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Demand for Fish by Species in India: Three-stage Budgeting Framework*

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Abstract

The demand studies for the fish sector are limited by their high degree of aggregation, and the lack of empirical basis for estimating the underlying elasticity of demand. In this study, the three-stage budgeting framework with quadratic almost ideal demand system (QAIDS) model has been used for fish demand analysis by species, using consumer expenditure survey data of India. Income and price elasticities of fish demand have been evaluated at mean level for different economic groups and have been used to project the demand for fish to a medium-term time horizon, by the year 2015. The domestic demand for fish by 2015 has been projected as 6.7-7.7 million tonnes. Aquaculture would hold the key to meet the challenges of future needs. Among species, Indian major carps (IMC) would play a dominating role in meeting the fish demand. Results have shown that the estimated price and income elasticities of demand vary across species and income classes. Fish species have not been found as homogenous commodities for consumers. All the eight fish types included in the study have been found to have positive income elasticity greater than one for all the income levels. Hence, with higher income, fish demand has been projected to increase substantially with change in the species mix. The own-price elasticities by species have been found negative and near to unitary.

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1. Introduction

The emerging production technologies, higher economic growth, population explosion and shifts in dietary pattern are the driving force for rapid growth in the demand for food of animal origin. During 1980 to 2000, the per capita consumption of milk increased from 43 kg to 63 kg, of fish from 3.5 kg to 5.8 kg, and of meat and poultry from 5 kg to 6.8 kg (Paroda and Kumar, 2000). The consumption of fish has grown faster than that of any other animal product. Disparities in the fish consumption pattern exist widely across the income groups, location of the households (rural, urban, costal, etc.), and regions (Kumar and Dey, 2004). The fish production and consumption in India is characterized by a large number of species coming from marine and inland sources. Each species varies with its commercial value which is governed by the catch and production pattern, consumer's taste and preference. Production requirements, consumer's preference and demand elasticity may vary across sources of fish and its species. A useful description of trends in the fish sector requires a disaggregated demand analysis of fish by the species groups.

The available demand studies on the fish sector are limited by their high degree of aggregation, and lack of empirical basis for estimating the underlying elasticity of demand (Dey, 2000; Delgado *et al*., 2003; Dey and Ahmed, 2005). A description of fish demand is imperative for the rational and pragmatic planning for specific fish types. The disaggregated results of the study are useful in the developments of national fish production strategy, evaluation of impact assessment of technology, prioritization of fish technologies and management options to benefit the poor households, both consumers and producers. Demand elasticities are of crucial importance for ex-ante and ex-post evaluation techniques, and for finding the current and future status of fish industry in the country. To date, there has been virtually no published literature about fish demand analysis in India at the species level. In the few available studies, fish has been treated as an aggregate commodity in their demand models (Paroda and Kumar 2000; Kumar and Dey, 2004). The present paper has examined the fish consumption pattern with analysis of fish demand by species group[4], based on food survey data in India. The demand parameters have been used to project fish demand by species group in the medium term, by the year 2015.

2. The Data

The National Sample Survey (NSS) in India is the only source of data on consumer expenditure survey. But this national survey does not collect

[4] Fish species were grouped into species groups with the help of experts based on biological value, commercial value and market destinations.

Table 1. Consumption pattern based on present study survey and National Sample Survey (NSS) data

Item	NSS survey 1999-00 (Large national sample)	Study survey 2002-03 (Small sample of selected states)
Food consumption (kg/capita/annum)		
Cereals	149.0	162.3
Pulses	12.8	11.4
Milk	61.2	46.5
Eggs(number)	31.3	29.4
Meat	5.0	6.8
Fish	5.6	7.5
Share of total expenditure (%)		
Food	57.7	70.3
Non-food	42.2	29.7
Total expenditure (Rs/capita/year)	8174	7338

the data on fish consumption by species. Therefore, for this study, a household dietary-pattern survey was conducted in the states of Andhra Pradesh, Haryana, Karnataka, Uttar Pradesh, West Bengal and Orissa in the year 2002. The data on dietary pattern and fish consumption by species during the last 7 days from the visit date were collected from 591 fish-eating families in the rural and 569 families in the urban areas. The survey was conducted in two rounds, covering peak and lean periods of fish production (for detailed sampling plan, see Mruthyunjaya, 2004). The dietary pattern based on the current survey was consistent with the NSS survey data (Table 1).

A large number of fish species was used by the consumers in their dietary pattern. The fish species were aggregated into 8 groups (given in Table 2) to keep the demand model simple. These groups were formed on the basis of commercial value, price, taste and preferences of fish species by consumers and experts' opinion. The Indian major carps constituted almost half of the total fish consumption, followed by the pelagic low-value (17.6 %), fresh water carps (13.2 %), shrimps, including freshwater and marine (6.6 %), pelagic high-value (6.1 %), demersal (4.4 %) and molluscs (2.7%).

