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Demand for Imported versus Domestic Fish in Nigeria

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Abstract

Fish is among the most important animal-sourced foods in Africa and is crucial in combatting malnutrition. Fish demand in Africa has far outpaced supply as the import share rose from 16% in 1970 to 39% by 2017. Little is known about who is consuming the imports: rural versus urban, rich versus poor. This is the first fish consumption analysis in Africa distinguishing imported and domestic fish, and within domestic fish, fresh versus traditional-processed. We analyse three rounds of nationally representative data from Nigeria, disaggregating the richer South from the poorer North, and urban and rural. Frozen (imported) fish accounted for 34% of urban fish consumption in the North (23% for rural), compared with 67% in urban areas in the South (54% for rural). The large difference in frozen fish consumption between regions is due mainly to differences in income and refrigerator ownership. For other fish forms (fresh, dried, smoked), regional differences are far less pronounced. Income and price elasticities confirm that imported fish have become deeply incorporated into fish consumption habits. From a policy perspective, this intensifies concerns about import bills as fish demand grows. However, our elasticity results show that Nigerian consumers are keen to consume fresh fish as incomes increase, and that demand for smoked and dried fish also remains strong at high levels of income. Promoting aquaculture is a promising policy path to reduce import dependence. Domestic capture fisheries remain a major source of

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fish, making it important to maintain productivity at sustainable levels through better management.

Keywords: *Africa*; *demand systems*; *fish*; *imports*; *Nigeria*; *EASI.*

1. Introduction

Developing countries' share of consumption of global fish output rose from 61% in 1990 to 78% in 2017, according to FAOSTAT. Despite the rising dominance of developing regions in world fish consumption, Bush *et al.* (2019) note that demand for fish in developing countries is under-researched. However, the gap in the literature is distinctly different between Asia and Africa.

Asia has been the focus of the great majority of fish demand literature for developing countries. The rise of Asian fish demand and supply occurred earlier than Africa. Asia also dominates developing country fish output: in 2014 Asia's share of fish output from developing countries was 84%, with Africa only 10% and Latin America and the Caribbean, 4%. A wave of household survey studies in the past two decades showed that the rapid increase in Asian fish consumption was driven by rising incomes, falling fish prices, and shifting preferences associated with urbanisation, lifestyle changes and employment: Huang and Bouis (2001) for Taiwan; Hovhannisyan and Gould (2014) for China; Dey *et al.* (2011), Toufique and Belton (2014) and Toufique *et al.* (2018) for Bangladesh.

Africa has received far less attention in the developing country fish demand literature. This may be because of a perception of African fish production being stagnant and small, which was largely the case in the 1970s and 1980s when its share of world fish production was about 5%. Yet FAOSTAT data in Table 1 show that from 1970 to 1990 African fish production rose 1.25 fold; from 1990 to 2010 it rose 1.5 fold; and if the growth rate from 2010 to 2017 holds, production will rise 2.0 fold from 2010 to 2030. From 1970 to 2017, fish output in Africa rose 2.5 fold. But as African population rose 3.5 fold, per capita consumption of fish should have fallen over time if it had been only sourced from domestic production. Instead, consumption hovered around 10 kg per capita for those five decades. The gap between demand and supply was met by rapidly rising imports, which rose from 16% to 39% of African fish consumption over those decades. We discuss imports in more detail below.

Fish is crucial to nutrition in Africa (Chan *et al.*, 2019). Ensuring adequate levels of animal-sourced food consumption is considered to be one key to combatting malnutrition (Headey *et al.*, 2018). Africa experiences high levels of food insecurity and malnutrition (Akombi *et al.*, 2017), and fish is among the most important animal-sourced foods across most of the continent (Desiere *et al.*, 2018). This is also the scenario in Nigeria, where rates of malnutrition are high and fish is one of the main animal-sourced foods (Kuku-Shittu *et al.*, 2016; Ogundari, 2017). We analyse nationally representative data for Nigeria – the most populous country with the largest economy in Africa. We find that fish consumption accounted for about 35% of consumption expenditure for animal proteins in 2015 and constituted about 10% of food consumption expenditure by the average Nigerian – as much as any of the individual main staples (rice or maize or tubers or pulses). Changes in fish consumption therefore have important implications for food and nutrition security in Nigeria (Bradley *et al.*, 2020).

Table 1
Sub-Saharan African fish production (capture + farmed), imports, exports and apparent consumption per capita, 1970–2017

	1970	1980	1990	2000	2010	2017
Production in millions of tons	3.1	2.9	3.9	4.9	5.8	7.7
Imports in millions of tons	0.4	1.2	2.0	1.6	3.8	3.3
Percentage (%) of imports in apparent consumption	16	32	38	33	48	39
Exports in millions of tons	1.0	0.4	0.6	1.6	1.6	2.5
Apparent consumption (production + imports – exports) in millions of tons	2.5	3.7	5.3	4.9	8.0	8.5
Population (millions)	267	350	465	600	776	928
Apparent consumption per capita (in kg)	9	11	11	8	10	9

Source: Authors' calculations from FAOSTAT data.

Despite the importance of fish consumption in Africa, particularly for addressing malnutrition, examination of fish demand has been limited. There are few survey-based analyses of fish demand in Africa, though exceptions include: Abdulai and Aubert (2004) for Tanzania; Tambi (2001) for Cameroon; and local area studies such as Amao *et al*. (2006) for Lagos State in Nigeria. Zhou and Staatz (2016) used Living Standards Measurement Study (LSMS) data from around 2012 to estimate income elasticities for fish as a general category compared with other food categories for West Africa. Desiere *et al*. (2018) also used LSMS and FAO data to assess current and future meat and fish consumption in a group of countries in sub-Saharan Africa. Genschick *et al*. (2018) analysed urban Zambian fish consumption patterns of the poor strata.

Moreover, there has been little research globally on the determinants of the form in which fish is purchased. 'Traditional forms' include dried/salted, smoked, and fresh, all of which were common prior to the advent of refrigeration and freezing. The main non-traditional product form is frozen fish, which is thawed after purchase for use at home or in restaurants. Fish consumption analyses have often treated fish (and 'seafood') as a homogeneous group of products and few studies differentiate either species or form. There are some exceptions: Toufique *et al*. (2018) distinguish fish originating from capture or aquaculture. Dey et al. (2008) distinguish dried fish from other fish in Asia. In Europe and the US, Trondsen *et al*. (2004) distinguish processed from fresh, and Verbeke *et al*. (2007) distinguish traditional preservation styles versus fresh. In the United States, Muhammad and Hanson (2009) distinguish fresh and frozen catfish. In Africa, studies of demand for different fish forms are either of a locality, or of one species, or limited product forms (Kumar *et al*., 2005; Jimoh *et al*., 2013; Dauda *et al*., 2016).

