FUTURE SCENARIOS (PROJECTIONS TO 2050)

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Introduction

The Bangladesh fish sector has experienced both rapid growth and rapid change over the past several decades. With plentiful waterways, access to the sea, and a subtropical climate, prospects for future production growth are equally bright. Domestic demand for fish products is also increasing as rising incomes and more efficient value chains make fish products more accessible and affordable for both rural and urban households. How fast supply grows relative to demand will determine not only future movements in real prices of fish products but also the feasibility of significant levels of exports.

Our analysis of future production trends involves modeling different growth rates of the various fish production systems: inland capture, aquaculture, and marine fisheries. Aquaculture development has recently been stressed by both private and public sector organizations (FAO 2014). Indeed, aquaculture productivity has increased, although this has not been the case for other fishery systems such as inland capture and marine fisheries. All these systems are beset with their own constraints, but each have unique opportunities to contribute to future growth.

The analysis of future demand is based on econometric estimates of own price and expenditure elasticities for four different fish groups using a modified Quadratic Almost Ideal Demand System (QUAIDS). Elasticities are estimated within rural and urban household groups, and within these subsets, poor and nonpoor. These parameters are then used, along with other exogenous parameters, in a multimarket model. Using this model, we can provide a baseline estimation of future fish production, demand, and prices. We also model the effects of hypothetical shocks to fish production to investigate their impacts on the fish economy.

The next section of the chapter provides a brief overview of fish production systems in Bangladesh along with their historical trends. The following

section discusses the estimation of demand parameters, including the equations and variables used as well as the empirical results. Thereafter, we provide a description of the multimarket model and the other parameters involved, along with the results of the baseline estimations and the policy simulations. The final section concludes.

Fish Production Systems: Present and Past

As discussed in [Chapter 1](#), there are three primary systems of fish production in Bangladesh: aquaculture, inland capture, and marine capture. Aquaculture is primarily made up of pond culture, which accounts for nearly 86 percent of this fish production system. Although this type of fish production is more easily accessible at the household level, unless a household invests with the intent of making aquaculture its primary income source, production levels tend to remain low. Inland capture involves the capture of wild fish from streams, rivers, and lakes, and the types of various freshwater fish produced from inland capture have historically been staples in Bangladeshi diets. Finally, marine fishing (including shrimp), the third fish production system, is mostly dominated by small-scale fisheries and faces the significant challenge of overfishing. All three production systems have notable costs and benefits, and all play considerable roles in the Bangladeshi economy and Bengali diets.

The prominence of aquaculture has increased significantly in Bangladesh since 2004, both as a share of fish production and as kilograms produced per capita. As discussed in [Chapter 1](#), of the three systems, aquaculture production has grown the most over the past 15 years. Marine and inland capture also grew but not to the extent of aquaculture. The historical consumption data mirrors these patterns, with the consumption of aquaculture fish growing significantly and that of inland capture decreasing in importance (consumption of marine fish decreased in rural areas but increased in urban areas, likely because it is considered a luxury good). In terms of value shares of fish in total expenditures, urban areas previously consumed the larger share of aquaculture relative to total consumption compared with rural areas; however, this flipped by 2010, likely due to expanding production and lower prices. Finally, calculating the real prices over time shows that the real prices of fish from mixed, inland capture, and marine systems rose by 21, 29, and 32 percent respectively, but prices of aquaculture fish dropped by 12 percent.

Determinants of Fish Demand

Economic Specification

To obtain expenditure and price elasticities for the simulations, we estimate a QUAIDS model using data from the Bangladesh Bureau of Statistics (BBS) Household Income and Expenditure Survey (HIES) in the years 2000, 2005, and 2010. The main variables of interest were those of quantity of items consumed, total expenditures on items, and price (which was imputed from the total expenditure and quantity consumed of each item).¹ A three-stage methodology was used for the analysis, adapted from Ecker and Qaim (2010). The first stage estimates the elasticity for food versus nonfood. This eliminates the need for predicting missing nonfood prices but relies on the assumption that consumption decisions are first made by the individual at a food versus nonfood level, rather than nonfood versus any particular food category. The second stage estimates the elasticities within the six major food groups of the study, and the third stage estimates the elasticities within the four different types of fish. Again, the assumption is that consumption decisions are more likely to be made within these smaller groups than across them. Unconditional elasticities were then calculated using the estimates from the three stages.

The households in the sample were divided into rural and urban subgroups, and the methodology was applied separately within these groups. This was done with the idea that the rural and urban samples would most likely differ in their responses to price and expenditure changes. Full sample estimates were potentially troublesome due to excessive heterogeneity within the sample. As such, full sample elasticities were calculated by adding up the quantity weighted elasticities of the two smaller samples. Elasticities were also calculated, within the rural and urban samples, at the means for the bottom three and top two quintiles of expenditure (in later tables these are referred to as “poor” and “nonpoor”). Standard errors for the elasticities estimation were calculated via bootstrapping at the sample mean for the poor and nonpoor populations. The number of repetitions was calibrated using Poi’s *bssize* command in Stata statistical software.²

1 Outliers for quantity and expenditure observations were defined as those outside of five standard deviations from the mean, within each category, and were removed from the final sample.

2 The *bssize* (Poi 2004) command was calibrated to identify the number of repetitions needed to return standard errors that did not deviate by more than 5 percent from the ideal bootstrapped values with 99 percent probability.

Possible endogeneity of total expenditures was a concern in estimation. To address this, in all stages of the estimation, an instrumental regression was used to obtain a predicted value of total expenditures. The instrumental regression used is given in equation 1:

$$E_b = \beta_0 + \beta_1(\ln Y_b) + \varepsilon_b \quad (1)$$

where E_b is total household expenditures, Y_b is the real income of household b , and ε_b is an error term. A description of the variables in this and the following regressions is in [Table 6.A1](#).

In the first stage of the estimation, a Working–Leser (Working 1943; Leser 1963) model was used to estimate the price and expenditure elasticities of food versus nonfood consumption. The expenditure share of food, w_{if} , was estimated using equation 2:

$$w_{if} = \beta_1 \log(\hat{E}_i) + \beta_2 P_f + \sum \beta_3 (Dem_i) + \sum \beta_4 (District_i) + \varepsilon_{ij} \quad (2)$$

where $\log(\hat{E}_i)$ is the log of the estimated total expenditure (on food and non-food) from the instrumental regression, P_f is the average price of food, Dem_i is a vector of household-level demographics that includes household size, age and sex of the head of household, square footage of the household, and the log of total household assets. $District_i$ is a set of district dummies for all 94 districts, and ε_{ij} is an error term. The conditional expenditure and Marshallian price elasticities were calculated using Leser's (1963) formulae shown in equations 3 and 4:

$$e_i = 1 + \frac{\beta_1}{w_i} \quad (3)$$

$$e_{if} = -\delta_{ij} + \frac{\beta_2}{w_i} \quad (4)$$

where e_i is the expenditure elasticity, and e_{if} is the price elasticity. The Kronecker delta is represented by δ .

Within the second and third stages a modified QUAIDS model is estimated. The model (as well as the Stata statistical software code) was again adapted from Ecker and Qaim (2010). Adjustments were made to the standard QUAIDS model to account for censoring, explained below, and potential endogeneity, explained above. The same demographic control variables used in the Working–Leser model were also accounted for.

In the food consumption data there were a number of zero-consumption observations, particularly among the observations for the separated four types of fish. To account for these, first a multivariate probit model was estimated for household consumption of the six categories of food, in the second stage,

and the four categories of fish, in the third stage. The probit model was estimated using equation 5:

$$d_{ij} = \beta_1 \log(\hat{E}_i) + \sum \beta_2 (Dem_i) + e_{ij} \quad (5)$$

where i and j index households and commodity subgroups respectively, d_{ij} indicates whether a household consumed a certain commodity (with $d_{ij} = 1$ if household i consumed good j), Dem_i is the same vector of household characteristics used before, and e_{ij} is an error term. From these probit models the respective probability density and cumulative distribution functions were estimated and used to create the inverse mills ratio for each of the zero-observation commodities. These were incorporated into the final QUAIDS models as demographic shifters to act as instruments correcting for zero observations.

With these adjustments the final QUAIDS model is shown in equation 6:

$$w_{ij} = \alpha_i + \sum_{j=1}^n \gamma_{ij} \ln P_i + \beta_i \ln \left[\frac{m}{a(p)} \right] + \frac{\lambda_j}{b(p)} \{ \ln \left[\frac{m}{a(p)} \right] \}^2 \quad (6)$$

where w_{ij} is the consumption share of good j in household i , and $\ln P_i$ and p are the trans-log price aggregator functions.³ Demographic shifters are incorporated into the equation through the α 's.

Finally, unconditional price elasticities were calculated using the estimates from all three stages. The expenditure elasticities are calculated relatively simply, by multiplying through the elasticities for all stages by good. The unconditional Marshallian were calculated using Edgerton's (1997) formula in equation 7:

$$e_{ij}^u = \delta_{rs} e_{(r)ij}^e + E_{(r)i} w_{(s)j}^* (e_{rs}^e + E_r w_s^* e_f^e) \quad (7)$$

where i and j represent the subgroups at the third stage, r and s are the larger food subgroups in the second stage, and f represents the first stage of aggregate food. The Kronecker delta is calculated at the second stage and is again represented by δ .⁴

3 Table 6.A2 in Annex III contains the descriptive statistics of all consumption shares and prices for the various food groups.