3. The Demand Model

A multi-stage (three-stage) budgeting framework was used for modelling the behaviour of fish-eating households (see, for example, Blundell *et al*.,1993; Fan *et al*., 1995; Tiffin and Tiffin, 1999; Dey, 2000; Kumar and Dey, 2004; Dey *et al*., 2005; Garcia *et al*., 2005). In the first stage, the household makes decisions on how much of its total income (expenditure) is to be

Table 2. Basic characteristics of different fish groups, India, 2002-03

Fish group	Average price (Rs / kg)	Share of different fish groups in total fish consumption in the sample households (%)	Major fish species
I : Indian major carps (IMC)	43	49.4	Rohu, catla, mirgal
II : Other freshwater fish (OFWF)	39	13.2	Common carp, silver carp, tilapia, mangur grass carp, fresh water captured fish
III :Prawn/Shrimp	107	6.6	High-value crustaceans (prawn, shrimp, lobsters), crabs
IV: Pelagic high-value (PHV)	91	6.1	Pomfrets, seerfish, pelagic sharks, tunas
V: Pelagic low-value (PLV)	25	17.6	Anchovies, Bombay duck, sardines, mackerel, clupeid, horse mackerel
VI: Demersal high-value (DHV)	67	1.6	Rock cods, snappers, lactarius, threadfins
VII: Demersal low-value (DLV)	31	2.8	Catfish, goat fish, silverbellies, nemipterids, lizard fishes
VIII: Molluscs	29	2.7	Mussels, oysters, other low-value fishes

allocated for food consumption, conditional on consumption of the non-food commodities and the household and demographic characteristics. In the second stage, the household allocates a portion of food expenditure on fish consumption. In the third stage, the household distributes the total fish expenditure among different fish species. The specific functional form was used in the three stages as given below.

3.1. Food Expenditure Function

The food expenditure function was given by Equation (1):

$$\ln (M) = \alpha + \gamma_1 \ln (P_f) + \gamma_2 \ln (P_{nf}) + \beta \ln (Y) + \Sigma\, \theta_j Z \qquad \ldots(1)$$

where, M was the per capita food expenditure; Y was the per capita total expenditure (income); P_f was the household-specific Stone price index for food; and P_{nf} was per capita non-food expenditure. The socio-demographic and conditioning variables (vector Z) included the ratio of adults in the household, family size, and urban dummy. The parameter β was allowed to vary with income as per Eq. (2):

$$\beta = \beta_0 + \beta_1 \ln (Y) \qquad \ldots (2)$$

Equation (1) was estimated by the ordinary least squares (OLS) method, and homogeneity of degree zero in prices and income was imposed by restricting $\gamma_1 + \gamma_2 + \beta_0 + 2\beta \ln (Y) = 0$ at the sample mean of ln (Y).

3.2. Fish Expenditure Function

In the second stage, fish expenditure was specified as follows:

$$\ln (F) = \alpha' + \Sigma\, \gamma'_i \ln (P_i) + \beta' \ln (M^*) + \Sigma\, \theta'_j Z \qquad \ldots(3)$$

where, F was per capita fish expenditure; P_i was the vector of prices including cereal, pulses, milk, eggs, meat and household-specific Stone price index for fish; and M^* was the predicted per capita food expenditure derived from Eq. (1). Vector (Z) included family size, and urban dummy. The parameter β' was allowed to vary with total food expenditure as:

$$\beta' = \beta'_0 + \beta'_1 \ln (M^*) \qquad \ldots(4)$$

Equation (3) was estimated by the OLS method by imposing homogeneity restriction of degree zero in prices and food expenditure at sample mean of ln(M^*). The data used in the study belonged to the fish-eating sample households and thus, fish consumption was non-zero across sample households.

3.3. Quadratic Almost Ideal Demand System (QUAIDS) Model

In the third stage of the analysis, the quadratic extension to Deaton and Muellbauer's (1980) almost ideal model (QUAIDS) for fish demand system was used. This formulation is quite useful and was adopted recently by Meenakshi and Ray (1999) for food demand analysis in the case of India and by Dey *et al*. (2005) for the Asian fish demand. The specific functional form used in the present analysis was:

$$S_i = a_i \sum_j b_{ij} \ln(FP_i) + c_i \ln\left(F^*/I\right) + d_i Urban + e_i IMR_i \qquad \ldots(5)$$

where, FP_i was the price of the i^{th} species of fish; F^* was the predicted per capita fish expenditure derived from stage 2; I was the Stone price index for fish; *Urban* was a binary dummy variable for urban areas; and the IMR_i were the inverse mills ratios that were incorporated to correct for the sample bias created by the presence of numerous zero consumption of the i^{th} fish type (see below for estimation procedure of IMR). The coefficient c_i was allowed to vary with per capita fish expenditure as:

$$c_i = c_{i0} + c_{i1} \ln\left(F^*/I\right) \qquad \ldots(6)$$

The parameters of the model (a_i, b_{ij}, c_i, d_i and e_i) were estimated by imposing the homogeneity (degree zero in prices), symmetry (cross-price effects were same across the goods), and adding up (all the budget shares added up to one) restrictions.

The following restrictions were econometrically imposed:

Homogeneity: $\sum_{j=1}^{n} b_{ij} = 0$

Symmetry: $b_{ij} = b_{ji}$

Adding up: $\sum a_i = 1, \ \sum_i c_{i0} = \sum_i b_{ij} = \sum_i d_i = 0$.

