6] We also did a robustness check using different elasticities for some of the major seafood producing and consuming countries, and our analysis showed that the results are not particularly sensitive to the choice of elasticity values.

High- income countries show remarkably low demand growth, and may have reached a point of saturation. All other income categories had substantially higher demand growth than high- income countries.

The results raise numerous questions, some of which are: why has global seafood demand been slowing down since the 1980s? Why has demand in Africa and South America been so high in recent years? Why has seafood demand growth in high income countries been consistently low for 30 years? Why is fish demand contracting in Oceania and North America?

In this study we show demand growth for seafood over time, globally, across regions, and across income groups. There is considerable variation on all measures, but it is not within the scope of this study to explain or understand the causes behind these. While one could therefore argue that the results of this study raise more questions than they answer, knowing which questions to ask can also be valuable knowledge. Hopefully this study has contributed both in terms of providing a thorough picture of demand growth for seafood, and in inspiring future research to answer some of the questions that the results have raised.

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Conflict of interest

The authors declare that they have no conflicts of interest.

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Figures

(a) (b)

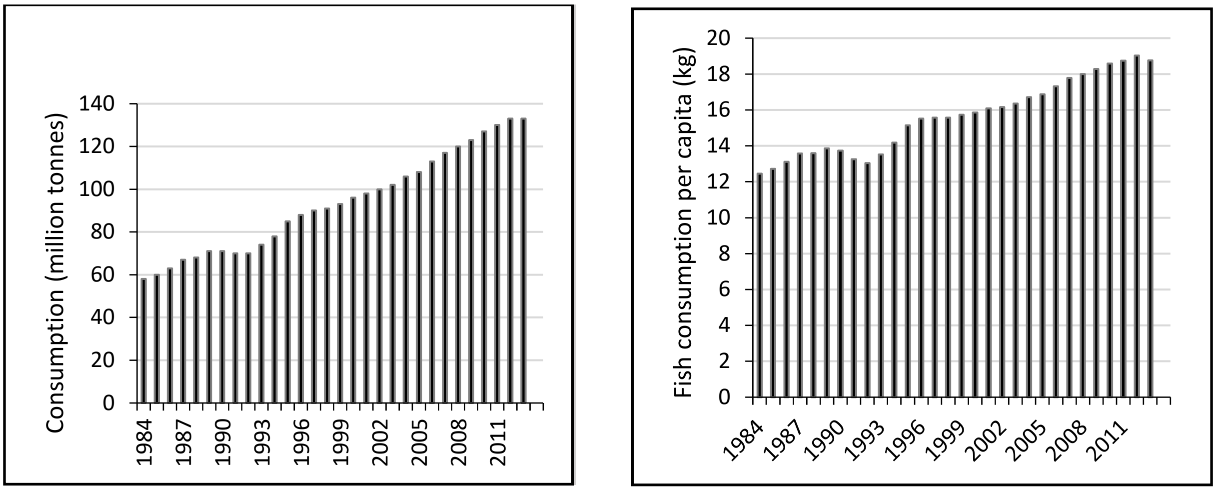

Figure 1: Trend of global seafood consumption and consumption per capita, from 1984 to 2013.