4 Alternative elasticity estimates were also calculated via an iterative linear least squares approach (using Lecoq and Robin's *aidsills* command [2015]) and a QUAIDS model which did not account for censoring (using Poi's QUAIDS command [2012]). Standard errors in the first of these alternative models are calculated from the command itself using the delta methodology, while standard errors for the second of these were calculated in the same method as our primary specification. Results can be found in Tables 6.A6a and 6.A6b. Generally, the expenditure elasticity estimates produced by the alternate methods fell within the range of the model sensitivity testing described in Annex II. Those that did not were nearly all larger in magnitude and in the marine fish category—the category with the most censoring. The alternative price elasticity estimates also mostly fell within the sensitivity testing range. All of those outside the range were on the higher end. Since neither of the

Demand Parameter Results

[Table 6.1](#) presents the results of the demand parameter estimation, including estimated expenditure elasticities for all three years of the HIES used in this study. Consistent with the historical increase in aquaculture fish consumption, aquaculture expenditure elasticities increased for all household groups from 2000 to 2010. Inland capture, which saw much slower growth than aquaculture and increasing prices, showed mixed results across rural and urban households. Inland capture expenditure elasticities decreased in rural areas and increased in urban areas, with the biggest shift being a decrease for the rural poor. As this is the largest group in Bangladesh, the overall effect was a decrease in expenditure elasticities. Note that expenditure elasticities for the rural poor decreased for all types of fish except for aquaculture. For the other household groups, however, expenditure elasticities increased for most of the categories of fish.

As shown in [Table 6.2](#), estimates of the own-price elasticities of aquaculture decrease (that is, become more negative) for all household groups from 2000 to 2010. Thus demand for aquaculture fish has become less responsive to price changes over time. In contrast, the price responsiveness of most other fish has increased (that is, become more elastic) over time. As we saw before, expenditure elasticities for aquaculture increased across all groups, so this move toward a more inelastic price response is surprising. Further data and analysis, disaggregated by type of fish, is needed.

Also surprising is that the cross-price elasticity between aquaculture and inland capture decreases by relatively large margins within each group, in some cases with changes in sign from positive to negative across the three surveys. This could indicate that the two are becoming stronger complements rather than substitutes. However, further detailed analysis of consumption by fish type is needed to untangle the reasons for these changes. Note also that the cross price of elasticities of demand of inland capture fish with respect to the price of aquaculture increase for nearly all household groups, with positive cross-price elasticities of demand for all household groups in 2010 (indicating the two types of fish are substitutes). Again, further analysis is needed.⁵

alternative estimates account for censoring, it makes sense that the estimates produced by these methods are larger, as a household's zero-consumption observation is always treated as a direct response to increases in price or income. As such, we believe our primary estimation technique, and estimates, to be more valid.

5 Annex III contains alternative estimates of own-price and cross-price elasticities used to validate the parameters estimated for the model.

TABLE 6.1 Bangladesh: Expenditure elasticities by fish production system (QUAIDS model estimates)

	Rural poor	Standard error	Rural nonpoor	Standard error	Urban poor	Standard error	Urban nonpoor	Standard error
2000 expenditure elasticities								
Primarily aquaculture	0.99	(0.0001)	0.66	(0.002)	0.91	(0.0001)	0.57	(0.004)
Mixed	0.95	(0.0001)	0.64	(0.002)	1.16	(0.0001)	0.80	(0.006)
Primarily inland capture	1.04	(0.0001)	0.68	(0.002)	0.97	(0.0001)	0.68	(0.005)
Primarily marine	0.98	(0.0001)	0.64	(0.002)	0.70	(0.0001)	0.32	(0.002)
2005 expenditure elasticities								
Primarily aquaculture	1.29	(0.002)	1.07	(0.004)	1.44	(0.004)	1.15	(0.009)
Mixed	0.84	(0.001)	0.57	(0.002)	0.94	(0.003)	0.61	(0.005)
Primarily inland capture	0.91	(0.001)	0.67	(0.002)	1.02	(0.003)	0.72	(0.005)
Primarily marine	1.23	(0.002)	1.11	(0.004)	1.38	(0.004)	1.19	(0.009)
2010 expenditure elasticities								
Primarily aquaculture	1.03	(0.001)	0.93	(0.002)	1.19	(0.001)	1.19	(0.003)
Mixed	0.83	(0.0001)	0.77	(0.001)	0.62	(0.001)	0.53	(0.001)
Primarily inland capture	0.72	(0.0001)	0.57	(0.001)	1.13	(0.001)	0.99	(0.003)
Primarily marine	0.86	(0.001)	0.74	(0.001)	0.93	(0.001)	0.78	(0.002)

Source: Authors' calculations from BBS HIES 2000, 2005, and 2010.

Note: QUAIDS = Quadratic Almost Ideal Demand System.

Model Simulations

Model Specification

To project future fish supply, demand, and prices and to analyze the effects of various shocks, we use a simple partial equilibrium multimarket model.⁶ We specify a set of demand and supply equations for the fish market in Bangladesh and input parameters across four types of fish and four household groups. As explained above, some of the demand parameters were estimated using the various HIES results in Bangladesh. The HIES was also used to calculate household incomes and consumption and population. The other

6 Multimarket models are particularly useful for looking at sectoral-level analysis rather than full economies and can allow for disaggregated policy impact evaluation (Braverman and Hammer 1986; Sadoulet and de Janvry 1995; Croppenstedt et al. 2007).

TABLE 6.2 Bangladesh: Econometric estimates of price elasticities of demand for fish, 2000, 2005, and 2010

2000 price elasticities		Rural							
		Primarily aquaculture	Standard error	Mixed	Standard error	Primarily inland capture	Standard error	Primarily marine	Standard error
Poor (households in bottom 40% of expenditures)	Primarily aquaculture	-0.71	(0.0001)	0.10	(0.0001)	-0.01	(0.0001)	-0.09	(0.0001)
	Mixed	-0.10	(0.0001)	-0.86	(0.0001)	-0.06	(0.0001)	-0.19	(0.0001)
	Primarily inland capture	-0.06	(0.0001)	0.06	(0.0001)	-0.91	(0.0001)	-0.16	(0.0001)
	Primarily marine	0.04	(0.0001)	0.21	(0.0001)	0.12	(0.0001)	-0.88	(0.0001)
Nonpoor (households in top 60% of expenditures)	Primarily aquaculture	-0.81	(0.0000)	0.01	(0.0001)	-0.07	(0.0001)	-0.14	(0.0001)
	Mixed	0.03	(0.0001)	-0.88	(0.0000)	-0.02	(0.0001)	-0.12	(0.0001)
	Primarily inland capture	0.05	(0.0001)	0.07	(0.0001)	-0.89	(0.0000)	-0.06	(0.0001)
	Primarily marine	0.08	(0.0001)	0.13	(0.0001)	0.10	(0.0001)	-0.88	(0.0000)
2005 price elasticities		Rural							
		Primarily aquaculture	Standard error	Mixed	Standard error	Primarily inland capture	Standard error	Primarily marine	Standard error
Poor (households in bottom 40% of expenditures)	Primarily aquaculture	-0.83	(0.0001)	0.10	(0.0001)	-0.05	(0.0001)	-0.16	(0.0001)
	Mixed	0.02	(0.0001)	-0.88	(0.0001)	-0.14	(0.0001)	-0.13	(0.0001)
	Primarily inland capture	0.24	(0.0001)	-0.04	(0.0001)	-0.86	(0.0001)	0.02	(0.0001)
	Primarily marine	-0.23	(0.0001)	0.38	(0.0001)	0.14	(0.0001)	-0.91	(0.0001)
Nonpoor (households in top 60% of expenditures)	Primarily aquaculture	-0.92	(0.0001)	0.01	(0.0001)	-0.14	(0.0001)	-0.21	(0.0001)
	Mixed	0.15	(0.0001)	-0.94	(0.0001)	-0.11	(0.0001)	-0.11	(0.0001)
	Primarily inland capture	0.44	(0.0001)	-0.12	(0.0001)	-0.92	(0.0001)	0.05	(0.0001)
	Primarily marine	-0.22	(0.0001)	0.44	(0.0001)	0.15	(0.0001)	-0.92	(0.0001)

Urban							
Primarily aquaculture	Standard error	Mixed	Standard error	Primarily inland capture	Standard error	Primarily marine	Standard error
-0.69	(0.0001)	0.11	(0.0001)	0.13	(0.0001)	0.03	(0.0001)
0.18	(0.0001)	-0.83	(0.0001)	0.19	(0.0001)	-0.02	(0.0001)
0.09	(0.0001)	0.12	(0.0001)	-0.81	(0.0001)	0.08	(0.0001)
0.02	(0.0001)	0.01	(0.0001)	0.17	(0.0001)	-0.69	(0.0001)
-0.69	(0.0001)	0.03	(0.0001)	0.02	(0.0001)	-0.02	(0.0001)
0.34	(0.0001)	-0.89	(0.0001)	0.08	(0.0001)	0.02	(0.0001)
0.28	(0.0001)	0.13	(0.0001)	-0.86	(0.0001)	0.09	(0.0001)
-0.02	(0.0001)	0.05	(0.0001)	0.06	(0.0001)	-0.66	(0.0001)
Urban							
Primarily aquaculture	Standard error	Mixed	Standard error	Primarily inland capture	Standard error	Primarily marine	Standard error
-0.53	(0.0001)	0.41	(0.0001)	0.25	(0.0001)	0.14	(0.0001)
0.25	(0.0001)	-0.66	(0.0001)	0.09	(0.0001)	0.09	(0.0001)
0.39	(0.0001)	0.11	(0.0001)	-0.71	(0.0001)	0.17	(0.0001)
-0.06	(0.0001)	0.54	(0.0001)	0.31	(0.0001)	-0.75	(0.0001)
-0.56	(0.0001)	0.37	(0.0001)	0.22	(0.0001)	0.15	(0.0001)
0.29	(0.0001)	-0.80	(0.0001)	0.03	(0.0001)	0.03	(0.0001)
0.55	(0.0001)	-0.01	(0.0001)	-0.81	(0.0001)	0.16	(0.0001)
-0.06	(0.0001)	0.60	(0.0001)	0.31	(0.0001)	-0.77	(0.0001)

(continued)

TABLE 6.2 Continued

2010 price elasticities

		Rural							
		Primarily aquaculture	Standard error	Mixed	Standard error	Primarily inland capture	Standard error	Primarily marine	Standard error
Poor (households in bottom 40% of expenditures)	Primarily aquaculture	−0.81	(0.0001)	−0.03	(0.0001)	−0.20	(0.0001)	−0.21	(0.0001)
	Mixed	0.10	(0.0001)	−0.79	(0.0001)	−0.08	(0.0001)	−0.17	(0.0001)
	Primarily inland capture	0.12	(0.0001)	0.14	(0.0001)	−0.80	(0.0001)	0.00	(0.0001)
	Primarily marine	0.25	(0.0001)	0.15	(0.0001)	0.04	(0.0001)	−0.80	(0.0001)
Nonpoor (households in top 60% of expenditures)	Primarily aquaculture	−0.87	(0.0002)	−0.03	(0.0001)	−0.25	(0.0001)	−0.20	(0.0001)
	Mixed	0.20	(0.0001)	−0.81	(0.0002)	−0.08	(0.0001)	−0.14	(0.0001)
	Primarily inland capture	0.15	(0.0001)	0.11	(0.0001)	−0.85	(0.0002)	0.05	(0.0001)
	Primarily marine	0.30	(0.0001)	0.05	(0.0001)	0.01	(0.0001)	−0.81	(0.0002)

Source: Authors' calculations from BBS HIES 2000, 2005, and 2010.

exogenous variables and parameters derive from a variety of sources, including World Bank data (growth rates of population and GDP per capita) and BBS data (quantities of fish production and exports).⁷ The full list of model variables and parameters is given in Table 6.3 below.