In sum, the African literature has not had a systematic analysis of: (i) consumption of domestically produced versus imported fish; (ii) consumption of different forms of fish, such as frozen, fresh, dried and smoked; (iii) consumption of fish over spatial categories such as agroecological zones, and regions with different levels of development. These gaps are important for the following reasons.

First, unlike Asia, food imports are among the top policy concerns in Africa (African Development Bank, 2016) due to their viewed foreign exchange burden and their competition with the domestic fish sector. In Africa, the share of imports in total apparent consumption of fish more than doubled over the four decades 1970s–2000s, to a high of 39% by 2017 (Table 1). This compares to the import share (derived from FAOSTAT) in all food for 2017 of 13% (Liverpool-Tasie et al., 2020). Despite the importance of fish imports, no survey-based analysis of the patterns and determinants of imported versus domestic fish consumption has been done for Africa. As discussed below, imports are mainly in the form of frozen fish, and the latter are nearly all imported, so there is a correlation between a lack of analysis of demand for different forms of fish and demand for imported fish.

Second, food demand analyses using nationally representative surveys in developing regions are often focused only on the national level. However, in African countries such as Nigeria, there are particularly sharp inter-regional differences in development levels as well as consumption habits. We posit that this holds for Northern versus Southern Nigeria. Northern Nigeria is often in the international news because of the Boko Haram insurgency, but it has also long had severe development constraints and lagged growth because of its semi-arid agroecology and lower education compared with the much richer South, which benefits from more oil revenue and has higher education. Nigeria thus presents a pertinent case concerning how different – or similar – food consumption transformation is in the two regions, and whether the 'imported fish' phenomenon is driven more by the larger middle class of the South or is occurring in both regions. This is more broadly interesting than just Nigeria: the dichotomy of poorer interior and more developed coastal regions is found over a large part of Africa.

To address these three gaps, we analyse consumption patterns, food expenditure, and price elasticities of imported versus domestic fish consumption using data from a nationally representative panel survey, the Nigeria Living Standard Measurement Study-Integrated Survey on Agriculture (LSMS-ISA). It has data on the same households for 5 years over 2010 to 2015. The LSMS data allow stratification by urban and rural as well as by North and South Nigeria. We also explore the heterogeneity of demand across rural and urban areas as proxies for employment, lifestyle and preferences, found to be so important in the Asian studies noted above. Following the same households over multiple years is our fourth contribution to the literature. The great majority of fish demand studies in developing countries (and, to our knowledge, all those in Africa) use cross-section analysis. We are able to track changes over time, something not yet done in Africa for fish consumption, to see whether changes in the two regions diverge or converge.

However, the Nigeria LSMS data do not directly indicate whether the fish consumed is from imports or domestic sources. While fish indicated as fresh are, with near certainty, from domestic capture or aquaculture (although these two sources are not indicated in the data), processed fish can be either domestic or imported. We have assigned dried and smoked fish to the domestic category because the great majority of dried and almost all smoked fish are domestically produced except for a small amount received in informal cross-border trade, and for Norwegian dried cod (stock fish) imports.[1] By contrast, we assign all frozen fish to the imported category because Nigeria lacks a significant fish freezing industry using domestic fish as inputs, and nearly all the frozen fish purchased in the country are imported.[2]

The paper proceeds as follows. In Section 2 we discuss the data used. Section 3 presents a description of fish consumption patterns across Nigeria. Section 4 presents the econometric approach featuring an Exact Affine Stone Index (EASI) demand model and section 5 presents the associated regression results. Section 6 concludes.

2. Data

We use data from three rounds of the Nigeria World Bank Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA); 2010/11, 2011/12,

[1]Given the unconditional dried fish consumption by households derived from the nationally representative LSMS data and extrapolated to annual national levels (assuming 5–7 people per household) we compare the expected total dried fish demand to the amount of dried fish recorded to have been imported by COMTRADE and find this to be between 4% and 6% depending on the assumed household size.

[2]We also conducted a rapid reconnaissance with frozen fish sellers in one to three fish markets (and/or cold rooms) in the capital cities of six Nigerian states that cover the six geopolitical zones of Nigeria (one per geopolitical zone). We asked over 50 frozen fish sellers in each state (minimum of five per market) the source of their frozen fish. We found that 100% of their frozen fish was imported.

and 2015/16 . It includes about 5,000 households in each survey year surveyed twice a year during the agricultural season and post-harvest season. This generates a panel as the same individuals were interviewed during each period of data collection. The survey was nationally representative, covering rural and urban areas in the two geographical regions that also capture agroecological variation; the North and the South, as discussed above. The data cover household demography, assets, production and food consumption from own production, purchases and gifts.

We computed household food consumption expenditure as the total value of consumption (from purchases, own production and gifts) for 10 categories of food used to categorise all the food items available in the data: cereals and tubers, pulses, dairy, beef and other meats, poultry and eggs, dairy products, fresh fish, frozen fish, smoked fish, dried fish, and other foods. The choice of the categories was informed by other consumption studies in developing countries (Fashogbon and Oni, 2013; Dolislager, 2017). We disaggregated fish consumption into the four categories reported in the survey: fresh, frozen, dried and smoked. Price indices were computed for each of the food categories as a weighted average of transaction-derived prices of items included in the specific group. Nominal prices and values were converted into real values using the consumer price index (CPI) at the national level for each survey year with 2010 being the base year.

3. Fish Consumption Patterns

Table 2 shows overall fish consumption in the country and the two regions. Several points stand out. First, fish consumption is widespread and increasing: 59% of Nigerians ate fish in 2010 versus 72% in 2015. The North stayed steady at about 50%, while the South leapt from 71% to 90% in the 5 years.

Second, per capita consumption of fish products (unconstrained) in the South in 2015 was more than double that of the North. Annual fish consumption per capita is 13 kg. This is slightly higher than the average apparent consumption per capita for Africa as a whole (Table 1), but about half the global average of 20.3 kg (FAO, 2018).

Table 3 compares the North and South over 5 years, and disaggregates fish consumption into frozen fish (largely imported), and fresh, dried and smoked fish (primarily domestic origin).[3] There are several striking points. First, the share of people consuming frozen fish is far higher in the South compared to the North. Only 14% of Northern fish consumers ate frozen fish in 2015, versus 62% in the South. This gap grew over the 5 years. Frozen fish might be more accessible in the South because the ports are close by and more households own refrigerators. Only 10% of households in the North own refrigerators, all of them in urban areas, as compared to 30% of households in the South (20% rural and 40% urban) (Table 4, below).

Second, there is surprisingly little difference between the North and South in terms of the share of people eating fresh fish (14% and 12%, respectively). The share of fresh fish in total food consumption expenditure is even closer, around 1.5% in both regions. This similarity may be because capture fisheries in rivers and lakes in the

[3]National average annual consumption per capital (unconstrained) of fresh, frozen, smoked and dried fish is 15.6 kg, 22.7 kg, 8.7 kg, and 5.1 kg, respectively.