Source: Authors' plots using data from the FAOSTAT database

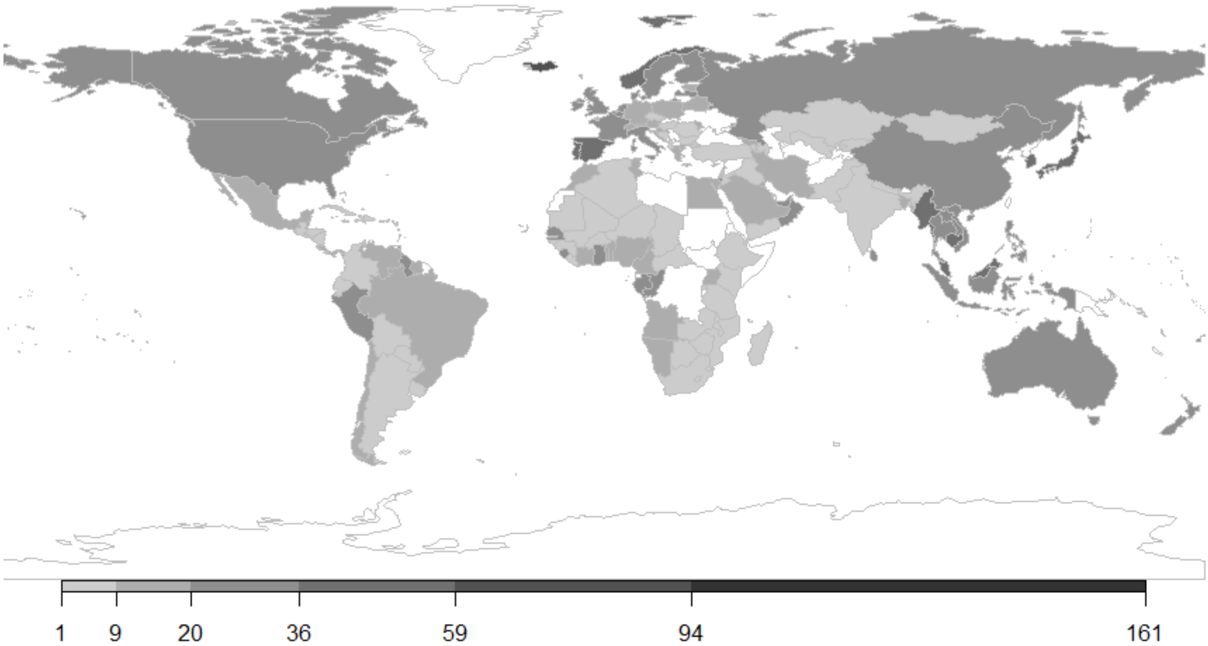

Figure 2: Seafood consumption per capita for 157 countries in the world, in 2013. Note that white in the figure represents missing data. *Source: Authors' plots using data from the FAOSTAT database.*

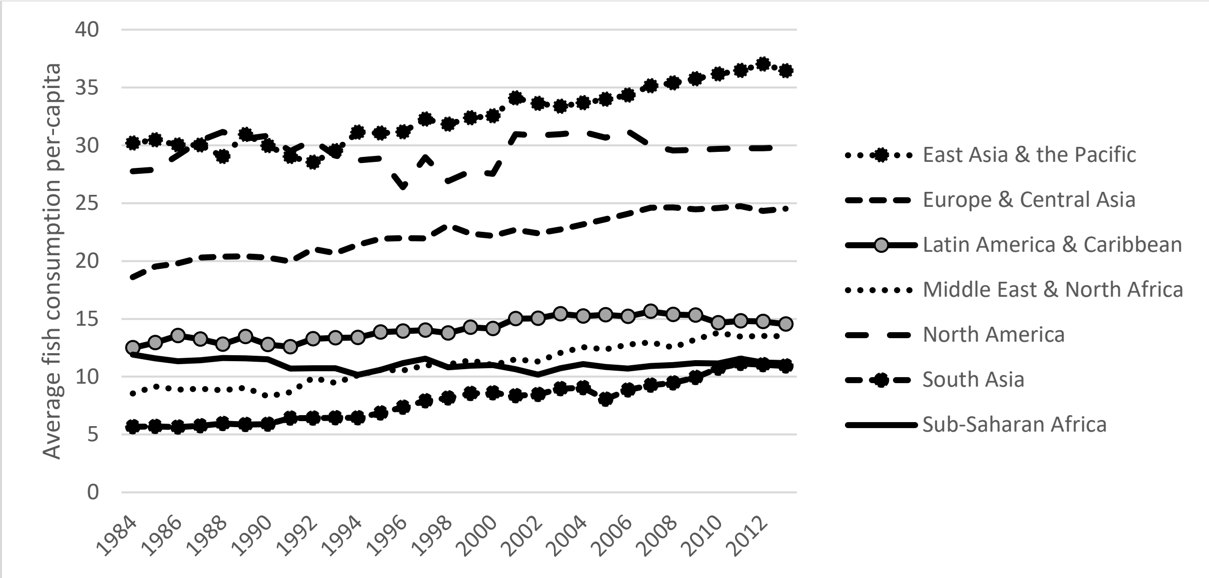

Figure 3: Seafood consumption per capita from 1984 to 2013. *Source: Authors' plots using data from the FAOSTAT database*