The model consists of five sets of equations. Household income per capita is estimated as the base level of per capita income ($Y0_b$) multiplied by an exogenous rate of growth ($1 + \gamma gr_b$) (equation 8):

$$Y_b = Y0_b * (1 + \gamma gr_b) \quad (8)$$

Quantity supplied (production) of each fish type i is calculated as the base level of quantity $QS0$ supplied, the (exogenous) productivity growth rate ($qsgri$) and current to base year prices ($P_i / P0_i$):

$$QS_i = QS0_i * (1 + qsgri) * \frac{P_i^{\epsilon_i}}{P0_i} \quad (9)$$

where ϵ_i is the elasticity of supply of fish type i .

7 A table documenting the historical trend of exports can be found in Table 6.A3 in Annex III.

Urban							
Primarily aquaculture	Standard error	Mixed	Standard error	Primarily inland capture	Standard error	Primarily marine	Standard error
-0.92	(0.0001)	0.09	(0.0001)	-0.27	(0.0001)	-0.18	(0.0001)
0.11	(0.0001)	-0.78	(0.0001)	-0.14	(0.0001)	-0.09	(0.0001)
0.15	(0.0001)	0.14	(0.0001)	-0.83	(0.0001)	0.17	(0.0001)
0.16	(0.0001)	0.06	(0.0001)	0.12	(0.0001)	-0.80	(0.0001)
-0.98	(0.0001)	0.06	(0.0001)	-0.25	(0.0001)	0.01	(0.0001)
0.17	(0.0001)	-0.76	(0.0001)	-0.14	(0.0001)	-0.01	(0.0001)
0.12	(0.0001)	0.02	(0.0001)	-0.80	(0.0001)	0.35	(0.0001)
0.04	(0.0001)	-0.07	(0.0001)	0.04	(0.0001)	-0.82	(0.0001)

TABLE 6.3 Model variables and parameters

$QD_{h,i}$	Per capita quantity demanded/consumed
Y_h	Per capita household income
ygr_h	Household income growth rate
Pop_h	Population, by household group
$popgr_h$	Population growth rate
QS_i	Quantity produced, by fish type
$qsgr_i$	Production growth rate
E	Exports
P_i	Fish price
es_i	Elasticity of supply
$edhh_{i,h}$	Household price elasticity
$edy_{i,h}$	Household income elasticity

Source: Authors' calculations.

Per capita household demand of each fish type i for household b is calculated as a function of the base level of demand, $QD0_{bi}$, ratios of current to base year prices ($P_i / P0_i$), and the ratio of current to base year household income ($Y_h / Y0_h$):

$$QD_{bi} = QD0_{bi} * \Pi \frac{P_i^{ed_{ij}}}{P0_i} * \frac{Y_h^{ed_{hi}}}{Y0_h} \quad (10)$$

where ed_{ij} is the elasticity of demand of fish type i with respect to the price of commodity j .

Aggregate demand is simply the sum of per capita household demands multiplied by the population of the household group (the base year population multiplied by one plus the exogenous population growth rate) (equation 11).

$$QD_i = \Sigma(QD_{bi} * (Pop_b * (1 + popgr_b))) \quad (11)$$

Finally, equation 12 defines the market equilibrium condition: total quantity demanded by domestic households is equal to supply minus exports.⁸

$$QD_i = QS_i - E_i \quad (12)$$

Simulation Results

In the base scenario we set productivity growth for aquaculture and mixed production systems to an average of 3.7 and 1.5 percent per year, respectively—rates that are slightly lower than recent historical growth rates of production (Table 6.4). For inland capture and marine capture we assume no productivity growth, given possible limits on sustainable increases in production.⁹ Consistent with recent trends, urban population is projected to grow much faster than rural population (3.0 and 0.4 percent per year, respectively), with faster growth with overall incomes in urban areas as well (Table 6.5). Overall, we model five policy scenarios with various combinations of productivity growth and increased demand (arising from exogenous increases in household incomes).

Table 6.6 presents the simulation results in terms of annual growth rates of production and prices from 2015 to 2030. In the base simulation total fish production from 2015 to 2030 increases by an average of 2.61 percent per

8 Exports in the model are assumed to be 20 percent of the baseline production for all categories. For the following years, aquaculture exports are set at 50 percent of the previous year's production to reflect increased exports in this subcategory.

9 These productivity shocks are chosen to produce trends in production and real prices similar to those observed from 2010 to 2015. Similar assumptions were used in World Bank (2007).

TABLE 6.4 Model simulation assumptions for fish productivity growth

	Aquaculture	Inland capture	Mixed	Marine
Average growth rate (%)				
Base	3.7	0.0	1.5	0.0
High productivity	5.3	0.8	2.1	0.0
Very high productivity	6.7	0.8	2.1	0.0
Cumulative growth (%)				
Base	71.5	0.0	25.0	0.0
High productivity	118.0	12.7	36.6	0.0
Very high productivity	163.1	12.7	36.6	0.0

Source: Authors' calculations.

Note: Productivity growth rates for aquaculture in the base scenario are set equal to 5 percent for 2016 to 2020 and 3 percent for 2021 to 2030. For the high-productivity scenarios, productivity growth rates for aquaculture are set equal to 5 and 3 percent for 2016–2020 and 2021–2030. Similarly, for the very high-productivity growth scenarios, aquaculture productivity growth is set equal to 8 and 6 percent in the two periods, respectively.

year (47.2 percent in fifteen years), with very slow rates of growth for inland capture and marine fish production (1.56 and 1.37 percent per year, respectively), given the assumptions of zero productivity growth in these sectors. Production of inland capture fish in 2030 is projected to be only 26.1 percent higher than in 2015, and marine fish production is only 22.6 percent higher than in 2015. With increased demand as population and incomes rise, real prices of these types of fish increase over time, by 5.29 and 4.63 percent per year, respectively (with cumulative real price increases of 116.7 and 97.3 percent). By contrast, aquaculture and mixed system production increase relatively rapidly over time, by 3.65 and 1.76 percent per year, respectively, so that prices of aquaculture actually fall and mixed system production rises only slightly—by –0.02 and 0.84 percent per year (with cumulative price effects of –0.3 and 13.4 percent by 2030).¹⁰ Fish consumption per capita rises by 27 percent overall, between 2015 and 2030, with particularly large increases for urban households (Table 6.7).

10 Earlier fish projections by World Bank (2007) for 2001 to 2015 assumed a growth rate of aquaculture of 10 percent per year, as compared with our calculated growth rate for this period of 8.6 percent and our base line growth rate of 3.65 percent for 2016 to 2030. Both analyses assume minimal growth of marine fish production. The two projections differ more substantially for inland capture, however. World Bank (2007) projects a growth rate of –7.0 percent for 2001 to 2015. Our calculations for the period show a positive (though somewhat low) growth rate of 0.8 percent, with a projected growth rate of 1.56 percent for 2016 to 2030 in the base simulation.

TABLE 6.5 Model simulation assumptions for population and income growth

	Urban		Rural		Total
	Poor	Nonpoor	Poor	Nonpoor	
Base					
Population 2010 (millions)	20.50	18.75	52.50	57.50	149.25
Population growth (%)	3.0	3.0	0.4	0.4	1.1
Income growth (%)	6.0	4.0	3.0	2.0	4.2
Per capita income growth (%)	2.9	1.0	2.6	1.6	3.1
High demand					
Population growth (%)	3.0	3.0	0.4	0.4	1.1
Income growth (%)	8.0	6.0	5.0	4.0	6.5
Per capita income growth (%)	4.9	2.9	4.6	3.6	5.4

Source: Authors' calculations.

TABLE 6.6 Bangladesh fish production and prices: Simulation results

Annual growth rates: 2015–2030					
	Production				
	Aquaculture	Inland capture	Mixed	Marine	Total fish
Base 2015 level	1,654.8	467.5	1,022.2	496.5	3,641.0
Growth rates (%)					
Base	3.65	1.56	1.76	1.37	2.61
Sim 1	4.89	2.07	2.17	1.32	3.43
Sim 2	4.17	2.08	2.19	1.81	3.10
Sim 3	5.41	2.59	2.61	1.75	3.92
Sim 4	5.82	2.03	2.14	1.28	3.94
Sim 5	6.35	2.55	2.58	1.72	4.44
	Price				
	Aquaculture	Inland capture	Mixed	Marine	Average fish
Base 2015 level	103.99	127.61	109.01	220.20	140.2
Growth rates (%)					
Base	−0.02	5.29	0.84	4.63	3.8
Sim 1	−1.06	4.26	0.22	4.45	3.2
Sim 2	1.24	7.10	2.30	6.16	5.3
Sim 3	0.19	6.06	1.6	5.97	4.8
Sim 4	−1.97	4.12	0.12	4.34	3.0
Sim 5	−0.73	5.91	1.56	5.84	4.6

Source: Model simulations.