Table 2
Annual fish consumption in Nigeria by rural and urban locations and region, 2010–2015

Year	Total number of households	North	South	All
	Households consuming fish (%)			
2010	9,246	46	71	59
2012	9,284	48	90	72
2015	9,124	49	90	72
	National (kg/per capita)			
2010	9,246	6.4	17.0	12.1
2012	9,284	5.7	15.0	11.0
2015	9,124	6.3	18.7	13.2
	Urban (kg/per capita)			
2010	2,994	8.7	16.1	14.1
2012	2,853	7.3	15.2	13.4
2015	2,904	8.6	18.6	16.0
	Rural (kg/per capita)			
2010	6,252	5.7	18.1	10.8
2012	6,431	5.2	14.8	9.4
2015	6,220	5.5	18.8	11.2

Source: Authors' estimations from the LSMS-ISA 2010, 2012 and 2015 data. These values are unconstrained and in nominal terms to allow for comparison to other studies and international statistics.

North balance more abundant aquaculture and marine fisheries in the South in providing access to fresh fish.

Third, while dried and smoked fish are preserved product forms, often thought to be eaten in arid areas far from supplies of fresh fish, Southern consumers eat more of both (each consumed by around 25% of households) than those in the North (consumed by 17% and 11% of households, respectively).

In the North, the share of consumers eating fish was much higher in urban areas than in rural: 61% versus 45% in 2015. In the South, the shares of people eating fish were similar in urban and rural areas, at around 90%. Accordingly, the share of fish in overall food consumption is lower in the North (3%) than the South (12%) in 2015, likely reflecting higher incomes in the South as well as access to a wide variety of fish (including the more expensive fresh fish) and different food culture traditions (see Table S1). Comparing urban to rural per region shows that there was an increase in the share of households consuming fish in the South in both rural and urban areas from 2010 to 2012, but little change in the South from 2012 to 2015, or in the North in any year. Given that relative incomes of urban and rural areas did not change much over the 5 years, this appears to imply that access to fish has grown in the South, leading to increasing equality of fish market access between rural and urban areas. Food supply chains are critical for fish consumption; approximately 95% of fish consumed in both regions is purchased.

Fish expenditure by fish type, as a share of total fish budget (by region, and rural versus urban) is presented in Table S1. We find that in the North, frozen fish were 34% of all fish consumption in urban areas, versus 23% in rural areas where about half of fish consumption is dried or smoked fish. This could be because of differences

Table 3
Share of households consuming fish, share of fish in the food budget, and fish consumption per capita (by fish type and region, 2010–2015)

	Fresh fish			Frozen fish			Smoked fish			Dried fish			All fish		
	North	South	All	North	South	All	North	South	All	North	South	All	North	South	All
Households consuming fish (%)															
2010	14.3	11.4	12.7	12.9	49.9	33	10.8	18.2	14.8	15.9	19.5	17.9	46	71	59
2012	13.8	9.4	11.3	15.8	66.5	44.7	9.3	19.6	15.1	15.9	23.9	20.5	48	90	72
2015	13.9	12.3	13	13.5	61.5	40.2	11	24.6	18.6	17.2	26.4	22.3	49	90	72
Fish as share of food budget (%)															
2010	1.6	1.7	1.6	1.1	6.3	3.9	0.5	0.9	0.7	0.5	0.7	0.6	3.7	9.7	6.9
2012	2.1	1.8	1.9	1.5	7.6	5.0	0.5	0.8	0.7	0.7	0.8	0.7	4.7	11.0	8.3
2015	1.4	1.6	1.5	1.2	8.0	5.0	0.4	1.3	0.9	0.4	0.5	0.5	3.4	11.5	7.9
Per capita fish consumption (kg/capita)															
2010	12.4	10.1	11.2	7.9	39.6	25.0	6.6	7.5	7.1	8.2	9.8	9.1	6.4	17.0	12.1
2012	9.5	7.9	8.6	8.6	33.1	22.6	4.8	6.9	6.0	6.9	7.3	7.1	5.7	15.0	11.0
2015	16.7	14.7	15.6	7.8	34.6	22.7	4.7	11.9	8.7	5.0	5.2	5.1	6.3	18.7	13.2

Source: Authors' estimations from the LSMS-ISA 2010, 2012 and 2015 data. Note that these values are unconstrained and households can consume more than one fish form.

in income and shares of families with iceboxes or refrigerators. Rural areas are often poorly served by electricity grids or generators. Even when an area has electricity it is often shut off for significant periods, making it hard for consumers as well as retailers and wholesalers to store frozen fish. By contrast, in the South, frozen fish dominates in both urban areas (67% of fish consumption) and rural areas (54%).

In both the North and South, the share of dried fish is slightly higher in rural areas than urban. This appears to be due in part to the association of dried fish with lower incomes and transportability and ambient storability that favour consumption of it in less accessible rural locations, particularly in the North. Fresh fish consumption is similar in urban and rural areas (around 25% in the North, and 10% in the South). Smoked fish also has similar shares in urban and rural areas in both regions (roughly 18%).

Table 4 shows real prices. Frozen fish tends to be more expensive than the traditional processed forms of fish in both North and South. However, the price of fresh fish is higher than the price of frozen fish (up until 2015). In 2015, the price of frozen fish increased significantly (by about 50% in the South and 30% in the North) compared to the previous round. The price increase is largely due to the higher exchange rate from the currency devaluation following the oil price collapse in 2013/2014.[4] Interestingly, despite the large hike in imported frozen fish prices, consumption per capita dipped only slightly in the North but increased in the South. This shows that frozen fish is not viewed as a luxury to be dropped when its price rises, but is likely a price-inelastic product, having penetrated basic consumption habits at least of certain consumer strata, particularly in the South.

Contrary to expectations, frozen fish is more expensive in the South than the North. This is surprising because the North is further away from ports through which frozen fish is imported. The result might reflect heterogeneity in the dominant kinds of fish consumed per region. A rapid reconnaissance of fish markets conducted to add information on frozen fish indicated that the North tends to consume cheaper frozen fish such as herrings, whereas relatively more expensive frozen fish such as croaker are consumed more in the South.

Controlling for inflation, the average price of fish (irrespective of form) more than doubled between 2010 and 2015, from ₦319 to ₦666 per kg (Table 4). The price of dried fish increased by over 170% in the North and over 230% in the South. This appears to be partly driven by the Boko Haram insurgency in North-Eastern Nigeria, home to the Baga market, one of the largest fish trading centres supplying dried fish to the entire country (Mukhtar and Gazali, 2016).

The price of fish rose most sharply from 2010 to 2012 (70%). This price rise was linked to a drop in fish consumption per capita of 10%. Fish prices increased, but less sharply (by 20%), from 2012 to 2015 (Table 5). During that period, fish consumption per capita rose, likely due to fish remaining the cheapest animal sourced food. The price of fresh fish declined by 20% between 2012 and 2015, perhaps in response to rapidly growing aquaculture production. This change was accompanied by an 80% increase in consumption of fresh fish.