Linear SURE procedure with above restrictions was used and the share equations for seven types of fish [Indian major carp (IMC), other freshwater fish (OFWF), shrimp, pelagic high-value (PHV), pelagic low-value (PLV), demersal high-value (DHV), and demersal low-value (DLV)] were estimated. The coefficients of eighth fish group (molluscs) equation were obtained by using the theoretical (adding-up) restrictions in conjunction with the estimated coefficients of the other seven equations.

3.3.1. Estimation of IMR

The estimation procedure of IMR involves two steps (Heckman, 1979). First, a probit regression is computed that determines the probability that a household will consume a fish type in question. The decision to consume is modelled as a dichotomous choice problem, e.g. $Y_i = 1$ if the i^{th} fish type is consumed, otherwise $Y_i = 0$. Thus, for the i^{th} fish type, the probability that a given household would consume $P[Y_i = 1]$ was modelled as (the subscript for household has been omitted for simplicity):

Prob $[Y_i = 1] = f(P, F^*, U)$

where, P was a vector of prices of the different fish types (species group), including the i^{th} fish type, F^* was the predicted per capita fish expenditure obtained from stage 2, and U was the urban dummy. This probability was then used to compute IMR of the i^{th} fish type for each household.

For $Y_i = 1$ (i.e. consuming households)

$IMR_i = \phi\ (P[Y_i = 1])\ /\ \psi(P[Y_i = 1])$

For $Y_i = 0$ (i.e. non-consuming households)

$IMR_i = \phi\ \{P[Y_i = 1]\}\ /\{1 - \psi(P[Y_i = 1])\}$

where, ϕ and ψ were the density and cumulative probability functions, respectively.

3.3.2. Fish Income Elasticity

Using the estimated parameters, the fish expenditure elasticity fot the i^{th} fish type was computed as per Eq. (7):

$$\eta_i = \left(c_{i0} + 2c_{i1}\ln(F^*)/w_i\right) + 1 \qquad \ldots(7)$$

The income elasticity of demand for an individual type of fish (η_i^y) was computed as the product of fish expenditure elasticity of the individual fish type (η_i), fish expenditure elasticity with respect to food expenditure (η^f) and food expenditure elasticity with respect to total income (η^y) were computed as:

$$\eta_i^y = \eta_i \times \eta^f \times \eta^y \qquad \ldots(8)$$

where,

$$\eta^y = \partial\ln(M)/\partial\ln(Y) = \beta_0 + \beta_1\ln(Y) = \beta \text{, and} \qquad \ldots(9)$$

$$\eta^f = \partial\ln(F)/\partial\ln(M^*) = \beta'_0 + \beta'_1\ln(M^*) = \beta' \qquad \ldots(10)$$

The expenditure (income) elasticities were computed at the mean level of ln(F^*), ln(Y), and ln(M^*).

3.3.3. Price Elasticity

The uncompensated price elasticities were computed as:

$$\xi_{ij} = \left(\frac{b_{ij}}{w_i}\right) - \left(c_{i0} + 2c_{i1}\ln(F)\right)\left(\frac{w_j}{w_i}\right) - k_{ij}$$

where, k_{ij} was the Kronecker delta, which had the value of one for own-price elasticity and zero for cross-price elasticity; and w_i was the share of the i^{th} fish type used as a weight in constructing Stone's price index for fish. Once the expenditure and uncompensated price elasticities were estimated, the compensated (Hicksian) own- and cross-price elasticities were computed using the Slutsky equation in elasticity form:

$$\xi_{ij}^{H} = \xi_{ij} + w_j \eta_i$$

Thus, compensated elasticities captured both price effect as well as income effect. The uncompensated elasticities of demand captured only price effect. Both uncompensated and compensated price elasticities were computed at the mean levels of variables.

4. Results and Discussion

4.1. Fish Consumption by Species

Based on food expenditure survey in the six states of India, the annual per capita fish consumption by species group for rural and urban consumers has been given in Table 3. The average annual per capita consumption of IMC for rural consumers was 4.23 kg, which ranged from 2 kg for the lower (poor) to 7.89 kg for the higher (rich) expenditure classes. The average marine fish consumption of rural consumers was dominated by PLV, which ranged from 1.11 kg for the poor to 2.19 kg for the rich class. Among the marine fishes, the next important species group was DLV, which ranged from 110 grams for the poor to 280 grams for the rich classes. Among the urban consumers, the IMC dominated the consumption basket of fish. The lowest expenditure classes in the urban areas consumed 2.90 kg annually, which was slightly higher than by their counterparts in the rural areas. However, the consumption of IMC was only 3.18 kg for the rich class in the urban areas compared to 7.98 kg for their counterparts in the rural areas. The diversification of fresh water aquaculture had significantly increased the accessibility of fish in the rural areas and hence, the consumption of fish had replaced the other substitutes. On the other hand, in the urban areas carps were one among the many varieties of fish and hence, there was more uniformity in its consumption. Among the marine fishes, the consumption of PLV fishes ranged from 210 grams for the poor to 1.78 kg for the rich class. It was clear that the consumption of all types of fishes tend to increase significantly with increase in the per capita total expenditure, thus indicating that the per capita fish consumption would increase significantly under higher income scenarios.