Note: Sim 1: High productivity, all systems; Sim 2: Increased household fish demand; Sim 3: Sim 1 with increased household demand; Sim 4: Sim 1 with extra aquaculture productivity gains; Sim 5: Sim 4 with increased household demand.

In Simulation 1 we model increased productivity and output of fish. In particular, we increase productivity of aquaculture by 5 percent per year for five years (2016–2020) and then slow the rate of productivity growth to 3 percent per year for the remaining ten years of the simulation (2021–2030). For inland capture and mixed systems we assume constant annual increases in productivity, increases of 0.8 and 2.1 percent per year over all fifteen years of the simulation. We assume no change in the productivity of marine fish (see [Table 6.4](#)).

Under these assumptions aquaculture production rises by 4.89 percent per year (120.50 percent over the 15-year period). Prices of aquaculture fish fall steeply, by 1.06 percent per year (14.70 percent by 2030). With faster growth in inland capture fish (2.07 percent per year, compared with 1.56 percent per year in the base simulation), prices rise by only 4.26 percent per year (86.9 percent by 2030), compared with an increase of 5.29 percent per year (116.70 percent by 2030) in the base simulation. Likewise, production of the mixed system rises by 2.17 percent per year (compared with 1.76 percent per year in the base simulation) and prices of mixed system fish only increase by 0.22 percent per year (3.30 percent by 2030). Total fish consumption per capita in 2030 is 56 percent higher than in 2015; 29 percent higher than in 2030 in the base simulation.

Simulation 2 models faster household income growth that results in increased demand for fish, along with higher prices relative to the base simulation. Increased demand leads to moderate increases in prices and a corresponding supply response. Overall, fish production increases by 3.10 percent per year, compared with 2.61 percent per year in the base simulation. By 2030, increased demand results in an overall gain of 58 percent in fish production relative to the base simulation.

Simulation 3 is a combination of the first two simulations (higher productivity growth along with increased fish demand). Overall, the effects of increased productivity and supply outweigh the impacts of increased demand. Overall fish production in 2030 is 17 percent higher than in the base simulation and only 5 percent lower than in the high-productivity scenario with no demand increase (Simulation 1).

Simulation 4 models an additional increase in productivity growth and production of aquaculture, relative to the high-productivity scenario (Simulation 1). As a result, aquaculture production increases by 5.82 percent per year, compared with 3.65 percent per year in the base simulation. Prices of aquaculture fall by 1.97 percent per year, as compared with a decline of 0.02 percent per year in the base simulation, resulting in a decline of

TABLE 6.7 Bangladesh fish consumption: Simulation results (per capita consumption)

		Aquaculture	Inland capture	Mixed	Marine	All fish
		Level (kilogram per capita)				
Base 2015	Rural nonpoor	12.09	2.29	5.72	1.72	21.81
	Rural poor	7.46	1.88	4.33	0.89	14.56
	Urban nonpoor	13.72	3.78	6.88	5.78	30.15
	Urban poor	11.23	3.03	5.94	2.75	22.96
	All Bangladesh	10.49	2.46	5.41	2.16	20.53
		Percent change, 2015–2030 (%)				
Base	Rural nonpoor	–5.1	–35.4	–2.4	–26.8	–9
	Rural poor	16.7	–24.3	9.5	–10.7	8
	Urban nonpoor	69.1	22.8	10.4	–7.3	35
	Urban poor	105.5	61.7	31.4	44.1	73
	Total	42.2	9.1	12.7	10.3	27
Sim 3	Rural nonpoor	47.2	–15.8	34.3	–1.9	33
	Rural poor	65.8	–3.3	37.1	14.6	45
	Urban nonpoor	125.9	60.5	15.6	–1.0	68
	Urban poor	89.2	55.8	16.1	26.9	58
	Total	83.0	29.8	29.8	19.0	56
Sim 5	Rural nonpoor	67.7	–16.4	32.7	–4.6	44
	Rural poor	87.1	–3.5	37.4	12.0	56
	Urban nonpoor	159.9	59.3	14.6	–0.1	83
	Urban poor	116.8	54.4	16.2	25.4	72
	Total	108.9	28.9	29.2	18.1	69

Source: Model simulations.

Note: Sim 1: High productivity, all systems. Sim 2: Increased household fish demand. Sim 3: Sim 1 with increased household demand. Sim 4: Sim 1 with extra aquaculture productivity gains. Sim 5: Sim 4 with increased household demand.

26 percent and 0.30 percent, respectively, in 2030. Finally, Simulation 5 combines the higher income growth of Simulation 2 with the accelerated productivity gains of Simulation 4. Again, increased demand results in a smaller price decrease in aquaculture (only 0.73 percent per year, as compared with 1.97 percent per year in Simulation 4).

Figure 6.1 summarizes the results of base scenario, high-productivity/high-demand scenario (Simulation 3), and the highest-productivity aquaculture/high-demand scenario (Simulation 5). As indicated, total fish production is

FIGURE 6.1 Simulation results: Bangladesh fish production (thousand metric tons)

Source: Model simulations.

projected to grow rapidly if aquaculture investment and productivity continue to increase, potentially reaching 6.48 million metric tons in 2030 in Simulation 3 and 6.99 million metric tons in Simulation 5 (20.9 and 30.3 percent increases relative to the baseline figure).

Annex II (Tables 6.A8 and 6.A9) presents sensitivity analysis using an alternative set of (more inelastic) demand parameters equal to 0.6 times those used in the main simulations. As expected, more inelastic demand implies larger price declines due to production increases (for example, Simulation 1a), but greater rises in the simulations involving exogenous increases in household incomes (for example, Simulation 2a). Aquaculture fish prices fall by 1.34 percent per year in Simulation 3a and 2.62 percent per year in Simulation 5a, compared with small yearly increases of 0.19 percent and decline of 0.73 percent per year in the corresponding simulations using the base parameters. More inelastic demand and resulting larger price declines also dampen production increases, so that overall fish production rises by only 3.41 percent and 3.81 percent per year in Simulations 3a and 5a.

Conclusion

Fish production, particularly production from aquaculture, has increased rapidly in Bangladesh in the past decade. As a result, despite rising household incomes and consumer demand, real prices of fish produced from aquaculture systems have fallen. Moreover, prospects for future growth of household incomes are good, given public, private, and foreign investment in infrastructure. Improved infrastructure and changes in information and telecommunication and technology could further raise productivity and household incomes. Thus household demand for fish products will likely increase substantially if per capita incomes continue to rise as expected.

Our analysis of potential increases in fish production (most of which would likely come from aquaculture) suggests that if present rates of investment in aquaculture and productivity growth continue, fish production growth is likely to outpace these increases in demand. In our base (moderate productivity growth) scenario, aquaculture and total fish production increase by an average of 3.65 percent and 2.61 percent per year from 2015 through 2030, contributing to a decline in real prices of aquaculture by 0.02 percent per year through 2030. Increases in aquaculture investment and productivity could lead to greater overall increase in production of as much as 120 percent in 2030 relative to 2015. If demand also increases rapidly, real aquaculture prices may fall by only 0.73 percent through 2030. Even greater aquaculture investments and larger productivity gains (by another 2 percent) could raise production to 6.99 million metric tons by 2030, 152 percent greater than in 2015 and a 69 percent increase in per capita consumption. Poor households who currently consume only small quantities of fish (14.56 kilograms per capita in 2015 for the rural poor as compared with 30.15 kilograms per capita for the urban nonpoor) stand to gain significantly from greater production and lower prices, with potential increases of 6.5 and 20.5 kilograms per capita, respectively, provided that improvements in storage, transport, and basic processing can increase their access to these increased supplies.

These trends also imply significant changes in relative prices of various types of fish. Investments in aquaculture have the potential to lead to significant increases in production and possibly reduce real prices of aquaculture fish. In contrast, ecosystem constraints on sustainable fish production in inland capture and marine fishing are likely to limit production gains in these systems. All the model simulations indicate major shifts in consumption patterns and relative prices arising from these significant differences in production potential.

Thus inadequate demand is unlikely to be a major constraint on the Bangladesh fish sector, particularly for aquaculture. Although other production systems (inland capture and marine fishing) face serious constraints and are unlikely to increase their output significantly over time, the simulations suggest that sustained increases in aquaculture production at rates approximating those of recent years would be sufficient to meet rising fish demand in Bangladesh. Moreover, increased supply could lead to moderate declines in the real price of fish products and enable poor Bangladeshi households to increase their consumption of this nutrient-rich food.

References

- BBS (Bangladesh Bureau of Statistics). 2000. *Household Income and Expenditure Survey 2000*. Dhaka.
- . 2005. *Household Income and Expenditure Survey 2005*. Dhaka.
- . 2010. *Household Income and Expenditure Survey 2010*. Dhaka.
- . 2016. *Statistical Yearbook of Bangladesh 2015*. Ministry of Planning. Dhaka.
- Braverman, A., and J. Hammer. 1986. "Multimarket analysis of agricultural pricing policies in Senegal." In *Agricultural Household Models: Extensions, Applications, and Policy*, 233–254. Washington, DC: World Bank.
- Croppenstedt, A., L. G. Bellú, F. Bresciani, and S. DiGiuseppe. 2007. *Agricultural Policy Impact Analysis with Multimarket Models: A Primer*. ESA Working Paper 07–26. Rome: Food and Agriculture Organization of the United Nations.
- Dervis, K., J. de Melo, and S. Robinson. 1982. *General Equilibrium Models for Development Policy*. World Bank Research Publication. Washington, DC: World Bank.
- Dorosh, P. A. 2006. *Accelerating Income Growth in Rural Bangladesh*. Background Report to World Bank (2007). Washington, DC: World Bank.
- Ecker, O., and M. Qaim. 2010. "Analyzing Nutritional Impacts of Policies: An Empirical Study for Malawi." *World Development* 39 (3): 412–428.
- Edgerton, D. L. 1997. "Weak Separability and the Estimation of Elasticities in Multistage Demand Systems." *American Journal of Agricultural Economics* 79 (1): 62–79.
- FAO (Food and Agriculture Organization of the United Nations). 2014. *Fishery and Aquaculture Country Profiles: Bangladesh*. Country Profile Fact Sheets. Rome.
- FishBase. 2018. "List of Freshwater Fishes Reported from Bangladesh." Accessed June 2018. www.fishbase.org.