[4]Crude oil prices declined from about $80 a barrel in 2010 to about $40 a barrel in 2015 (US Energy Information Administration, 2017).

Table 4
Descriptive statistics for key regression variables

	2010			2012			2015		
	North	South	All	North	South	All	North	South	All
Mean prices (Naira/kg)									
Price of other food	394	553	480	361	478	427	1215	1313	1270
Price of cereals and tubers	230	392	318	221	323	279	1621	1138	1352
Price of pulses	210	251	232	342	440	398	435	466	452
Price of beef and other meats	610	710	664	926	979	956	1289	1379	1339
Price of poultry and eggs	492	566	532	1070	843	940	852	788	816
Price of dairy products	414	949	704	659	1495	1136	1347	2142	1789
Price of fresh fish	360	578	478	1025	820	909	763	699	727
Price of frozen fish	324	452	393	561	614	591	723	901	822
Price of smoked fish	189	260	228	302	313	308	712	435	558
Price of dried fish	156	194	176	383	364	372	436	655	558
Price of fish	257	371	319	568	528	545	659	673	666
Other demographic characteristics									
Education (0/1)	0.6	0.7	0.7	0.6	0.7	0.7	0.6	0.7	0.7
Female head of household (0/1)	0.1	0.2	0.1	0.1	0.2	0.2	0.1	0.3	0.2
Own refrigerator/ freezer	0.1	0.3	0.2	0.1	0.3	0.2	0.1	0.3	0.2
Household adult equivalent	5.1	3.7	4.3	5.3	3.6	4.3	5.6	3.7	4.5
Total expenditure on fish (Naira/week)	26	141	88	56	145	106	53	213	142
Total expenditure on food (Naira/ week)	683	902	802	1,032	1,333	1,204	1,270	1,861	1,599
Total expenditure on non-food items (Naira/week)	412	909	677	614	1514	1116	327	741	557
Total expenditure on food and non-food items (Naira/ week)	1,085	1,761	1,451	1,637	2,760	2,277	1,597	2,602	2,156
Number of observations	4,395	4,851	9,246	4,517	4,767	9,284	4,527	4,597	9,124

Source: Authors' estimations from the LSMS-ISA 2010, 2012 and 2015 data. The prices are real prices created using CPI from the World Bank: 2010 is the base year, CPI for 2012 and 2015 are 124.382 and 158.943 respectively. Expenditure values are per capita. Due to significant variation in prices and components of categories such as other foods and cereals and tubers, median prices were also computed and show similar trends but less dramatic changes.

Table 5
Changes in fish consumption per capita and real prices, by fish type, time period, rural and urban locations and region

	2010–2012			2012–2015			2010–2015		
	North	South	National	North	South	National	North	South	National
Change in consumption per capita (%)									
Fresh fish	–23.7	–21.8	–23.2	76.7	85.2	81.5	34.8	44.9	39.5
Frozen fish	10.0	–16.4	–9.8	–9.4	4.6	0.6	–0.4	–12.5	–9.2
Smoked fish	–26.4	–8.7	–15.4	–3.0	73.4	45.2	–28.6	58.4	22.9
Dried fish	–16.1	–25.3	–21.4	–28.0	–29.5	–28.9	–39.6	–47.4	–44.1
All fish	–11.7	–11.6	–9.4	10.8	24.2	19.6	–2.2	9.8	8.4
Change in real prices (%)									
Fresh fish	184.72	41.87	90.17	–25.56	–14.76	–20.02	111.94	20.93	52.09
Frozen fish	73.15	35.84	50.38	28.88	46.74	39.09	123.15	99.34	109.16
Smoked fish	59.79	20.38	35.09	135.76	38.98	81.17	276.72	67.31	144.74
Dried fish	145.51	87.63	111.36	13.84	79.95	50.00	179.49	237.63	217.05
All fish	121.01	42.32	70.85	16.02	27.46	22.20	156.42	81.40	108.78

Source: Authors' estimations from the LSMS-ISA 2010, 2012 and 2015 data. The prices are real prices created using CPI from the World Bank: 2010 is the base year, CPI for 2012 and 2015 are 124.382 and 158.943 respectively.

4. Econometric Analysis

4.1. Empirical approach

Our demand analysis focuses on four forms of fish (fresh, frozen, smoked and dried) with other foods (beef, cereals and tubers, pulses, dairy, poultry, and eggs and 'other foods'). We assume, as is usual, that household food consumption is determined in a two-stage budgeting process (Deaton and Muellbauer, 1980). In the first stage, households allocate their total household consumption expenditures to food versus non-food items conditional on prices, income and household characteristics. In the second stage, the household allocates food consumption to different food types including the various forms of fish. We allow substitution between different fish products and other protein sources or other food groups, and estimate a full food demand system.

Preliminary local polynomial regressions (Figure 1) of fish consumption shares and total food consumption (in logs) for the North and the South[5] show that the consumption shares for most fish forms are non-linear – but also show that they are not quadratic in total food consumption (as a proxy for income). Thus, neither the Linear Approximate nor the Quadratic Almost Ideal Demand System model is appropriate for the analysis of fish demand in Nigeria. We address this by using the more flexible Exact Affine Stone Index (EASI) demand system of Lewbel and Pendakur (2009). The preliminary analysis also shows clear regional differences in the Engel curves.

4.2. The EASI demand system

We apply the EASI demand system of Lewbel and Pendakur (2009) with a pooled cross-section data.[6] The EASI demand system does not impose any particular functional form on the relationship between income and food consumption but allows for arbitrarily complex Engel curves. In addition, it allows us to control for individual preference heterogeneity across households and time-specific factors rather than leave them as part of the error term as is done in other models (Lewbel and Pendakur, 2009).