Among the rural consumers and producers, carps constituted 70 per cent of the total consumption, followed by PLV fishes. The DHV fishes were mostly consumed only by the rich class and it constituted 1.3 per cent and 2.5 per cent only of the quantity of fish consumed by the rural and urban consumers, respectively. IMC and pelagic constituted the major share of the total fish consumption. Further, the fish consumption generally tended

Table 3. Annual per capita fish consumption (kg) in India by species: 2002-03

Fish Group	Expenditure groups				
	I	II	III	IV	All groups
Rural consumers					
Freshwater fish					
Indian major carps	2.04	3.47	4.83	7.98	4.23
Other freshwater fish	0.66	0.87	0.96	1.66	0.97
Prawn	0.02	0.07	0.07	0.13	0.07
Marine fish					
Pelagic high-value	0.01	0.31	0.45	0.88	0.37
Pelagic low-value	1.11	1.03	1.43	2.19	1.35
Demersal high-value	0.00	0.07	0.18	0.19	0.10
Demersal low-value	0.11	0.31	0.17	0.28	0.22
Shrimp	0.00	0.06	0.16	0.19	0.10
Crabs	0.01	0.15	0.06	0.39	0.13
Molluscs	0.02	0.21	0.42	0.65	0.30
Urban consumers					
Freshwater fish					
Indian major carps	2.90	2.56	2.37	3.18	2.80
Other freshwater fish	0.67	1.33	1.03	0.99	1.04
Prawn	0.06	0.15	0.29	1.15	0.57
Marine fish					
Pelagic high-value	0.01	0.16	0.49	1.17	0.63
Pelagic low-value	0.21	0.70	1.54	1.78	1.28
Demersal high-value	0.02	0.04	0.17	0.23	0.14
Demersal low-value	0.13	0.13	0.24	0.23	0.20
Shrimp	0.02	0.05	0.13	0.23	0.14
Crabs	0.07	0.14	0.26	0.12	0.15
Molluscs	0.00	0.00	0.00	0.01	0.00
All sample households					
Freshwater fish					
Indian major carps	2.23	3.22	4.00	5.17	3.72
Other freshwater fish	0.66	1.00	0.98	1.27	1.00
Prawn	0.03	0.09	0.15	0.72	0.25
Marine fish					
Pelagic high-value	0.01	0.27	0.46	1.05	0.46
Pelagic low-value	0.91	0.94	1.47	1.95	1.32
Demersal high-value	0.00	0.06	0.18	0.21	0.12
Demersal low-value	0.11	0.26	0.19	0.25	0.21
Shrimp	0.01	0.06	0.15	0.22	0.11
Crabs	0.02	0.14	0.13	0.23	0.14
Molluscs	0.01	0.15	0.28	0.27	0.19

I : Quartile 1- Per capita weekly expenditure < Rs 85
II : Quartile 2- Per capita weekly expenditure Rs 85 - 121
III : Quartile 3- Per capita weekly expenditure Rs 122 - 170
IV : Quartile 4- Per capita weekly expenditure > Rs 170

to increase with income and the share of total expenditure on fish was almost two-fold for rich as compared to poor classes.

4.2. Estimation of Demand Model

The estimated parameters of total food expenditure function are given in Table 4. The explanatory variables included in the model explained 59 per cent of the total variation. The coefficients of food and non-food price factors had negative and significant effect on the total food expenditure, as expected. The squared-term of per capita total income variable was not significantly different from zero, indicating that the response of food expenditure to income changes was not non-linear. The linear term of per capita total income variable was positive and significant, indicating that the response of food expenditure to income changes was substantial. The per capita expenditure on food declined with increase in the number of persons in a family. The family composition with more adults depicted a decline on per capita food expenditure. Urbanization had a positive impact on the food expenditure. The food expenditure elasticity with respect to income was estimated to be 0.96, implying that the household would allocate 96 per cent of their additional income to food.

The estimated fish food expenditure function is given in Table 5. The adjusted R^2 value of the function was 0.52. The coefficients of the total food expenditure variable and its squared-terms were significant. This suggested that the response of food expenditure to changes in fish expenditure was non-linear. At the mean level, the fish expenditure elasticity with respect to food expenditure was estimated to be highly elastic (1.69). It ranged from 1.71 for the poorest quartile to 1.69 for the richest quartile, suggesting

Table 4. Estimated food expenditure function, India: 2002-03

Variables	Regression coefficient	Standard error	t-value
Intercept	2.29673	0.2946	7.8
ln (Stone price index for food)	-0.40797	0.0122	-33.45
ln (per capita non-food expenditure)	-0.54473	0.0143	-38.09
ln (per capita total income)	0.99024	0.10926	9.06
[ln (per capita total income)]^2	-0.00343	0.00968	-0.35
Ratio of adults in the household	0.18196	0.0323	5.63
Family size	-0.00318	0.00128	-2.47
Urban dummy	0.11647	0.0141	8.26
Adjusted R^2	0.5926		
Number of observations	1911		