- FSR (Fisheries Sector Review). 2003. *Fisheries Sector Review and Future Development: Theme Study: Economic Performance*. Dhaka: World Bank, Danida (Danish International Development Assistance), USAID (United States Agency for International Development), FAO (Food and Agriculture Organization of the United Nations), and UK, DFID (United Kingdom, Department for International Development).
- Heckman, J. 1979. "Sample Selection Bias As a Specification Error." *Econometrica* 47 (1): 153–161.
- Lecoq, S., and J. M. Robin. 2015. "Estimating Almost-Idea Demand Systems with Endogenous Regressors." *The Stata Journal* 15 (2): 554–557.
- Leser, C. E. V. 1963. "Forms of Engel Functions." *Econometrica* 31 (4): 694–703.
- Poi, B. 2004. "From the Help Desk: Some Bootstrapping Techniques." *The Stata Journal* 4 (3): 312–328.
- . 2012. "East Demand-System Estimation with QUAIDS." *The Stata Journal* 12 (3): 433–446.
- Portley, N. 2016. *Report on the Shrimp Sector: Asian Shrimp Trade and Sustainability*. Honolulu, HI, US: Sustainable Fisheries Partnership.
- Sadoulet, E., and A. de Janvry. 1995. *Quantitative Development Policy Analysis*. Baltimore; London: Johns Hopkins University Press.
- Wikipedia. 2018. "List of Fishes in Bangladesh." Wikimedia Foundation. Accessed August 2, 2018. www.wikipedia.org/wiki/List_of_fishes_in_Bangladesh.
- Working, H. 1943. "Statistical Laws of Family Expenditure." *Journal of the American Statistical Association* 38 (221): 43–56.
- World Bank. 2007. *Bangladesh: Strategy for Sustained Growth*. Bangladesh Development Series 18. Washington, DC.

Annex I: Alternate Demand Elasticity Estimates

Given the importance of the household demand parameters for the model results, we present alternative estimates of these parameters based on econometric estimates using a Linear Expenditure System specification (Dervis, de Melo, and Robinson 1982). We first estimate expenditure elasticities from simple Engel functions using a Heckman two-step methodology (Heckman 1979; Leser 1963). Following this methodology, we correct for the possibility of zero consumption for each fish type by running a multivariate probit model (shown below).

$$d_{ij} = \beta_1 \log(E_{ij}) + \sum \beta_2(Dem_i) + e_{ij}$$

where i and j index households and commodity subgroups respectively, d_{ij} indicates whether a household consumed a certain commodity (with $d_{ij} = 1$ if household i consumed good j), E_{ij} is household i 's expenditure on good j , and Dem_i is a vector of household-level demographics that includes household size, age and sex of the head of household, square footage of the household, and district. From these probit models, the respective probability density and cumulative distribution functions were estimated and used to create the inverse mills ratio for each of the zero-observation commodities.

We then correct for endogeneity of household expenditures using an instrumental regression to obtain a predicted value of total expenditures. The instrumental regression used was:

$$TE_{ij} = \beta_1(\ln Y_i) + e_{ij}$$

where TE_{ij} and Y_i are the total expenditure and real incomes of household h .

Next, the instrumented total expenditures and inverse mills ratio were used in the following regression:

$$w_{hfood} = \beta_1 \ln(T\hat{E}_h) + \beta_2 * \ln(T\hat{E}_h)^2 + \beta_3 \ln P_{food} + \sum \beta_4(Dem_i) + \sum \beta_5(District_i) + \lambda_i + e_{ij}$$

where $\ln(T\hat{E}_h)$ is the log of the estimated total expenditure (on food and non-food) from the instrumental regression, $\ln P_{food}$ is the natural log of the average price of food, Dem_i is the vector of household level (now excluding the district variable), $District_i$ is a set of district dummies for all 94 districts, and λ_i is the inverse mills ratio.

Finally, expenditure elasticities are calculated from these Engel functions using the following equation:

$$e_i = 1 + \frac{\beta_1}{w_i}$$

where e_i is the expenditure elasticity. And then own-price and cross-price elasticities are calculated using the Linear Expenditure System (LES) equations as such:

$$e_{ii} = -e_i \left(\frac{AvgP_i * TE_i}{w_i} - \frac{1}{\phi} \right)$$

$$e_{ij} = -e_i \left(\frac{P_j * TE_j}{w_i} \right)$$

where e_{ii} is the own-price elasticity, e_{ij} is the cross-price elasticity, and ϕ is the Frisch parameter (Dervis, de Melo, and Robinson 1982).

The resulting elasticities are presented in [Table 6.A5](#). We have done this exercise across the four fish categories used in the main analysis, but we have also done it between freshwater and marine fish categories for further exploration. The freshwater category was calculated by simply combining the three categories that are not marine. Comparing these results to the ones used in the model, we can see similarities in the direction of the signs and in the general magnitudes. For example, the own-price elasticities are all mostly negative and less than 1. Note that the magnitude of the cross-price elasticities are smaller than those estimated using the QUAIDS model ([Table 6.A6](#)). The small magnitudes of the cross-price elasticities may be due to aggregating various types of fish by production system rather than by characteristics reflecting consumer preferences. Further work on fish demand by fish type could shed light on these issues.

Annex II: Model Calibration and Validation

After the model was constructed, calibration was employed to match the simulation productivity and price growth rates with the historical price and growth trends. Calibration targets were calculated using available BBS data on price and production for different fish types. The exogenous parameter we used in calibration was supply elasticity. [Table 6.A7](#) shows the final results of the calibration, with the most reasonable price and production errors we arrived at given plausible supply elasticities. The highest overall error rates are those for price in aquaculture and production in mixed. It is interesting that we see too high of a price decrease in our model even though we also see too low of a production rate increase. More could be done to investigate this dichotomy.

Validation was also undertaken to investigate how well the trends from the model matched the historical trends from the BBS data. [Figure 6.A1](#) has the results of this. We graphed the BBS data from 2000 to 2015 and then overlaid the graphs of our model results from 2010 to 2015. The model matched the results relatively well. Although the initial levels differ due to the model being based on the HIES data and the historical trends being from the BBS, the slopes tend to match well.

For aquaculture we provide additional trend lines. The solid line represents production results using the demand parameters estimated from the QUAIDS model. The lines above and below this represent the results when we double the price elasticities for aquaculture and halve them, respectively. Both of these have a visible effect on the trend line, with halving the elasticities causing a more dramatic shift in production. In the end, we decided on the original parameters for the final estimates.

Annex III: Figures and Tables

FIGURE 6.A1 Model validation: Production by fish system (million metric tons)

Source: Model simulations.

TABLE 6.A1 Demographic variables used in the econometric estimation of household demand parameters, 2000, 2005, and 2010

Variable	Description	2000			
		Mean	Std. dev.	Min	Max
log real income	Natural log of real income	11.40	0.90	4.94	15.68
sqft	Square footage of residence	402	420	0	20,000
hysize	Continuous household size	4.5	1.9	1.0	17.0
sex	Binary variable denoting sex of head of household	0.86	0.35	0.00	1.00
lnage	Natural log of age of head of household	3.78	0.30	2.40	4.80
tasset	Total household assets, in thousands	43	280	-2,240	13,100

Source: Authors' calculations from BBS HIES 2000, 2005, and 2010.

Note: Std. dev. = standard deviation.

2005				2010			
Mean	Std. dev.	Min	Max	Mean	Std. dev.	Min	Max
10.97	0.88	5.99	16.25	10.84	0.81	5.39	16.38
391	308	30	4,207	368	1,435	0	120,000
4.9	2.1	1.0	20.0	5.2	2.2	1.0	25.0
0.90	0.30	0.00	1.00	0.09	0.29	0.00	1.00
3.77	0.30	2.48	4.60	3.75	0.30	2.48	4.60
18	85	-2,800	4,094	25	257	-45	16,300

TABLE 6.A2 Share and price variables: Descriptive statistics, 2000, 2005, and 2010

Variable	Description	2000			
		Mean	Std. dev.	Min	Max
w1	Consumption share of primarily aquaculture (%)	3	4	0	38
w2	Consumption share of mixed (%)	4	4	0	48
w3	Consumption share of primarily inland capture (%)	4	4	0	30
w4	Consumption share of primarily marine (%)	2	4	0	39
w5	Consumption share of food grains and pulses (%)	45	15	0	87
w6	Consumption share of dairy, eggs, and meat (%)	6	5	0	52
w7	Consumption share of vegetables and fruit (%)	11	10	0	64
w8	Consumption share of oils, fats, and sugars (%)	14	5	0	44
w9	Consumption share of misc. (%)	12	7	0	100
p1	Price of primarily aquaculture	55.9	19.9	6.6	300.0
p2	Price of mixed	47.7	19.0	10.0	400.0
p3	Price of primarily inland capture	48.3	20.3	7.1	328.0
p4	Price of primarily marine	80.9	41.0	10.9	2,000.0
p5	Price of food grains and pulses	12.5	1.8	5.5	36.0
p6	Price of dairy, eggs, and meat	26.9	10.0	2.4	103.6
p7	Price of vegetables and fruits	448.0	913.7	9.0	4,000.0
p8	Price of oils, fats, and sugars	8.6	3.0	2.5	38.5
p9	Price of misc.	86.6	78.6	7.9	5,457.5

Source: Authors' calculations from BBS HIES 2000, 2005, and 2010.