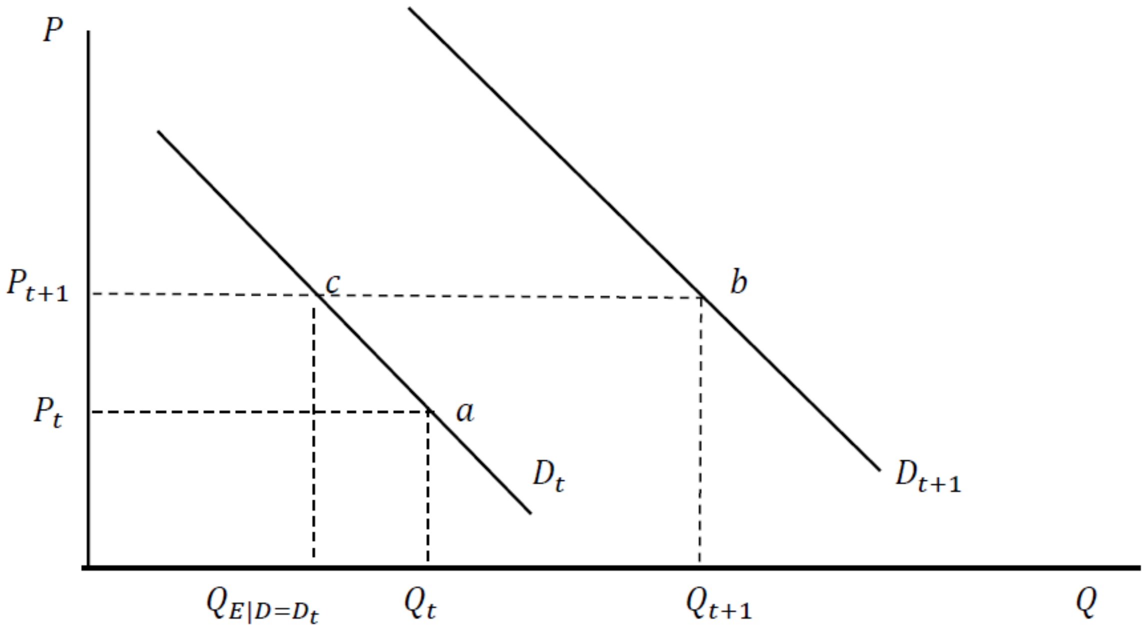

Figure 4: Horizontal shift in demand between two periods.

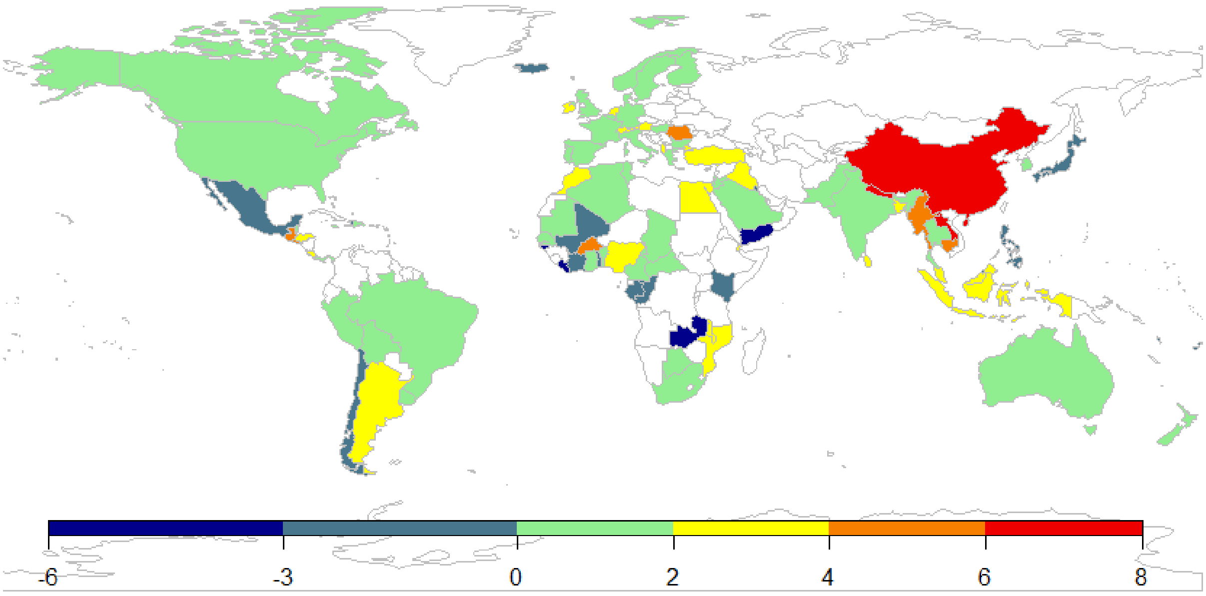

Figure 5: Average annual seafood demand growth (in %) across countries from 1984 – 2013. Note that white in the figure represents missing data. *Source: Authors' plot*