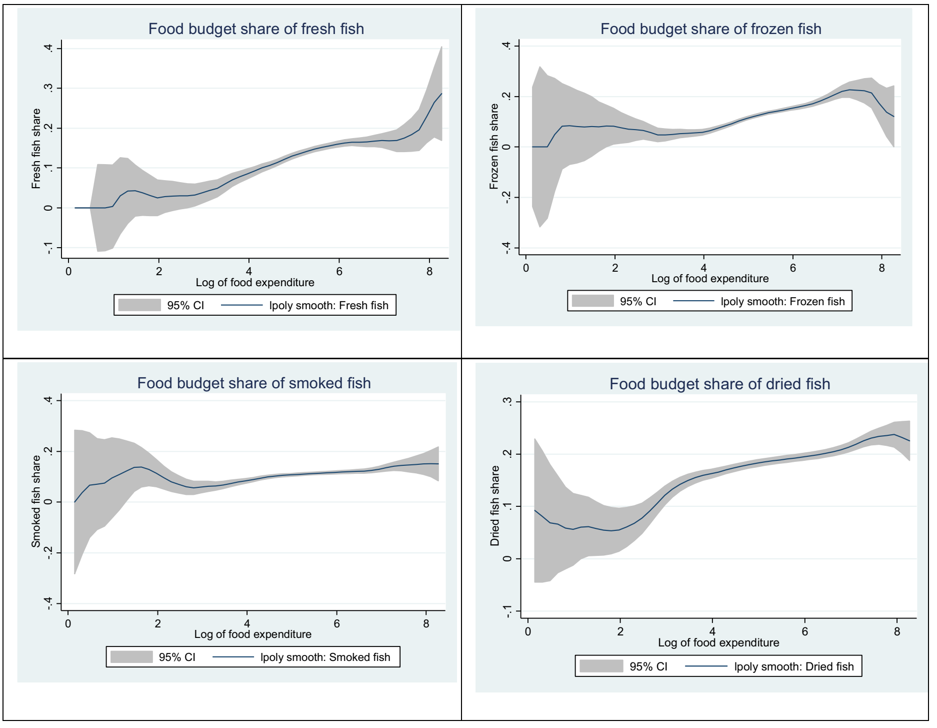
We assume that: households have demographic and other characteristics that affect food preferences, including fish products, in vector $\mathbf{z}$; households have log nominal total food consumption x; they face a vector of log prices $\boldsymbol{p}$. Households then choose a vector of consumption shares $\mathbf{w}$, to maximize utility subject to the household budget constraint.

Lewbel and Pendakur (2009) and Pendakur (2008) show how the Hicksian budget shares associated with the households utility function expressed as a function of $\mathbf{p}$ and $\mathbf{z}$ and utility level $\mathbf{u}$ can be expressed as a function of log real consumption with an implicit Marshallian consumption shares function. We follow Lewbel and Pendakur to define an implicit utility function y which only depends on observed variables. The implicit utility function is used to derive the implicit Marshallian consumption (budget) shares as follows:

[5]The advantage of this approach is that the relationship is modelled as linear in the neighbourhood but may vary across values of the log of total fish consumption. The degree of polynomial smoothing used here is 1, meaning that the graphs are a locally weighted least squares model.

[6]For the estimation of the EASI the panel data are treated as a pooled cross-section. However, for the data processing using a multivariate probit estimation approach before application to the EASI, we fully exploit the panel structure of the data.

North


Food budget share of fresh fish
Fresh fish share
Log of food expenditure
95% CI
lpoly smooth: Fresh fish
Food budget share of frozen fish
Frozen fish share
Log of food expenditure
95% CI
lpoly smooth: Frozen fish
Food budget share of smoked fish
Smoked fish share
Log of food expenditure
95% CI
lpoly smooth: Smoked fish
Food budget share of dried fish
Dried fish share
Log of food expenditure
95% CI
lpoly smooth: Dried fish

South

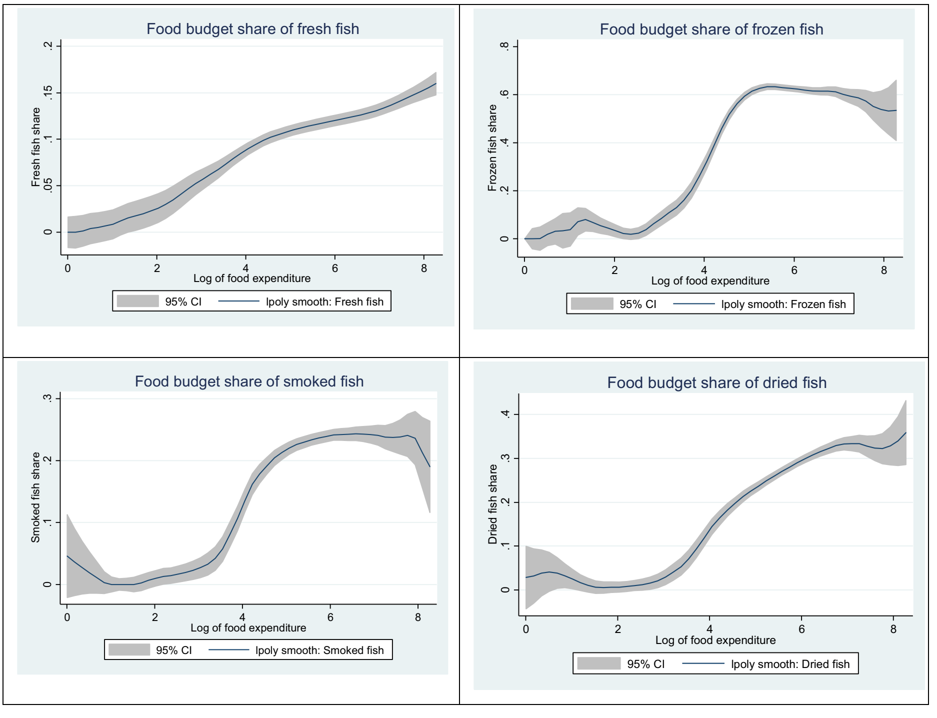

Food budget share of fresh fish
Fresh fish share
Log of food expenditure
95% CI
lpoly smooth: Fresh fish
Food budget share of frozen fish
Frozen fish share
Log of food expenditure
95% CI
lpoly smooth: Frozen fish
Food budget share of smoked fish
Smoked fish share
Log of food expenditure
95% CI
lpoly smooth: Smoked fish
Food budget share of dried fish
Dried fish share
Log of food expenditure
95% CI
lpoly smooth: Dried fish

Figure 1. Engel curves.*Note*: Conditional on the household having consumed fish.Source: Authors' estimations from the LSMS-ISA 2010, 2012 and 2015 data.

$$w = \sum_{r=0}^{R} b_r y^r + Cz + Dzy + \sum_{l=0}^{L} z_l A_l p + Bpy + \varepsilon \tag{1}$$

where ***p*** and **z** are the vector of *J* prices and *L* demographic variables and **ϵ** is a vector of error terms which include unobservable preference heterogeneity. *y* is a measure of real total food consumption and is specified as the equal affine transform of the Stone index-deflated log nominal consumption levels. That transform, by Lewbel and Pendakur (2009), is:

$$y = \frac{\ln x - p'w + \sum_l^L z_l p' A_l p/2}{1 - p'Bp/2} \tag{2}$$

The budget share expressed in equation (1) has all the desirable properties of traditional demand models with some added advantages. Similar to the Almost Ideal Demand System (AIDS) model, these implicit Marshallian budget shares are linear in parameters (thus easy to estimate) and have additive error terms including unobserved preferences due to taste and time. However, while the AIDS budget shares are linear in **p**, **z**, and *y*, the EASI budget shares are linear in **p** but are polynomials of any order in **z**and *y*. Thus, as noted above, the EASI Engel curves can take any shape through the addition of polynomials of any order in real consumption.[7] The budget shares can also include interaction terms such as **p***y*, **z***y*, and **pz'**.