Note: Prices are directly from HIES and have not been adjusted for inflation.

2005				2010			
Mean	Std. dev.	Min	Max	Mean	Std. dev.	Min	Max
4	4	0	30	5	5	0	36
4	4	0	40	4	4	0	42
3	3	0	32	2	3	0	34
2	4	0	39	3	4	0	53
44	15	0	100	40	15	0	86
6	4	0	39	7	5	0	48
11	10	0	62	12	11	0	80
13	5	0	48	13	5	0	61
13	8	0	100	13	7	0	100
58.1	16.6	8.0	200.0	103.4	25.1	40.0	300.0
56.3	20.9	12.0	200.0	109.9	33.0	40.0	500.0
62.5	22.7	4.0	750.0	126.8	42.9	48.0	800.0
103.1	34.2	10.0	800.0	220.4	84.8	40.0	1,000.0
17.4	1.9	3.6	29.0	33.3	4.5	20.4	76.0
38.0	11.9	2.5	512.5	66.9	27.6	11.1	283.1
537.9	1,066.1	11.8	5,000.0	1,084.8	2,091.5	14.0	8,000.0
9.7	3.7	3.0	81.1	18.0	7.9	4.2	88.7
87.0	40.0	18.3	500.0	132.3	66.2	32.8	1,108.8

TABLE 6.A3 Bangladesh fish exports, 2000–2014 (thousand metric tons)

Year	Frozen shrimp	Frozen fish	Dry fish	Salted fish	Turtles/crab	Shark fish+others	Total
2000	28.51	9.48	0.22	0.81	0.11	0.26	39.39
2001	29.71	7.97	0.14	0.84	0.15	0.18	38.99
2002	30.21	9.86	0.52	0.29	0.34	0.26	41.48
2003	36.86	8.85	0.33	0.53	0.63	0.17	47.37
2004	42.94	10.23	0.47	0.38	0.12	0.18	54.14
2005	46.53	15.76	0.27	0.77	0.04	0.17	63.38
2006	49.32	17.43	0.15	0.59	1.11	0.08	68.83
2007	53.36	18.38	0.08	0.44	1.12	0.24	73.70
2008	49.91	23.52	0.21	0.66	0.44	0.27	75.30
2009	50.37	19.29	0.34	0.08	1.22	0.28	72.89
2010	51.60	21.46	0.62	0.19	0.69	0.96	77.64
2011	54.89	16.74	0.62	0.58	4.49	1.78	96.47
2012	48.01	15.51	1.00	0.41	5.77	1.76	92.48
2013	50.33	11.44	1.28	0.54	7.43	1.60	84.91
2014	47.64	11.68	2.63	0.26	7.71	2.39	77.33

Source: BBS Statistical Yearbook (2016).

Note: To compute production values for use in the model, processing loss was assumed to be 50 percent (Portley 2016). As such, the base levels of exports in the model are double what is presented in the table.

TABLE 6.A4 Scientific names for all fish by category

Category	Fish name	Scientific names
Aquaculture	Rui	<i>Labeo rohita</i>
	Katla	<i>Catla catla</i>
	Mrigel	<i>Cirrhinus cirrhosus</i>
	Kalibaus	<i>Cyprinus calbasu</i>
	Silver carp	<i>Hypophthalmichthys molitrix</i>
	Grass carp	<i>Ctenopharyngodon idella</i>
	Mirror carp	<i>Cyprinus carpio carpio</i>
	Pangas	<i>Pangasius pangasius</i>
	Boaal	<i>Wallago attu</i>
	Air	<i>Bagarius bagarius</i>
Mixed	Kai	<i>Xenentodon cancila</i>
	Magur	<i>Clarias batrachus</i>
	Shingi	<i>Heteropneustes fossilis</i>
	Khalisha	<i>Tirchogaster chuna</i>

Category	Fish name	Scientific names
Mixed (cont.)	Koi	<i>Anabas testudineus</i>
	Mala–kachi	<i>Corica soborna</i>
	Chala–chapila	<i>Gudusia chapra</i>
	Puti	<i>Puntius sophore</i>
	Big puti	<i>Barbonymus gonionotus</i>
	Tilapia	<i>Oreochromis mossambicus</i>
	Nilotica	<i>Oreochromis niloticus niloticus</i>
Inland capture	Shoal	<i>Channa striata</i>
	Gajar	<i>Channa marulius</i>
	Taki	<i>Channa punctata</i>
	Tangra	<i>Devario anomalus</i>
	Eelfish	<i>Gong magor</i>
	Balia	<i>Glossogobius giuris</i>
	Tapashi	<i>Polynemus paradiseus Linnaeus</i>
	Shrimp	<i>Macrobrachium rosenbergii</i>
Marine	Illich	<i>Tenualosa ilisha</i>

Source: Wikipedia 2018; FishBase 2018.

TABLE 6.A5 Own-price elasticity estimates using the Linear Expenditure System (LES)

Category	Own-price elasticity			
	Rural poor	Rural nonpoor	Urban poor	Urban nonpoor
Primarily aquaculture	–0.24	–0.42	–0.52	–0.08
Inland capture and culture	–0.22	0.14	–0.38	–0.73
Primarily inland capture	–0.06	–0.53	–0.03	–0.04
Primarily marine	0.08	–0.18	0.21	–1.60
Freshwater	–0.29	–0.26	–0.22	–0.26
Marine	0.08	–0.18	0.21	–1.60

Source: Authors' calculations from BBS HIES 2000, 2005, and 2010.

TABLE 6.A6 Cross-price elasticity estimates using the Linear Expenditure System (LES)

	Wealth group	Cross-price elasticities			
		Primarily aquaculture	Mixed	Primarily inland capture	Primarily marine
Primarily aquaculture	Rural poor	—	−0.0023	−0.0013	−0.0021
	Rural nonpoor	—	−0.0039	−0.0022	−0.0048
	Urban poor	—	−0.0076	−0.0045	−0.0105
	Urban nonpoor	—	−0.0011	−0.0007	−0.0025
Mixed	Rural poor	−0.0024	—	−0.0012	−0.0019
	Rural nonpoor	0.0018	—	0.0007	0.0015
	Urban poor	−0.0053	—	−0.0033	−0.0076
	Urban nonpoor	−0.0106	—	−0.0069	−0.0240
Primarily inland capture	Rural poor	−0.0006	−0.0005	—	−0.0005
	Rural nonpoor	−0.0069	−0.0049	—	−0.0060
	Urban poor	−0.0004	−0.0004	—	−0.0006
	Urban nonpoor	−0.0006	−0.0005	—	−0.0013
Primarily marine	Rural poor	0.0009	0.0008	0.0004	—
	Rural nonpoor	−0.0023	−0.0017	−0.0009	—
	Urban poor	0.0029	0.0030	0.0018	—
	Urban nonpoor	−0.0229	−0.0218	−0.0148	—
		Freshwater	Marine		
Freshwater	Rural poor	—	−0.0025		
	Rural nonpoor	—	−0.0030		
	Urban poor	—	−0.0044		
	Urban nonpoor	—	−0.0083		
Marine	Rural poor	0.0020	—		
	Rural nonpoor	−0.0049	—		
	Urban poor	0.0076	—		
	Urban nonpoor	−0.0605	—		

Source: Authors' calculations from BBS HIES 2000, 2005, and 2010.

Note: — = not applicable.

TABLE 6.A6a Alternative specifications of expenditure elasticity parameters, 2000, 2005, and 2010

Iterated linear least-squares approach								
	Rural Poor	Standard error	Rural nonpoor	Standard error	Urban Poor	Standard error	Urban nonpoor	Standard error
2000 expenditure elasticities								
Primarily aquaculture	1.46	(0.109)	1.46	(0.080)	1.76	(0.296)	1.47	(0.187)
Mixed	0.87	(0.059)	0.81	(0.072)	0.74	(0.198)	0.76	(0.244)
Primarily inland capture	0.79	(0.068)	0.06	(0.081)	0.45	(0.160)	0.29	(0.284)
Primarily marine	0.97	(0.143)	1.23	(0.098)	1.00	(0.261)	1.16	(0.219)
2005 expenditure elasticities								
Primarily aquaculture	1.18	(0.055)	1.10	(0.043)	1.20	(0.074)	1.12	(0.063)
Mixed	0.97	(0.045)	0.94	(0.052)	0.79	(0.067)	0.62	(0.088)
Primarily inland capture	0.83	(0.064)	0.71	(0.079)	0.85	(0.097)	0.87	(0.104)
Primarily marine	0.89	(0.105)	1.27	(0.099)	1.19	(0.133)	1.45	(0.105)
2010 expenditure elasticities								
Primarily aquaculture	1.07	(0.048)	1.02	(0.044)	1.07	(0.063)	0.99	(0.068)
Mixed	0.89	(0.048)	0.83	(0.056)	0.87	(0.060)	0.77	(0.075)
Primarily inland capture	0.94	(0.077)	0.90	(0.086)	1.15	(0.108)	0.99	(0.100)
Primarily marine	1.13	(0.112)	1.37	(0.078)	0.96	(0.125)	1.31	(0.084)
Alternative QUAIDS approach								
2000 expenditure elasticities								
Primarily aquaculture	1.32	(0.031)	1.49	(0.039)	1.05	(0.056)	-0.45	(1.005)
Mixed	0.67	(0.029)	0.50	(0.033)	1.06	(0.04)	2.34	(0.68)
Primarily inland capture	0.62	(0.065)	0.57	(0.039)	0.51	(0.11)	-3.83	(3.661)
Primarily marine	1.23	(0.025)	1.40	(0.039)	1.46	(0.15)	2.01	(0.412)
2005 expenditure elasticities								
Primarily aquaculture	1.20	(0.008)	1.15	(0.005)	1.00	(0.003)	0.98	(0.002)
Mixed	0.79	(0.02)	0.70	(0.016)	0.70	(0.03)	0.54	(0.034)
Primarily inland capture	0.91	(0.005)	0.94	(0.003)	1.04	(0.011)	1.10	(0.012)
Primarily marine	1.26	(0.031)	1.35	(0.025)	1.53	(0.048)	1.52	(0.036)
2010 expenditure elasticities								
Primarily aquaculture	0.91	(0.007)	0.84	(0.008)	0.58	(0.023)	0.29	(0.034)
Mixed	0.74	(0.019)	0.60	(0.019)	0.55	(0.033)	0.41	(0.03)
Primarily inland capture	0.99	(0.003)	0.98	(0.004)	1.03	(0.01)	0.91	(0.009)
Primarily marine	1.72	(0.048)	2.19	(0.086)	2.73	(0.134)	2.89	(0.166)

Source: Authors' calculations from the BBS HIES 2000, 2005, and 2010.