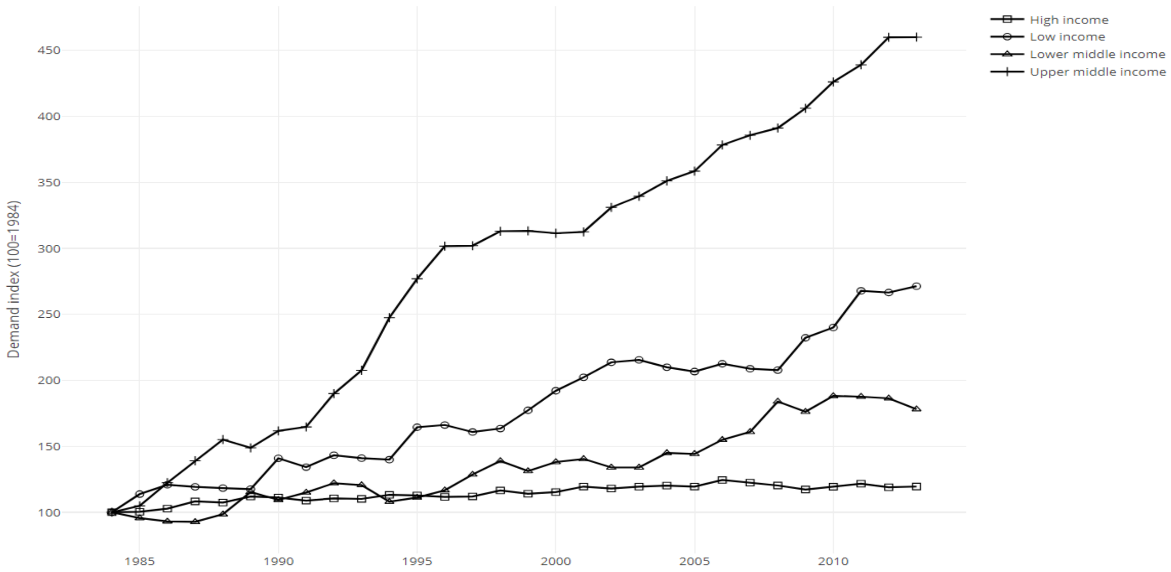

Figure 6: Aggregate global seafood demand index calculated based on countries' income category from 1984 – 2013. *Source: Authors' plot*