Subsequently, income and price elasticities of different fish forms across regions in Nigeria can be estimated using the semi-elasticities in equations (3) and (4) below (i.e., the derivatives of the budget shares with respect to total consumption expenditures (as a proxy for income) and prices) following Lewbel and Pendakur (2009).

$$\nabla_{y'} w(p, y, z, \in) = c_l + d_l y + A_l p \tag{3}$$

$$\nabla_{p'} w(p, y, z, \in) = \sum_{l=0}^{L} z_l A_l + By \tag{4}$$

These semi-elasticities in equations (3) and (4) are easier to present algebraically and they can be converted into the relevant elasticities by dividing these expressions by the budget share.

4.3. Resolving the zero consumption and endogeneity problems

Estimating demand systems for subgroups of food often faces the 'zero consumption' problem. Three main reasons for this problem are discussed in the literature. First, households may never consume that product. Second, a limited survey period may

[7]In our analysis R is equal to 3 and the budget shares are a third order polynomial in the log-budget.

not find the household consuming a product that it might consume in a period outside the survey recall period. Third, a household might not report consuming the product because it feels it would reveal its making a bad decision (e.g. because the product was too expensive or they could not really afford it but still bought it) (Meyerhoefer *et al.*, 2005; Tafere et al., 2011). In the LSMS-ISA data, there is zero consumption for one or more fish forms among 41%, 30% and 29% of the households in 2010, 2012 and 2015, respectively.

To address this, we employ a two-step procedure to estimate a system of equations with limited dependent variables to obtain a synthetic dataset with imputed consumption for households with zero consumption (e.g. Magrini *et al.*, 2017; Tefera *et al.*, 2018). In the first step, we estimate the determinants of consuming different forms of fish (and other food groups) with a Correlated Random Effect (CRE) multivariate probit model, which accounts for correlation among the food groups (Wooldridge, 2010).[8] The explanatory variables ($\mathbf{z}_{\mathrm{is}}$) used in the estimation include a vector of log of total household consumption expenditure on food, log of prices of the 10 food groups, and demographic variables (education, gender, asset index, living in an urban area, living in the north, household adult equivalent, round of data collection and the mean of all the time-varying household characteristics. In the second step, we calculate the cumulative distribution ($\boldsymbol{\varphi}(.)$) and normal probability density functions ($\boldsymbol{\varphi}(.)$) for each food group. This is then used to generate new consumption shares for all food groups w_{it}^{*} as:

$$w_{it}^{*} = \Phi_i\left(\theta_{is}' z_{is}\right) w_{it} + \delta_i \phi_i\left(\theta_{is}' z_{is}\right) \tag{5}$$

where w_{it} is the budget share of food group i at time t and the estimated partameter δ_i is the covariance between the first and second stage error terms. As mentioned above, z_{is}' refers to the explanatory variables explaining purchasing behaviour and θ_{is} are the associated parameters for the i food groups from the multivariate probit regressions.[9] One challenge with this transformation (equation 5) is that the new consumption shares w_{it}^{*} no longer satisfy the additivity condition as required by demand theory. We address this issue by reweighting the transformed shares (Steele and Weatherspoon, 2016) to obtain w_{it}^{**}. This approach has two advantages. First, we do not have to choose arbitrarily any of the fish groups as the residual category with no specific demand. Second, it avoids obtaining negative consumption shares for the good since it is possible that the sum of the other goods is greater than one when one imposes the following condition:

$$w_{it}^{**} = w_{it}^{*} / \sum_{i=1}^{k} w_{it}^{*} \tag{6}$$

Not accounting for the endogeneity of the allocation of consumption across fish forms with respect to the demand for fish as a product category relative to demand for other food products, can lead to biased and inconsistent demand parameter

[8]The correlated random effects (CRE) estimator allows for correlation between the time invariant unobserved household omitted variable and included explanatory variables. One class of CRE models allows for modelling the distribution of the unobserved household characteristic conditional on the means of time-varying exogenous variables (Mundlak, 1978; Chamberlain, 1980).

[9]Standard errors are clustered at the household level.

estimates. To address this, we follow Lewbel and Pendakur (2009) and use an instrumental variables approach. Our instruments are logged prices and logged assets and powers of both to the third order.[10] P represents prices for each of the food groups.[11]

4.4. *Accounting for time and regional effects on fish demand*

As noted above, culture and income vary significantly between the two regions. The importance of this variation on food choices is well acknowledged (e.g. Ma, 2015). The regions differ in other characteristics as well. The major ports through which imported fish enter the country are in the South. Also, while there are many lakes and rivers dispersed across the country, the South is closer to the Atlantic Ocean, which is a major source of fish from capture fisheries. The South has also experienced a rapid growth in fish farming over the past decade. All these are likely to influence fish demand. We account for regional differences by estimating the EASI demand model separately for the North and South. Thus, we derive consumption and price elasticities by region. We do the same for rural and urban areas.

Furthermore, we use a Linear EASI demand model that controls for time-specific factors (such as season) that influence food choices and preferences for particular fish forms. Thus, we estimate equation (7) for North and South Nigeria distinguishing between rural and urban areas.

$$\begin{aligned} w_{ir}^{**j} &= \alpha_{io} + \sum_{r=1}^{R} b_{ir}^{j} y_{it}^{r} + \sum_{l=1}^{L} g_{il}^{j} z_{lit} + \sum_{k=1}^{L} a_{jki} \ln p_t^k \\ &+ \sum_{k=1}^{L} \sum_{l=1}^{L} s_{jki} z_{lit} \ln p_t^k + \sum_{k=1}^{L} b_{jk} \ln p_t^k y_{it} + \sum_{l=1}^{L} h_t^j z_{lit} y_{it} + \varepsilon_{ijt} \end{aligned} \quad (7)$$

To account for the possible heteroscedasticity of error terms and the simultaneous determination of budget shares and total consumption, the estimation of the EASI demand system in the software R uses an iterative linear three-stage least squares (3SLS) estimator as in Hoareau *et al.* (2012) that is similar to Blundell and Robin (1999).

5. Regression Results

The estimated expenditure elasticities from the EASI for different food items and fish forms are reported in Table 6. Several points stand out.

First, as incomes rise, Nigerians consume more of all forms of fish: frozen, fresh, smoked, or dried; imported or domestic. However, in Southern Nigeria imported frozen fish has the lowest expenditure elasticity (compared to all other fish forms). This shows it is likely a necessity in the South. By contrast, in the North, frozen fish has an expenditure elasticity above 1, and hence is a 'luxury'. This shows how deeply imports have penetrated the basic fish consumption habits of the South, but in the North are limited to the middle class.

Second, fresh fish have the highest consumption elasticities (among all fish forms) and remain a luxury. A 1% increase in income is associated with an increase of 1.1%

[10]The analysis was a three-stage least squares estimation and the budget shares are a third order polynomial in the log budget with R = 3.