Table 5. Fish expenditure function, India: 2002-03

Variables	Regression coefficient	Standard error	t-value
Intercept	63.6785	10.44812	6.09
ln (price of cereals)	2.36328	0.42233	5.6
ln (price of pulses)	5.80957	0.54646	10.63
ln (price of milk)	-1.63416	0.60504	-2.7
ln (price of eggs)	-7.89698	0.88107	-8.96
ln (price of meat)	-1.67384	0.66544	-2.52
ln (price of fish)	1.87336	0.252	7.43
ln (per capita food expenditure)[a]	-42.3494	4.35157	-9.73
[ln (per capita food expenditure)]^2	5.79777	0.47801	12.13
Ratio of adults in the household	-1.07616	0.49073	-2.19
Family size	-0.05532	0.01999	-2.77
Urban dummy	-2.68141	0.22517	-11.91
Adjusted R^2	0.5228		
Number of observations	1911		

[a] Predicted value of ln(per capita food expenditure) from stage 1 Table 4.

that the elasticities were not varying with the increase in food expenditure. The prices of livestock products (milk, meat, eggs) had a negative and significant effect on per capita consumption of fish food. Higher prices of milk, meat, and eggs would lead to substitution of livestock by fish and induce the fish demand. The higher price of fish would not lead to a cut in the fish expenditure. The substitution from livestock to fish seemed to be strong while reverse was not true. The higher price of foodgrains (cereals and pulses) would not result in a cut in the expenditure on fish. Fish seemed to be staple food for the fish-eating population in the study area. The larger family size in the household reduced the per capita consumption of fish food.

Estimates of the parameters of the quadratic LA/AIDS demand system for fish groups (IMC, OFWF, shrimp, PHV, PLV, DHV, and DLV) have been given in Table 6. The explanatory variables included in the model explained 70 per cent of the variation in IMC share equation, followed by OFWF (64 %), shrimp (73%), PHV (78 %), PLV (55 %), DHV (80 %) and DLV fish (69 %). The squared-terms of per capita expenditure on fish food were significantly different from zero for shrimp and PHV, suggesting that the additional allocation to fish food expenditure would induce higher demand for shrimp and PHV. The coefficient of urbanization dummy suggested that the urbanization would increase the demand for inland fish, with the exception of IMC which had already high share in fish consumption. The shrimp consumption would increase with urbanization. The coefficients of own-

Table 6. Estimated parameters of the QUAIDS fish demand system, 2002-03

Particulars	IMC	OFWF	Prawn/Shrimp	PHV	PLV	DHV	DLV	Molluscs[a]
Intercept	-0.54956	-0.10043	-0.31765	-0.04812	0.211021	-0.188	-0.16341	2.156149
t-value	-8.54	-2.92	-12.2	-2.04	4.11	-10.01	-7.83	
Fish price (Rs/kg) in logarithmic form								
Indian major carps	0.00353	-0.00061	0.00005	-0.00042	0.000668	0.000606	0.000111	-0.003935
t-value	3.37	-1.35	0.31	-2.07	1.01	2.42	0.44	
Other freshwater fish	-0.00061	0.001221	0.000319	-0.0003	-0.00216	0.000234	-0.00001	0.001306
t-value	-1.35	3.18	3.17	-2.37	-5.41	1.60	-0.08	
Prawn/shrimp	0.00005	0.000319	0.000722	-0.00055	-0.00064	-0.00031	-0.00004	0.000449
t-value	0.31	3.17	8.24	-7.99	-4.78	-7.15	-0.98	
Pelagic high-value	-0.00042	-0.0003	-0.00055	0.001311	-0.00093	-0.00008	0.000086	0.000883
t-value	-2.07	-2.37	-7.99	12.37	-5.54	-1.47	1.57	
Pelagic low-value	0.000668	-0.00216	-0.00064	-0.00093	-0.00486	0.001095	-0.0004	0.007227
t-value	1.01	-5.41	-4.78	-5.54	-6.00	4.44	-1.54	
Demersal high-value	0.000606	0.000234	-0.00031	-0.00008	0.001095	0.001247	0.000493	-0.003285
t-value	2.42	1.6	-7.15	-1.47	4.44	6.9	3.02	
Demersal low-value	0.000111	-0.00001	-0.00004	0.000086	-0.0004	0.000493	0.002406	-0.002646
t-value	0.44	-0.08	-0.98	1.57	-1.54	3.02	6.45	
Molluscs [a]	-0.003935	0.001306	0.002615	-0.00476	-0.00191	-0.00206	-0.00096	0.009704
ln (per capita fish exp)[b]	-0.00534	-0.0000465	-0.0139	-0.00686	0.00395	-0.000221	-0.00000846	0.0224349
ln (per capita fish exp) × ln (per capita fish exp)[b]	0.001378	0.000012	0.000449	0.000883	0.007227	-0.003285	-0.002646	-0.004018
t-value	1.38	0.02	2.7	2.38	-1.27	0.25	0.01	
Urban dummy	-0.16472	0.04913	0.0128	-0.02156	-0.01063	-0.00282	0.005799	0.132001
t-value	-12.73	6.25	1.97	-3.64	-1.02	-0.84	1.79	
IMR	1.123837	0.498564	0.53586	0.580554	0.556116	0.434126	0.289837	
t-value	60.82	54.85	67.22	77.76	39.85	82.53	63.44	
Adjusted R^2	0.7098	0.6412	0.7315	0.78	0.5539	0.8021	0.6914	

[a] Significance cannot be assessed since these were derived from adding-up restriction.
[b] Predicted value of ln(per capita fish expenditure), derived from stage 2.