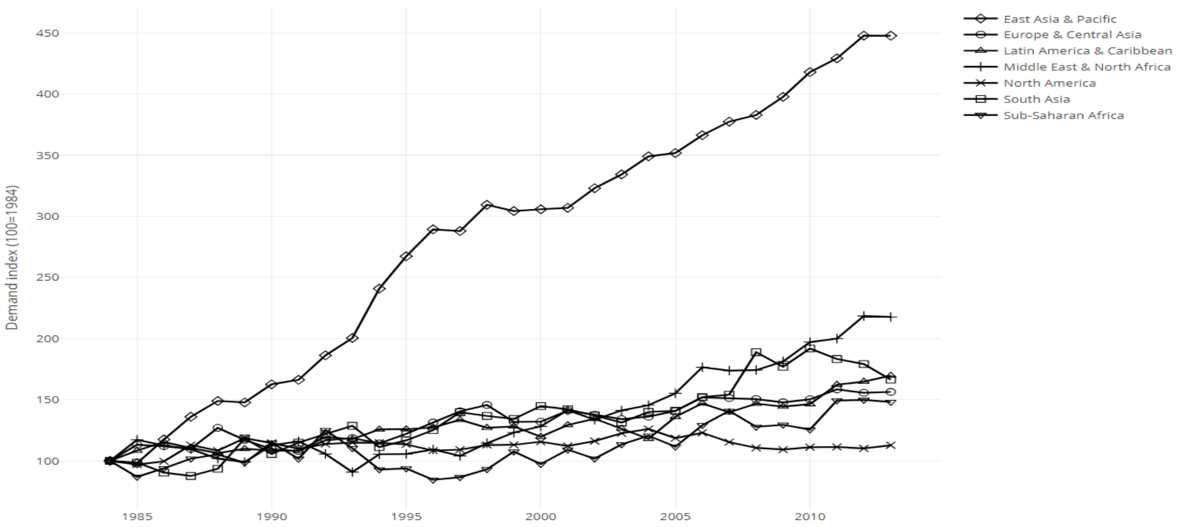

Figure 7: Aggregate global seafood demand index calculated based on countries region, from 1984 - 2013. *Source: Authors' plot*

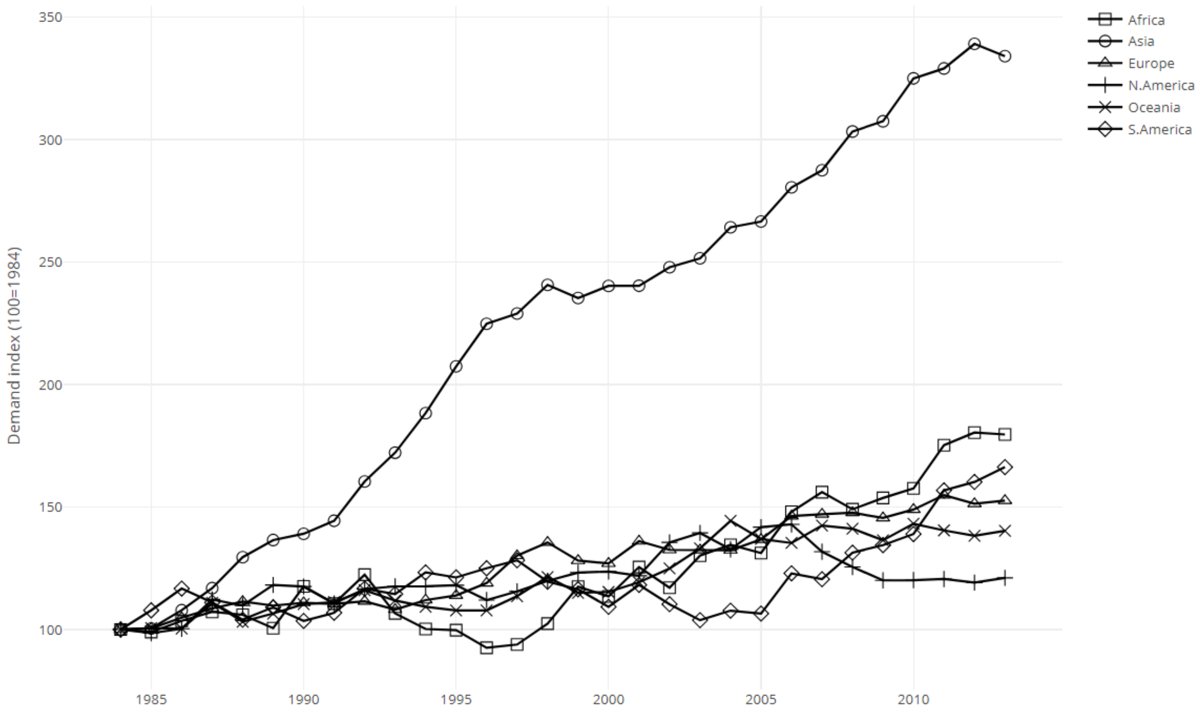

Figure 8: Aggregate global seafood demand index calculated based on continents from 1984 – 2013.
Source: Authors' plot