TABLE 6.A6b Alternative specifications of price elasticity parameters, 2000, 2005, and 2010**Iterated linear least-squares approach****2000 price elasticities**

		Rural							
		Primarily aquaculture	Std. error	Mixed	Std. error	Primarily inland capture	Std. error	Primarily marine	Std. error
Poor (households in bottom 40% of expenditures)	Primarily aquaculture	-2.25	(0.15)	-0.31	(0.12)	-0.20	(0.11)	0.28	(0.08)
	Mixed	0.02	(0.08)	-0.95	(0.07)	-0.24	(0.07)	0.20	(0.05)
	Primarily inland capture	0.55	(0.09)	0.25	(0.08)	-0.59	(0.08)	-0.21	(0.06)
	Primarily marine	1.24	(0.19)	-0.16	(0.18)	0.13	(0.16)	-1.69	(0.14)
Nonpoor (households in top 60% of expenditures)	Primarily aquaculture	-2.03	(0.10)	-0.28	(0.10)	-0.23	(0.09)	0.23	(0.07)
	Mixed	0.01	(0.09)	-0.93	(0.08)	-0.25	(0.08)	0.24	(0.06)
	Primarily inland capture	0.55	(0.10)	0.31	(0.09)	-0.42	(0.09)	-0.22	(0.07)
	Primarily marine	1.01	(0.16)	-0.19	(0.14)	-0.11	(0.13)	-1.55	(0.10)

2005 price elasticities

		Rural							
		Primarily aquaculture	Std. error	Mixed	Std. error	Primarily inland capture	Std. error	Primarily marine	Std. error
Poor (households in bottom 40% of expenditures)	Primarily aquaculture	-1.71	(0.08)	-0.26	(0.06)	0.02	(0.05)	0.12	0.04
	Mixed	0	(0.06)	-1.09	(0.05)	-0.14	(0.04)	0.31	0.04
	Primarily inland capture	0.75	(0.09)	0.34	(0.07)	-1.02	(0.06)	-0.37	0.05
	Primarily marine	0.64	(0.15)	0.38	(0.12)	0.42	(0.11)	-1.61	0.09
Nonpoor (households in top 60% of expenditures)	Primarily aquaculture	-1.57	(0.06)	-0.19	(0.05)	0.04	(0.04)	0.10	0.04
	Mixed	0	(0.07)	-1.10	(0.06)	-0.15	(0.05)	0.36	0.04
	Primarily inland capture	0.89	(0.12)	0.42	(0.09)	-0.98	(0.08)	-0.43	0.06
	Primarily marine	0.57	(0.16)	0.24	(0.12)	0.23	(0.10)	-1.61	0.08

Iterated linear least-squares approach							
2000 price elasticities							
Urban							
Primarily aquaculture	Std. error	Mixed	Std. error	Primarily inland capture	Std. error	Primarily marine	Std. error
-2.26	(0.37)	-0.07	(0.27)	-0.37	(0.31)	0.78	(0.23)
0.13	(0.26)	-0.76	(0.23)	0.09	(0.25)	0.10	(0.17)
0.29	(0.22)	0.07	(0.19)	-0.47	(0.20)	-0.07	(0.14)
1.32	(0.33)	-0.27	(0.29)	-0.36	(0.33)	-2.19	(0.24)
-1.93	(0.24)	-0.03	(0.22)	-0.27	(0.24)	0.60	(0.17)
0.12	(0.29)	-0.74	(0.27)	0.09	(0.29)	0.12	(0.11)
0.33	(0.29)	0.09	(0.26)	-0.28	(0.30)	-0.07	(0.19)
1.07	(0.31)	-0.28	(0.25)	-0.38	(0.27)	-2.02	(0.20)
2005 price elasticities							
Urban							
Primarily aquaculture	Std. error	Mixed	Std. error	Primarily inland capture	Std. error	Primarily marine	Std. error
-1.55	(0.08)	-0.24	(0.07)	0.04	(0.06)	0.45	(0.05)
0.23	(0.07)	-1.06	(0.06)	-0.03	(0.05)	0.25	(0.04)
0.41	(0.10)	0.16	(0.09)	-1.22	(0.08)	-0.33	(0.06)
0.24	(0.14)	0.47	(0.12)	0.28	(0.10)	-2.13	(0.09)
-1.47	(0.07)	-0.19	(0.06)	0.05	(0.05)	0.40	(0.04)
0.33	(0.09)	-1.01	(0.08)	-0.01	(0.07)	0.31	(0.05)
0.43	(0.11)	0.16	(0.09)	-1.23	(0.08)	-0.36	(0.06)
0.10	(0.12)	0.26	(0.10)	0.18	(0.09)	-1.95	(0.08)

(continued)

TABLE 6.A6b Continued**Iterated linear least-squares approach****2010 price elasticities**

		Rural							
		Primarily aquaculture	Std. error	Mixed	Std. error	Primarily inland capture	Std. error	Primarily marine	Std. error
Poor (households in bottom 40% of expenditures)	Primarily aquaculture	-1.69	(0.08)	-0.15	(0.06)	0.24	(0.05)	0.25	0.03
	Mixed	0.2	(0.08)	-0.97	(0.06)	-0.13	(0.05)	0.11	0.04
	Primarily inland capture	0.61	(0.12)	0.28	(0.09)	-1.79	(0.08)	-0.39	0.06
	Primarily marine	0.92	(0.16)	0.01	(0.13)	0.71	(0.12)	-1.60	0.09
Nonpoor (households in top 60% of expenditures)	Primarily aquaculture	-1.64	(0.07)	-0.13	(0.05)	0.23	(0.05)	0.25	0.03
	Mixed	0.24	(0.09)	-0.94	(0.07)	-0.14	(0.06)	0.13	0.04
	Primarily inland capture	0.68	(0.14)	0.32	(0.11)	-1.86	(0.09)	-0.43	0.06
	Primarily marine	0.62	(0.14)	-0.10	(0.10)	0.50	(0.09)	-1.49	0.06

Alternative QUAIDS approach**2000 price elasticities**

		Rural							
		Primarily aquaculture	Std. error	Mixed	Std. error	Primarily inland capture	Std. error	Primarily marine	Std. error
Poor (households in bottom 40% of expenditures)	Primarily aquaculture	-1.84	(0.06)	-0.10	(0.03)	0.03	(0.03)	0.58	(0.04)
	Mixed	0.1	(0.05)	-0.89	(0.03)	-0.10	(0.02)	0.22	(0.02)
	Primarily inland capture	0.48	(0.14)	-0.33	(0.08)	-0.10	(0.07)	-0.68	(0.05)
	Primarily marine	1.46	(0.17)	0.27	(0.02)	-0.97	(0.12)	-1.99	(0.09)
Nonpoor (households in top 60% of expenditures)	Primarily aquaculture	-1.65	(0.04)	-0.36	(0.04)	-0.23	(0.03)	0.75	(0.05)
	Mixed	-0.1	(0.02)	-0.69	(0.03)	0.08	(0.02)	0.21	(0.01)
	Primarily inland capture	0.11	(0.06)	-0.03	(0.04)	0.04	(0.07)	-0.68	(0.04)
	Primarily marine	2.02	(0.18)	0.22	(0.02)	-1.39	(0.12)	-2.25	(0.10)

Iterated linear least-squares approach							
2010 price elasticities							
Urban							
Primarily aquaculture	Std. error	Mixed	Std. error	Primarily inland capture	Std. error	Primarily marine	Std. error
-1.17	(0.08)	-0.31	(0.07)	-0.05	(0.05)	0.10	(0.04)
-0.12	(0.08)	-0.80	(0.07)	0.04	(0.05)	0.13	(0.04)
-0.14	(0.14)	0.02	(0.12)	-1.50	(0.09)	-0.23	(0.06)
0.77	(0.16)	0.29	(0.14)	0.51	(0.11)	-1.27	(0.08)
-1.15	(0.09)	-0.29	(0.07)	-0.04	(0.06)	0.11	(0.04)
-0.12	(0.09)	-0.74	(0.08)	0.06	(0.06)	0.16	(0.04)
-0.08	(0.13)	0.09	(0.11)	-1.46	(0.09)	-0.21	(0.06)
0.43	(0.12)	0.06	(0.10)	0.30	(0.08)	-1.22	(0.05)
Alternative QUAIDS approach							
2000 price elasticities							
Urban							
Primarily aquaculture	Std. error	Mixed	Std. error	Primarily inland capture	Std. error	Primarily marine	Std. error
-2.37	(0.23)	-0.07	(0.01)	-0.05	(0.01)	1.43	(0.25)
-0.08	(0.02)	-0.78	(0.05)	-0.23	(0.04)	0.02	(0.01)
0.14	(0.03)	-0.15	(0.04)	-0.26	(0.17)	-0.24	(0.06)
2.40	(0.51)	-0.03	(0.03)	-0.63	(0.14)	-3.19	(0.55)
-1.44	(0.46)	0.28	(0.23)	0.22	(0.17)	1.39	(0.25)
-0.58	(0.32)	-1.02	(0.16)	-0.49	(0.12)	-0.25	(0.12)
1.99	(1.73)	0.72	(0.82)	0.70	(0.68)	0.41	(0.59)
2.02	(0.70)	-0.16	(0.08)	-0.70	(0.23)	-3.17	(0.71)