[11]We recognise the possibility of price endogeneity due to the simultaneity between supply and demand. We attempt to reduce concerns about this with our location controls (rural and urban) and other household demographic characteristics.

and 1.2% in expenditure on fresh fish in the North and the South respectively. This is a strong indicator of the potential for domestic aquaculture to grow further as incomes increase in Nigeria.

Third, the expenditure elasticities for smoked and dried fish indicate they are luxuries in the South (Table 6) on average. This is surprising given that these are the traditional forms in which fish are consumed. By contrast, the lowest elasticity in the North (among fish forms) is for the traditional largely domestic dry fish, indicating it as a necessity rather than luxury. A closer look shows that rural consumers drive the inelasticity of dried fish in the North, as their consumption elasticity is lower than urban consumers for dried fish. Higher responsiveness among urban consumers in the North might reflect some sort of quality trade-off between types of dried fish. Our data cannot disaggregate between different types of dried fish such as stock fish, which is much more expensive than other traditional dried fish. Similar explanations could also explain the higher expenditure elasticities for dried fish in urban areas (compared to rural areas) in the South.

Table 7 shows the own- and cross-price elasticities of different foods and fish forms, by region, and by urban versus rural. As predicted by demand theory, compensated own-price elasticities are negative for all the food groups and fish forms. The own-price elasticities of all food groups (except dairy in the North and cereals, poultry and dairy in the South) are inelastic.

When own price increases, households in the North tend to reduce the quantities of fresh fish purchased the most while households in the South tend to reduce the quantities of frozen fish consumed the most, for both urban and rural areas in both regions. For the North, this finding is consistent with our earlier finding that fresh fish is a luxury with high consumption elasticities. Overall, southerners reduce the quantity of smoked fish the least while Northerners reduce that of frozen fish the least because of changes in own prices.

Finally, we compare the cross-price elasticities to see the substitutability and complementarity among fish types as well as food groups. Though statistically significant,

Table 6
Expenditure elasticities by fish type, rural and urban locations and region

	North			South		
	Rural	Urban	All	Rural	Urban	All
Fresh fish (domestic)	1.10***	1.09***	1.09***	1.17***	1.19***	1.18***
Frozen fish (imported)	1.07***	1.05***	1.05***	0.91***	0.91***	0.91***
Smoked fish (domestic)	1.07***	1.09***	1.08***	1.04***	1.09***	1.06***
Dried fish (domestic)	0.95***	0.97***	0.97***	0.99***	1.05***	1.02***
Cereals and tubers	0.97***	1.10***	0.99***	0.84***	0.83***	0.83***
Pulses	0.81***	0.75***	0.81***	0.90***	0.84***	0.88***
Beef and other meats	0.99***	0.91***	0.97***	1.05***	0.99***	1.03***
Poultry and eggs	1.42***	1.25***	1.35***	1.37***	1.24***	1.30***
Dairy products	1.19***	1.08***	1.15***	1.15***	1.08***	1.12***
Other food	0.74***	0.81***	0.75***	0.77***	0.89***	0.81***

Source: Authors' calculation from the EASI model estimation. ***$P < 0.01$, ** $P < 0.05$, * $P < 0.1$.

Table 7
Compensated own- and cross-price elasticities by rural and urban locations and region

	Cereals and tubers	Pulses	Beef and other meats	Poultry and eggs	Dairy products	Fresh fish	Frozen fish	Smoked fish	Dried fish	Other food
North – Rural										
Fresh fish(domestic)	0.02***	0.03***	–0.05***	–0.05***	–0.02***	–0.91***	–0.17***	0.03***	0.01***	0.09***
Frozen fish (imported)	–0.003**	–0.06***	0.02***	0.007**	0.02***	–0.16***	–0.65***	–0.11***	0.05***	–0.06***
Smoked fish (domestic)	0.009***	–0.04***	–0.05***	–0.08***	–0.002***	0.02***	–0.11***	–0.73***	–0.002	0.05***
Dried fish (domestic)	–0.03***	–0.003	0.002	–0.12***	–0.002**	0.002	0.05***	–0.01***	–0.84***	–0.05***
Cereals and tubers	–0.98***	–0.005	0.01***	–0.03***	0.02***	0.03***	–0.002	0.02***	–0.05***	–0.04***
Pulses	–0.01***	–0.98***	0.06***	0.13***	–0.04***	0.04***	–0.14***	–0.10***	0.001	–0.006
Beef and other meats	0.01***	0.06***	–0.92***	–0.10***	–0.05***	–0.10***	0.05***	–0.10***	0.02***	–0.04**
Poultry and eggs	–0.01***	0.06***	–0.04***	–0.90***	0.01***	–0.04***	0.01***	–0.07***	–0.08***	0.07***
Dairy products	0.02***	–0.01***	–0.03***	0.02***	–1.03***	–0.02***	0.05***	0.01***	0.02***	0.02***
Other food	–0.03*	–0.002	–0.03	0.09***	0.01	0.09***	–0.07***	0.06***	–0.04***	–1.01***
North – Urban										
Fresh fish (domestic)	0.03***	–0.01*	–0.03***	0.01***	–0.02***	–0.93***	–0.17***	0.03***	0.02***	0.11***
Frozen fish (imported)	–0.02***	–0.01	–0.004	–0.01***	0.03***	–0.21***	–0.72***	–0.10***	0.03***	–0.10***
Smoked fish (domestic)	0.01***	–0.04***	–0.04***	–0.09***	–0.001	0.02***	–0.06***	–0.68***	0.02***	0.05***
Dried fish (domestic)	–0.02***	0.01*	–0.03***	–0.08***	0.01***	0.01**	0.02***	0.02***	–0.84***	–0.02***
Cereals and tubers	–0.99***	–0.04***	0.006	–0.002	0.01***	0.06***	–0.01***	0.03***	–0.02***	–0.02
Pulses	–0.07***	–0.95***	0.07***	0.04***	0.03***	–0.03***	–0.02**	–0.11***	0.01	–0.05
Beef and other meats	–0.01**	0.08***	–0.83***	–0.03***	–0.07***	–0.07***	–0.01	–0.12***	–0.06***	–0.03
Poultry and eggs	–0.01**	0.04***	–0.01*	–0.93***	–0.01***	0.02***	–0.01***	–0.16***	–0.10***	0.09***
Dairy products	0.01*	0.04***	–0.05***	–0.01***	–1.03***	–0.03***	0.04***	0.00	0.02***	0.02*
Other food	–0.03	–0.03	–0.02***	0.07***	0.01	0.12***	–0.06***	0.07***	–0.03*	–1.03**
South – Rural										
Fresh fish (domestic)	0.04***	–0.01***	–0.09***	–0.07***	–0.04***	–0.84***	–0.02***	0.01***	0.01***	0.09***
Frozen fish (imported)	0.01	–0.06***	0.05***	0.02***	–0.07***	–0.06***	–0.88***	0.002	–0.01***	–0.02**
Smoked fish (domestic)	0.04***	–0.08**	–0.06***	–0.10***	–0.004***	0.02***	0.01***	–0.86***	0.02***	0.06***