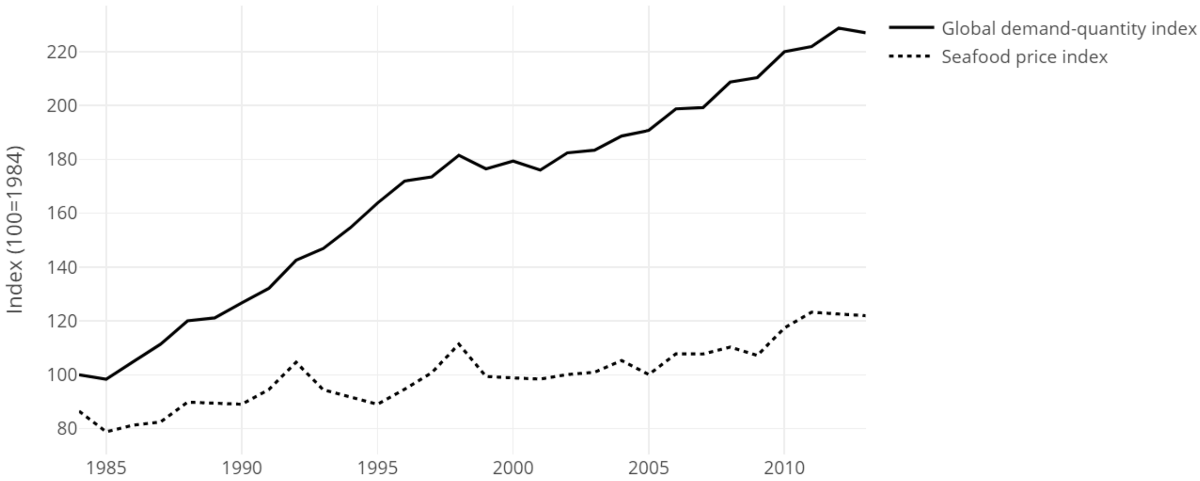

Figure 9: Graphs of the global demand-quantity index (the ratio of global seafood demand and global seafood production indices), and the global seafood price index, from 1984 - 2013. *Source: Authors' plot*

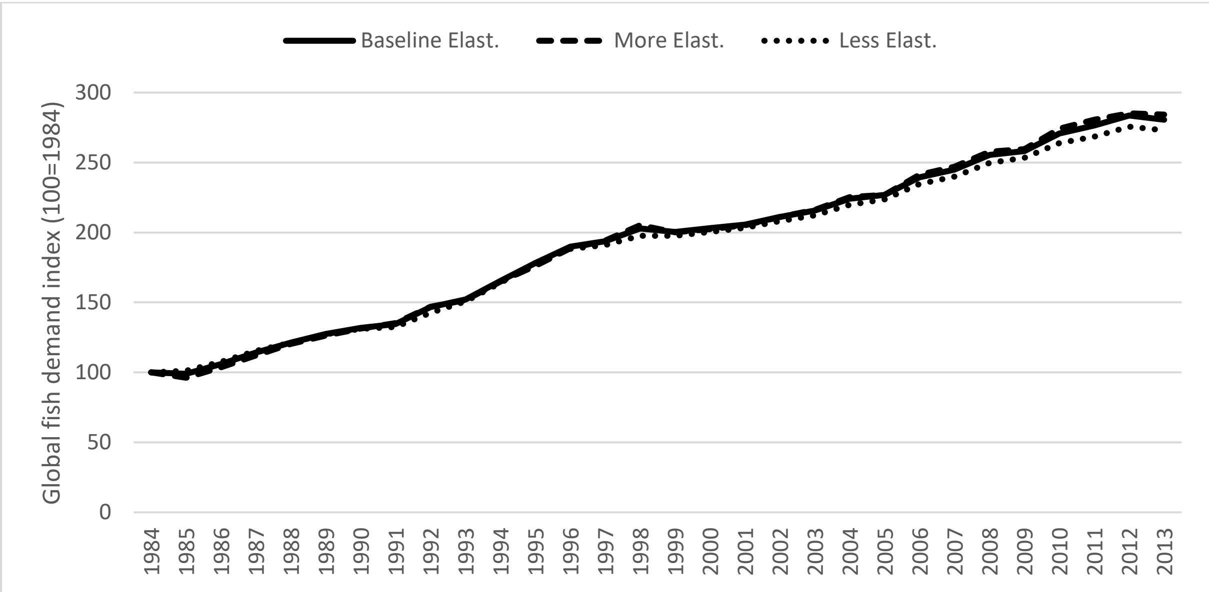

Figure 10: Global seafood demand indices calculated with different seafood demand elasticities (i.e., baseline elasticity refers to the elasticity from Muhammad et al.'s (2011) paper, while the other two are the baseline elasticities plus or minus 0.2), from 1984 – 2013. *Source: Authors' plot*