Table 7. Income elasticity of demand for different groups of fish in India

Fish groups	Expenditure quartile				
	I	II	III	IV	All
Indian major carps	1.63	1.79	1.54	1.36	1.62
Other freshwater fish	1.64	1.80	1.54	1.36	1.62
Prawn/Shrimp	1.14	1.72	1.54	1.39	1.61
Pelagic high-value	0.72	1.76	1.54	1.37	1.62
Pelagic low-value	1.66	1.81	1.54	1.34	1.62
Demersal high-value	1.56	1.79	1.54	1.36	1.62
Demersal low-value	1.64	1.80	1.54	1.36	1.62
Molluscs	3.75	2.01	1.55	1.12	1.66

I : Quartile 1- Per capita weekly expenditure < Rs 85
II : Quartile 2- Per capita weekly expenditure Rs 85 - 121
III : Quartile 3- Per capita weekly expenditure Rs 122 - 170
IV : Quartile 4- Per capita weekly expenditure > Rs 170

price were positive and highly significant on the share of fish species. Even when the prices of fish would go up, the households maintained the share of individual fish species in the total fish expenditure.

4.2.1. Income Elasticity of Demand

The income elasticities of different fish food groups across income groups are given in Table 7. The income elasticities of fish demand were positive and high, but varied substantially across fish species by the income group. At the national level, the magnitude of income elasticities varied in a narrow range among the fish types (1.61 for shrimp to 1.66 for molluscs). Looking at the variability in elasticities across fish types and income quartile, one would infer that all the species were not the homogenous products for the consumers. Fish demand would rise with income growth and preference for the species mix would also change. The income elasticities were greater than one and had fallen for the households living above the poverty line (Quartile II to Quartile IV). Fish would not be an inferior commodity even at the high income group of consumers. A high fish demand is expected with higher economic growth and shifts in the dietary pattern.

4.2.2. Price Elasticity of Demand

The uncompensated and compensated elasticities of various fish types were evaluated at the income quartile-specific means. Uncompensated elasticities of demand represent the change in quantity demanded as a result of change in prices by capturing both price effect and income effect. Compensated elasticities of demand refer to the portion of change in quantity

Table 8. Own-price elasticity of demand for different groups of fish in India

Fish groups	Expenditure quartile				
	I	II	III	IV	All
Uncompensated own-price elasticity					
Indian major carps	-0.99	-0.99	-0.99	-0.99	-0.99
Other freshwater fish	-0.99	-0.99	-0.99	-0.99	-0.99
Prawn/Shrimp	-0.96	-0.99	-0.99	-1.00	-0.99
Pelagic high-value	-0.78	-0.98	-0.99	-0.99	-0.99
Pelagic low-value	-1.04	-1.06	-1.04	-1.05	-1.05
Demersal high-value	-0.46	-0.92	-0.96	-0.95	-0.95
Demersal low-value	-0.88	-0.93	-0.85	-0.82	-0.88
Molluscs	-1.01	-1.00	-1.00	-0.99	-1.00
Compensated own-price elasticity					
Indian major carps	-0.36	-0.45	-0.50	-0.60	-0.52
Other freshwater fish	-0.83	-0.84	-0.89	-0.89	-0.87
Prawn/Shrimp	-0.95	-0.93	-0.90	-0.83	-0.88
Pelagic high-value	-0.78	-0.91	-0.87	-0.81	-0.86
Pelagic low-value	-0.90	-0.97	-0.93	-0.96	-0.95
Demersal high-value	-0.46	-0.90	-0.93	-0.92	-0.92
Demersal low-value	-0.86	-0.90	-0.84	-0.81	-0.86
Molluscs	-0.99	-0.96	-0.96	-0.97	-0.97

I : Quartile 1- Per capita weekly expenditure < Rs 85
II : Quartile 2- Per capita weekly expenditure Rs 85 - 121
III : Quartile 3- Per capita weekly expenditure Rs 122 - 170
IV : Quartile 4- Per capita weekly expenditure > Rs 170

demanded which captures only the price effect. The positive sign of compensated cross-price elasticities indicates a substitution relationship among species; the negative sign indicates a complementary relationship among species. Looking at the results in Table 8 and Appendix 1, the own-price elasticities were negative, whereas the cross-price elasticities were positive and highly inelastic. Fish demand was sensitive to the price changes. Uncompensated own-price elasticities were in the range of -0.88 for DLV to -1.05 PLV. The values of compensated elasticities were much lower than those of uncompensated elasticities for aquaculture, particularly for the IMC species. The compensated own-price elasticity was -0.97 for molluscs, followed by PLV (-0.95), DHV (-0.92), shrimp (-0.88), OFWF (-0.97), PHV (-0.86), DLV (-0.86) and the minimum for IMC (-0.52). The IMC species were the highly preferred fish species among consumers in India and its demand seemed to be low-responsive to price changes, keeping the income constant. A weak substitution among species and low price response to fish type demand were expected among consumers, keeping the income constant.