Table -0007
(*Continued*)

	Cereals and tubers	Pulses	Beef and other meats	Poultry and eggs	Dairy products	Fresh fish	Frozen fish	Smoked fish	Dried fish	Other food
Dried fish (domestic)	–0.02***	0.01***	–0.03***	–0.10***	–0.05***	0.01***	–0.01***	0.01***	–0.87***	0.01*
Cereals and tubers	–1.06***	–0.02***	0.02***	–0.002	0.02***	0.04***	0.002	0.02***	–0.01***	0.001
Pulses	–0.03***	–0.95***	0.07***	0.03***	0.02***	–0.03***	–0.06***	–0.12***	0.03***	–0.01
Beef and other meats	0.04***	0.05***	–0.97***	–0.02***	0.01**	–0.20***	0.06***	–0.08***	–0.03***	0.003
Poultry and eggs	0.01	0.02***	–0.01**	–0.99***	0.01***	–0.09***	0.02***	–0.08***	–0.07***	0.10***
Dairy products	0.05***	0.02***	0.01***	0.02***	–1.03***	–0.07***	–0.04***	0.002	–0.04***	0.06***
Other food	–0.02	–0.04***	–0.03**	0.13***	0.03***	0.18***	–0.04***	0.06***	–0.10*	–1.11***
South – Urban										
Fresh fish (domestic)	0.09***	–0.01**	–0.09***	–0.04***	–0.04***	–0.87***	–0.03***	–0.02***	0.01***	0.13***
Frozen fish (imported)	–0.01	–0.01	0.09***	0.02***	–0.03***	–0.10***	–0.95***	–0.01**	–0.08***	–0.01
Smoked fish (domestic)	0.03***	–0.08***	–0.07***	–0.05***	0.004**	–0.03***	0.003	–0.82***	0.02***	0.06***
Dried fish (domestic)	0.01***	–0.004	–0.01***	–0.06***	–0.02***	0.01***	–0.04***	0.02***	–0.85***	0.02**
Cereals and tubers	–1.01***	–0.04***	–0.001	0.002	0.02***	0.10***	–0.01***	0.01***	–0.002	–0.011
Pulses	–0.06***	–0.94***	0.03***	0.04***	0.03***	–0.03***	0.002	–0.13***	–0.01	–0.02
Beef and other meats	0.01*	0.03***	–0.93***	–0.01	0.003	–0.23***	0.09***	–0.11***	–0.03***	0.001
Poultry and eggs	0.02***	0.04***	–0.002	–1.00***	–0.01*	–0.09***	0.03***	–0.07***	–0.08***	0.08***
Dairy products	0.05***	0.03***	0.01**	–0.01*	–1.02***	–0.09***	–0.02***	0.01**	–0.03***	0.03***
Dried fish	0.01***	–0.004	–0.01***	–0.06***	–0.02***	0.01***	–0.04***	0.02***	–0.85***	0.02**
Other food	–0.02	–0.03	–0.01	0.06***	0.01	0.21***	–0.01	0.06***	0.004	–1.15***

***$P < 0.01$,
**$P < 0.05$,
*$P < 0.1$.

the cross-price elasticities of different fish forms are extremely small. This implies they occupy specific niches in local cuisines. Several fish forms are complements to poultry products. In the South, frozen fish is the exception as it is substitute to poultry products. Households appear to consider the different fish forms and poultry products as distinct food items, consistent with their use in different dishes in a given multi-dish meal for a family, or over different meals in the day, or even in joint use in various traditional dishes. Surprisingly, imported frozen fish is the only substitute for beef and other meats. Thus, as beef and other meat prices increase, more imported frozen fish is consumed.

6. Conclusions

Our analysis of nationally representative food expenditure data in Nigeria yield several key findings. First, fish is among the most important sources of animal protein in Nigeria. It accounts for 10% of the total food budget and 35% of the budget allocated to animal source foods of the average Nigerian, rising to 45% in the South.

Second, fish is the cheapest animal protein consumed, with a price significantly lower than that of poultry and eggs as well as other meats, and less than half that of dairy products. This status underlines the importance of fish in Nigeria for food and nutrition security.

Third, there are substantial differences in fish consumption between the poorer North and the richer South. In the South, 90% of households consume fish (accounting for 11% of total food consumption expenditures), versus 50% in the North (with 3% of food outlay). Conditional on consuming some fish, the per capita fish consumption is about 1.2 times higher in the South than the North but not too different between urban and rural areas in each region.

Fourth, frozen (imported) fish makes up 30% of total fish consumption in Nigeria. This national figure masks a large difference between the more developed South (closer to ports for imports, with more refrigeration and higher incomes), with 40% of fish consumption as frozen, compared with 13% in the North.

Fifth, the share of imported frozen fish in rural fish consumption is 20%, versus 35% in urban areas. Urbanization is associated with more consumption of imported frozen fish. Rural fish consumption is much more skewed toward traditional forms (dried, smoked) than frozen/imported, because of differences in access to and costs of the different product types and refrigeration facilities. Urban consumers appear more likely to shift to frozen and fresh fish (partly from rapidly growing aquaculture) and pay more for it. Yet despite these general differences, there is still a non-trivial share of frozen/imported fish consumed in rural areas, at levels similar to smoked and fresh fish. However, smoked and dried fish together account for half of total fish consumption in Nigeria, underlining the continuing importance of these product forms for food and nutrition security.

Sixth, our EASI elasticity estimates show that while frozen imported fish is largely a necessity in the South (but still a luxury in the North), domestically produced fish (particularly fresh fish) remains a luxury with much higher elasticities. These results indicate that if incomes increase in Nigeria, spending on most forms of domestically produced fish will increase more than proportionately.

Together, these findings suggest that fish plays an important role in food and nutrition security in Nigeria. This can be further supported with investment and interventions to increase supplies of fish and reduce the cost of fish to the consumer. This is of particular concern in the North where food security is low and still only about 50% of households consume fish. The higher cost of imported products since 2015 and the 2019 devaluation of the naira have created a greater opportunity for domestic fish production to compete with imported fish.[12]

The highly differentiated nature of demand for fish by product type and geographical region revealed here suggests that multiple policy responses may be required. These could include: (i) Ensuring that trade restrictions are not imposed on imported frozen fish, which are shown to make up a significant part of the food basket even in rural areas of the North (where ~95% is purchased); (ii) Supporting the expansion and increasing the productivity and efficiency of the domestic aquaculture sector to increase supplies of fresh fish and produce raw material for fish smokers and driers; (iii) Instituting governance arrangements and regulations that maintain the long-term productivity of inland and marine capture fisheries at sustainable levels, to ensure continued provision of fresh, dried and smoked fish from these sources.

Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Table S1

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