Table

Table 1. The annual average demand growth in different periods (in %)

	1984-1993	1994-2003	2004-2013	1984-2013
Asia	5.64	3.05	2.39	4.22
Africa	0.59	2.7	2.96	2.00
Europe	0.90	1.67	1.34	1.44
N. America	1.63	1.71	-0.91	0.64
South America	1.35	-1.70	4.44	1.71
Oceania	1.15	2.00	-0.30	1.16
World	4.28	2.69	2.27	3.50

Appendix

Table A1: Frisch own-price elasticities of demand for fish

Country	Elasticity	Country	Elasticity	Country	Elasticity
Albania	-0,431	Colombia	-0.432	India	-0.484
Angola	-0.512	Congo	-0.501	Indonesia	-0.456
Argentina	-0.389	Congo, Dem. R	-0.551	Iran	-0.395
Armenia	-0.419	Colombia	-0.432	Iraq	-0.479
Australia	-0.279	Congo	-0.501	Ireland	-0.287
Azerbaijan	-0.444	Congo, Dem. Rep.	-0.551	Israel	-0.328
Bahrain	-0.34	Croatia	-0.363	Italy	-0.287
Bangladesh	-0.49	Cyprus	-0.272	Japan	-0.279
Belarus	-0.398	Czech	-0.333	Jordan	-0.43
Belgium	-0.278	Côte d'Ivoire	-0.491	Kazakhstan	-0.403
Benin	-0.496	Denmark	-0.288	Kenya	-0.493
Bhutan	-0.476	Djibouti	-0.485	Korea, R	-0.351
Bolivia	-0.459	Ecuador	-0.434	Kuwait	-0.308
Bosnia and Herzegovina	-0.399	Egypt	-0.434	Kyrgyzstan	-0.462
Botswana	-0.458	Equatorial Guinea	-0.446	Lao People's Dem. Rep.	-0.49
Brazil	-0.419	Estonia	-0.356	Latvia	-0.374
Brunei Darussalam	-0.352	Ethiopia	-0.523	Lebanon	-0.364
Bulgaria	-0.39	Fiji, Republic	-0.441	Lesotho	-0.476
Burkina Faso	-0.504	Finland	-0.297	Liberia	-0.54
Burundi	-0.538	France	-0.273	Lithuania	-0.356
Cape Verde	-0.459	Gabon	-0.451	Luxembourg	-0.208
Cambodia	-0.483	Gambia	-0.518	Macedonia	-0.405
Cameron	-0.481	Georgia	-0.435	Madagascar	-0.502
Canada	-0.271	Germany	-0.269	Malawi	-0.527
Central Africana Rep.	-0.507	Ghana	-0.5	Malaysia	-0.422
Chad	-0.512	Guinea	-0.511	Maldives	-0.469
Chile	-0.402	Guinea-Bissau	-0.523	Mali	-0.509
China	-0.48	Hungary	-0.352	Malta	-0.309
China, Hong Kong SAR	-0.285	Iceland	-0.267	Mauritania	-0.491

Continued Table A1: Frisch own-price elasticities of demand for fish

Country	Elasticity	Country	Elasticity
Mexico	-0.371	Singapore	-0.325
Moldova, Rep	-0.445	Slovakia	-0.353
Mongolia	-0.479	Slovenia	-0.327
Montenegro	-0.415	South Africa	-0.415
Morocco	-0.463	Spain	-0.281
Mozambique	-0.516	Sri Lanka	-0.454
Namibia	-0.458	Sudan	-0.47
Nepal	-0.495	Swaziland	-0.441
Netherlands	-0.266	Sweden	-0.286
New Zealand	-0.299	Switzerland	-0.254
Niger	-0.524	Syrian Arab Republic	-0.445
Nigeria	-0.489	Taiwan	-0.297
Norway	-0.267	Tanzania, R	-0.504
Oman	-0.386	Thailand	-0.433
Pakistan	-0.463	Togo	-0.5
Paraguay	-0.44	Tunisia	-0.425
Peru	-0.425	Turkey	-0.409
Philippines	-0.455	Uganda	-0.504
Poland	-0.363	Ukraine	-0.418
Portugal	-0.316	United Kingdom	-0.258
Qatar	-0.32	United States of America	-0.191
Romania	-0.399	Uruguay	-0.398
Russian Federation	-0.39	Venezuela Rep	-0.417
Rwanda	-0.512	Viet Nam	-0.484
Sao Tome and Principe	-0.479	Yemen	-0.48
Saudi Arabia	-0.401	Zambia	-0.517
Senegal	-0.486	Zimbabwe	-0.528
Serbia	-0.402		
Sierra Leone	-0.511		