4.3. Demand Projections

The availability of fish in India was largely technology-driven. The contribution of technological change measured in terms of total factor productivity (TFP) remained substantial in both the inland and marine sources of fish production. The TFP annual growth was estimated to be 4.0 per cent for the aquaculture sector during 1992-1998 and 2.0 per cent for the marine sector during 1987-1998 (Mruthyunjaya, 2004). The technological development has lowered the production cost (at constant prices) per unit of fish and made available additional fish at cheaper prices to the consumers and improved their nutritional security. Following the Asia Fish Model (Dey *et al.*, 2005), the demand for various fish types was projected to a time horizon of 2005-2015 under various technological scenarios[5]. In addition to the technological scenarios, other baseline assumptions were set that the growth in the exogenous variables in the projected years would be the same as observed in the past, except the growth in income and population which were assumed at 6.5 per cent and 1.5 per cent, respectively.

Following the stagnating productivity scenario 5, fish prices would go up by 2.2 per cent (Table 9). However, if the scenario 1 continued during the projected period, the fish price would decline by 2.8 per cent per annum for inland fishes (IMC and OFWF) and 0.76-1.31 per cent for low-value marine fishes (PLV and DLV). The price of high-value fishes (shrimp, DHV, molluscs) would be on an increasing trend with annual growth of 1.6-2.1 per cent.

The domestic demand for fish under the baseline scenario is likely to grow at an annual rate of 2.4 per cent between 2000 and 2015 (Table 10). The highest growth in demand has been projected for IMC (3.9 %), followed by OFWF (3.8 %), PLV and DLV (2.0 % each). The availability of fish at a cheaper price has induced the fish demand. However, domestic demand for various exportable species (shrimps, DHV, molluscs) has been declining because of the high consumer price. Between 2005 and 2015, the consumer demand for shrimp has been projected to decline at an annual growth rate of 1.1 per cent, followed by DHV (-0.9 %) and molluscs (-0.7 %).

Scenarios 1 to 3 will be the most likely scenarios persisting in India. Thus, the domestic demand for fish is likely to grow to 6.3-6.8 million tonnes

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[5] S_1 = Baseline assumptions with the existing past growth in TFP for marine capture (2 %) and aquaculture (4 %);
S_2 = Baseline assumptions with 25 % deceleration in TFP growth by the year 2015
S_3 = Baseline assumptions with 50 % deceleration in TFP growth by the year 2015
S_4 = Baseline assumptions with 75 % deceleration in TFP growth by the year 2015
S_5 = Baseline assumptions without TFP growth during the projected period.

Table 9. Projected annual growth in consumer price of fish, India: 2000-15

(per cent)

Fish groups	Scenario 1	Scenario 3	Scenario 5
Indian major carps	-2.85	-1.80	1.03
Other freshwater fish	-2.72	-1.67	1.17
Shrimp	2.07	2.62	4.10
Pelagic high-value	-0.06	0.39	1.60
Pelagic low-value	-0.76	-0.22	1.21
Demersal high-value	1.61	1.99	2.99
Demersal low-value	-1.31	-0.75	0.73
Molluscs	1.66	2.09	3.24
All	2.40	1.55	-0.60

Scenario 1: Baseline TFP growth continues
Scenario 3: Decline in TFP growth reaching 50 per cent of base line value by 2015
Scenario 5: Zero TFP growth

Table 10. Projected annual growth in fish demand for consumers, India: 2000-15

(per cent)

Fish groups	Scenario 1	Scenario 3	Scenario 5
Indian major carps	3.88	2.78	-0.09
Other freshwater fish	3.81	2.71	-0.18
Shrimp	-1.07	-1.61	-3.05
Pelagic high-value	1.07	0.62	-0.56
Pelagic low-value	1.95	1.40	-0.05
Demersal high-value	-0.86	-1.21	-2.12
Demersal low-value	1.99	1.43	-0.01
Molluscs	-0.72	-1.02	-1.82
All	2.40	1.55	-0.60

Scenario 1: Baseline TFP growth
Scenario 3: Decline in TFP growth reaching 50 per cent of base line value by 2015
Scenario 5: Zero TFP growth

by 2010 and 6.7-7.7 million tonnes by 2015 (Table 11). The IMC would continue to consolidate its share in the total fish demand. Its share would increase to 35 per cent by 2015 from 31 per cent in the year 2005. By 2015, the inland fish species would contribute more than 60 per cent to the total fish demand. The share of shrimp in the total domestic demand would decline from 8.2 per cent in 2005 to 6 per cent by 2015. The share of marine fish species would decline to one-third of total demand by 2015. The additional demand of fish during the next one decade is expected to be 1.7 million tonnes. Out of this additional requirement, 50 per cent would be met from IMC, followed by OFWF (36 %) and marine and other fish species (14 %).