(continued)

TABLE 6.A6b Continued

Alternative QUAIDS approach									
2005 price elasticities									
Rural									
		Primarily aquaculture	Std. error	Mixed	Std. error	Primarily inland capture	Std. error	Primarily marine	Std. error
Poor (households in bottom 40% of expenditures)	Primarily aquaculture	-1.73	(0.03)	-0.17	(0.01)	0.34	(0.01)	0.36	(0.02)
	Mixed	-0.02	(0.01)	-1.05	(0.03)	0.01	(0.01)	0.28	(0.02)
	Primarily inland capture	0.62	(0.03)	-0.01	(0.01)	-1.14	(0.01)	-0.37	(0.02)
	Primarily marine	1.03	(0.07)	0.62	(0.04)	-0.75	(0.05)	-2.16	(0.08)
Nonpoor (households in top 60% of expenditures)	Primarily aquaculture	-1.58	(0.02)	-0.22	(0.01)	0.30	(0.01)	0.35	(0.01)
	Mixed	-0.1	(0.01)	-0.84	(0.02)	0.00	(0.00)	0.23	(0.01)
	Primarily inland capture	0.75	(0.03)	-0.07	(0.01)	-1.18	(0.01)	-0.45	(0.02)
	Primarily marine	1.1	(0.08)	0.42	(0.04)	-0.75	(0.05)	-2.11	(0.06)
2010 price elasticities									
Rural									
		Primarily aquaculture	Std. error	Mixed	Std. error	Primarily inland capture	Std. error	Primarily marine	Std. error
Poor (households in bottom 40% of expenditures)	Primarily aquaculture	-1.92	(0.04)	0.05	(0.00)	0.58	(0.03)	0.39	(0.02)
	Mixed	0.12	(0.01)	-1.03	(0.00)	0.10	(0.01)	0.06	(0.00)
	Primarily inland capture	1.06	(0.05)	0.10	(0.01)	-2.00	(0.04)	-0.14	(0.01)
	Primarily marine	0.56	(0.03)	-0.16	(0.01)	-0.28	(0.01)	-1.84	(0.04)
Nonpoor (households in top 60% of expenditures)	Primarily aquaculture	-1.86	(0.03)	0.06	(0.00)	0.57	(0.02)	0.39	(0.01)
	Mixed	0.19	(0.01)	-0.98	(0.00)	0.14	(0.01)	0.06	(0.00)
	Primarily inland capture	1.17	(0.05)	0.12	(0.01)	-2.11	(0.05)	-0.17	(0.01)
	Primarily marine	0.56	(0.04)	-0.35	(0.03)	-0.41	(0.03)	-2.00	(0.07)

Source: Authors' calculations from BBS HIES 2000, 2005, and 2010.

Alternative QUAIDS approach							
2005 price elasticities							
Urban							
Primarily aquaculture	Std. error	Mixed	Std. error	Primarily inland capture	Std. error	Primarily marine	Std. error
-1.73	(0.03)	-0.08	(0.01)	0.30	(0.01)	0.50	(0.02)
0.00	(0.01)	-1.13	(0.05)	0.01	(0.02)	0.41	(0.04)
0.52	(0.03)	-0.08	(0.03)	-1.33	(0.02)	-0.15	(0.02)
1.19	(0.11)	0.57	(0.07)	-0.33	(0.03)	-2.96	(0.16)
-1.69	(0.03)	-0.18	(0.01)	0.35	(0.01)	0.55	(0.02)
-0.11	(0.01)	-0.69	(0.05)	-0.12	(0.02)	0.38	(0.04)
0.61	(0.03)	-0.28	(0.02)	-1.31	(0.02)	-0.12	(0.02)
0.92	(0.07)	0.34	(0.04)	-0.25	(0.02)	-2.53	(0.09)
2010 price elasticities							
Urban							
Primarily aquaculture	Std. error	Mixed	Std. error	Primarily inland capture	Std. error	Primarily marine	Std. error
-0.81	(0.01)	-0.21	(0.01)	0.20	(0.01)	0.24	(0.02)
-0.24	(0.01)	-0.63	(0.02)	0.16	(0.01)	0.15	(0.01)
0.26	(0.02)	0.14	(0.01)	-1.42	(0.02)	0.00	(0.01)
-0.17	(0.05)	-0.33	(0.03)	-0.23	(0.02)	-2.00	(0.11)
-0.65	(0.02)	0.01	(0.29)	0.01	(0.25)	0.02	(0.02)
-0.24	(0.01)	-0.52	(0.02)	0.22	(0.01)	0.14	(0.01)
0.35	(0.02)	0.20	(0.01)	-1.44	(0.02)	-0.02	(0.00)
-0.48	(0.05)	-0.49	(0.05)	-0.33	(0.03)	-1.60	(0.07)

TABLE 6.A7 Model calibration

	Price target growth rate (%)	Current sim price growth rate (%)	Historical production growth rate (%)	Current sim prod. growth rate (%)	Current prod. shock	Current elast. of supply	Sim price change (%)	Price error (%)	Prod. error (%)
Aquaculture	-2.00	-5.24	8.61	6.72	0.08	0.4	-5.28	-3.31	-1.74
Inland capture	-2.00	-1.49	2.13	1.97	0.021	0.3	-1.52	0.52	-0.15
Mixed	-2.00	-3.19	-0.12	4.34	0.08	0.3	-3.19	-1.21	4.47
Marine	0.30	-0.30	3.01	1.10	0.03	0.3	-0.30	-0.60	-1.85

Source: Authors' calculations from simulations.

Note: All growth rates and changes are from 2010 to 2015.

TABLE 6.A8 Bangladesh fish production and prices: Simulation results (alternative parameters)

Annual growth rates (%): 2015–2030					
Production					
Base 2015 level (million metric tons)	Aquaculture	Inland capture	Mixed	Marine	Total fish
	1.5	0.5	1.0	0.5	3.5
Growth rates (%)					
Base	3.23	1.39	1.63	1.31	2.31
Sim 1	4.27	1.80	1.96	1.25	2.96
Sim 2	3.72	1.83	2.01	1.68	2.75
Sim 3	4.76	2.24	2.34	1.62	3.41
Sim 4	5.04	1.75	1.93	1.21	3.36
Sim 5	5.53	2.19	2.30	1.58	3.81
Price					
Base 2015 level (Bangladeshi taka per kilogram)	Aquaculture	Inland capture	Mixed	Marine	Average fish
	103.99	127.61	109.01	220.20	140.2
Growth rates (%)					
Base	-1.04	4.71	0.43	4.43	3.4
Sim 1	-2.51	3.33	-0.44	4.23	2.8
Sim 2	0.14	6.23	1.68	5.71	4.8
Sim 3	-1.34	4.84	0.79	5.50	4.1
Sim 4	-3.77	3.18	-0.56	4.10	2.6
Sim 5	-2.62	4.68	0.67	5.36	3.9

Source: Model simulations.

Note: Sim 1: High productivity, all systems. Sim 2: Increased household fish demand. Sim 3: Sim 1 with increased household demand. Sim 4: Sim 1 with extra aquaculture productivity gains. Sim 5: Sim 4 with increased household demand.

TABLE 6.A9 Bangladesh fish consumption: Simulation results (alternative parameters)

		Per capita consumption				
		Level (kilograms per capita)				
		Aquaculture	Inland capture	Mixed	Marine	All fish
Base 2015	Rural nonpoor	11.67	2.36	5.72	1.77	21.52
	Rural poor	7.03	1.90	4.25	0.89	14.07
	Urban nonpoor	12.30	3.61	6.77	5.72	28.40
	Urban poor	9.77	2.78	5.69	2.59	20.83
	All Bangladesh	9.78	2.43	5.33	2.15	19.69
Percent change, 2015–2030 (%)						
Base	Rural nonpoor	6.7	–21.3	0.3	–18.4	0
	Rural poor	19.9	–13.4	8.4	–8.1	10
	Urban nonpoor	51.4	15.5	8.2	–3.4	25
	Urban poor	69.9	36.0	21.0	23.4	46
	Total	33.7	6.0	10.4	9.1	21
Sim 3	Rural nonpoor	47.5	–4.6	25.2	–2.6	32
	Rural poor	56.4	3.6	28.6	6.6	38
	Urban nonpoor	90.7	39.7	14.7	2.2	48
	Urban poor	71.4	37.0	16.5	14.5	45
	Total	66.8	22.4	24.4	15.9	44
Sim 5	Rural nonpoor	64.4	–5.4	23.7	–5.2	40
	Rural poor	72.9	3.2	28.6	4.3	46
	Urban nonpoor	114.4	38.6	13.7	2.7	58
	Urban poor	92.0	35.6	16.3	13.1	54
	Total	86.2	21.5	23.6	15.0	53

Source: Model simulations.**Note:** Sim 1: High productivity, all systems. Sim 2: Increased household fish demand. Sim 3: Sim 1 with increased household demand. Sim 4: Sim 1 with extra aquaculture productivity gains. Sim 5: Sim 4 with increased household demand.

TABLE 6.A10 Bangladesh fish production projections to 2015

	1995/1996	2000/2001	2014/2015	Growth rates (%)	
				1996–2001	2001–2015
Inland capture	1,366	950	344	–7.00	–7.00
Inland culture	317	651	2,471	15.50	10.00
Marine	628	597	519	–1.00	–1.00
Total	2,311	2,198	3,334	–1.00	3.00

Source: FSR (2003), Dorosh (2006), and authors' calculations.

Note: Projections for 2014/2015 assume no change in real prices of fish. Inland culture is Department of Fisheries data. Inland capture is residual of Household Expenditure Survey (HES) data of total fish less DoF inland culture. Marine is HES consumption figure for dried fish (10:1 fresh-to-dry conversion). 1995/1996 and 2000/2001 are historical data. 2014/2015 is a projection.