	Elasticity value
Low-income countries average	-0.478
Middle-income countries average	-0.378
High-income countries average	-0.277

Source: Muhammad et al.,(2011)

Table A2. Seafood consumption per capita based on countries, in 2013

Country	Percapita	Country	Percapita	Country	Percapita	Country	Percapita
Albania	5.3	Czech Rep.	8.8	Kazakhstan	5.1	Poland	10.7
Algeria	4.0	Denmark	23.2	Kenya	4.2	Portugal	54.5
American Samoa	44.4	Djibouti	3.7	Kuwait	12.9	Romania	6.8
Angola	12.7	Dominica	20.4	Kuwait	12.9	Russia	22.8
Argentina	6.9	Dominican Rep.	8.2	Kyrgyzstan	2.2	Rwanda	4.1
Armenia	4.5	Ecuador	8.2	Laos	20.7	Saudi Arabia	13.0
Australia	26.3	Egypt	20.2	Latvia	24.1	Senegal	24.0
Austria	13.9	El Salvador	6.9	Lebanon	9.7	Sierra Leone	28.4
Azerbaijan	2.1	Estonia	14.4	Lesotho	0.8	Solomon Islands	33.5
Bahamas	27.6	Ethiopia	0.2	Liberia	4.2	South Africa	6.1
Bangladesh	19.1	Fiji	36.1	Madagascar	4.6	South Korea	51.6
Barbados	40.5	Finland	36.3	Malawi	7.2	Spain	42.7
Belarus	16.3	France	32.6	Malaysia	59.0	Sri Lanka	26.5
Belgium	24.9	Gabon	32.8	Maldives	160.5	Suriname	16.4
Belize	13.2	Gambia	23.9	Mali	7.2	Swaziland	1.3
Benin	13.8	Georgia	12.2	Malta	33.0	Sweden	31.9
Bolivia	2.3	Germany	12.9	Mauritania	9.0	Switzerland	17.8
Bosnia& Herz.	4.5	Ghana	25.8	Mauritius	23.2	Tanzania	5.4
Botswana	3.8	Greece	19.6	Mexico	10.4	Thailand	24.4
Brazil	10.8	Grenada	28.4	Moldova	12.7	Togo	11.3
Brunei Darussalam	48.1	Guatemala	1.3	Mongolia	0.7	Trinidad & Tobago	23.8
Bulgaria	6.9	Guinea	9.4	Morocco	17.6	Tunisia	13.6
Burkina Faso	6.7	Guinea-Bissau	1.4	Mozambique	7.9	Turkey	6.0
Cabo Verde	11.5	Guyana	31.2	Myanmar	56.3	Uganda	12.5
Cambodia	41.7	Haiti	4.8	Namibia	11.4	United Arab Em.	23.6
Cameroon	15.8	Honduras	3.7	Nepal	2.2	United Kingdom	20.5
Canada	22.5	Hungary	5.1	Netherlands	22.1	United States	21.8
Central African Rep.	8.0	Iceland	93.7	New Zealand	25.3	Uruguay	7.5
Chad	4.6	India	4.9	Nicaragua	4.9	Uzbekistan	0.7
Chile	12.6	Indonesia	27.9	Niger	2.6	Vanuatu	32.0
China	36.2	Iran	10.0	Nigeria	16.4	Venezuela	9.6
Colombia	6.4	Iraq	3.3	Norway	51.7	Viet Nam	32.7
Congo	24.8	Ireland	22.1	Oman	22.0	Yemen	2.3
Costa Rica	13.4	Israel	22.3	Pakistan	1.9	Yemen	2.3
Cote d'Ivoire	14.3	Italy	25.4	Panama	13.1	Zambia	6.0
Croatia	19.1	Jamaica	23.4	Paraguay	3.9	Zimbabwe	2.7
Cuba	5.5	Japan	48.5	Peru	22.0		
Cyprus	21.6	Jordan	4.6	Philippines	31.6		

Source: Authors' computation based on data extracted from the FAOSTAT database