Table 11. Per cent share in total fish demand by species in India under different TFP scenarios

Year	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Indian major carps					
2005	30.7	30.5	30.4	30.2	28.5
2010	32.9	32.6	32.2	31.6	29.2
2015	35.0	34.4	33.7	32.7	29.9
Other freshwater fish					
2005	20.9	22.4	22.3	22.2	20.9
2010	21.3	23.8	23.5	23.1	21.3
2015	21.8	25.1	24.5	23.9	21.8
Shrimp (marine and freshwater)					
2005	8.2	8.2	8.2	8.3	8.7
2010	6.9	6.9	7.0	7.1	7.6
2015	5.7	5.9	6.0	6.2	6.7
Pelagic high-value					
2005	6.2	6.3	6.3	6.3	6.8
2010	5.8	5.9	6.0	6.2	6.8
2015	5.4	5.6	5.8	6.0	6.8
Pelagic low-value					
2005	17.6	17.7	17.8	17.9	18.8
2010	17.2	17.4	17.7	18.0	19.3
2015	16.7	17.1	17.6	18.1	19.8
Demersal high-value					
2005	4.0	4.1	4.1	4.1	4.5
2010	3.4	3.5	3.6	3.7	4.2
2015	2.9	3.0	3.1	3.3	3.9
Demersal low-value					
2005	4.1	4.1	4.1	4.2	4.4
2010	4.0	4.1	4.1	4.2	4.5
2015	3.9	4.0	4.1	4.2	4.6
Molluscs and others					
2005	6.6	6.7	6.7	6.8	7.5
2010	5.7	5.8	5.9	6.1	7.0
2015	4.8	5.0	5.3	5.6	6.6
Fish demand (million kg)					
2005	6040	5978	5899	5783	4945
2010	6812	6594	6342	6021	4801
2015	7741	7240	6719	6141	4671

Table 12. Projected household and away from home demand for fish under base line scenario 1, India: 2005-2015

Year	Household demand	Outside-home demand	Total demand
	Demand (million kg)		
1998 (base)	3350	1824	5174
2005	3911	2129	6040
2015	5012	2729	7741
	Annual per capita demand (kg) at the national level		
2005	3.6	2.0	5.6
2010	3.7	2.1	5.8
2015	4.0	2.2	6.2
	Annual per capita demand (kg) for the fish eating population		
2005	10.3	5.7	16.0
2010	10.6	6.0	16.6
2015	11.4	6.3	17.7

The domestic consumption of fish types, which have export potential (shrimp, DHV and molluscs species) would decline by 9 per cent as a result of the higher consumer price.

The annual per capita consumption at the national level is projected to be 5.6 kg in 2005, 5.8 kg by 2010 and 6.2 kg by 2015. Only about 35 per cent of Indian population is fish eating. Thus, the annual per capita consumption of fish eating population would be about 16.6 kg by 2010, and 17.7 kg by 2015 (Table 12). In-home annual per capita consumption would be 10.6 kg by the year 2010 and would rise to 11.4 kg by 2015. Similarly, per capita annual consumption outside-home would be about 6.0 kg by 2010 and 6.3 kg by 2015. It would form one-third of the total fish demand.

5. Conclusions

The study has revealed that the estimated price and income elasticities of demand vary substantially across fish types (species) and across income groups. The results of demand analysis have inferred that all the fish types are not the homogenous commodity. Their consumers' preferences would vary by species. All the eight fish types included in the study have been found elastic and have positive income elasticity for all income levels. The own-price elasticity has been found negative and unitary for all the fish groups. With the rise in per capita income and technological development, the fish demand in India would increase substantially with change in species mix. The aggregate fish demand has been projected as 6.7-7.7 million tonnes by 2015. The aquaculture has been found to hold the key for meeting the future demand challenges.

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Appendix 1

Uncompensated and compensated price elasticities of demand for different fish species groups in India

Price of fish group	Demand of fish groups							
	I	II	III	IV	V	VI	VII	VIII
				Uncompensated price elasticities				
I: Indian major carps	-0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00
II: Other freshwater fish	-0.01	-0.99	0.00	0.00	-0.02	0.00	0.00	0.00
III: Prawn/Shrimp	0.00	0.00	-0.99	0.00	-0.01	0.00	0.00	0.00
IV:Pelagic high-value	0.00	0.00	0.00	-0.99	-0.01	0.00	0.00	0.00
V:Pelagic low-value	0.01	-0.02	-0.01	-0.01	-1.05	0.01	0.00	0.00
VI:Demersal high-value	0.03	0.01	-0.01	0.00	0.05	-0.95	0.02	0.00
VII: Demersal low-value	0.01	0.00	0.00	0.00	-0.02	0.03	-0.88	0.00
VIII: Molluscs	-0.13	0.04	0.01	0.02	0.22	-0.10	-0.08	-1.00
				Compensated price elasticities				
I: Indian major carps	-0.52	0.47	0.47	0.47	0.47	0.47	0.47	0.47
II: Other freshwater fish	0.11	-0.87	0.12	0.11	0.10	0.12	0.12	0.12
III: Prawn/Shrimp	0.11	0.12	-0.88	0.11	0.11	0.11	0.11	0.11
IV:Pelagic high-value	0.12	0.12	0.12	-0.86	0.12	0.12	0.13	0.12
V:Pelagic low-value	0.11	0.08	0.09	0.09	-0.95	0.11	0.10	0.10
VI:Demersal high-value	0.05	0.03	0.01	0.02	0.07	-0.92	0.04	0.02
VII: Demersal low-value	0.03	0.02	0.02	0.02	0.00	0.04	-0.86	0.02
VIII: Molluscs	-0.10	0.07	0.04	0.06	0.25	-0.07	-0.05	-0.97