Output and Input Subsidy Policy Options in Bangladesh

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Abstract *Recent changes in pricing policies emphasizing price supports and phasing out fertilizer subsidies are a step in the right direction, particularly if minimizing the combined foreign exchange and budgetary expenditures of Bangladesh and donor nations is the key objective. A normalized restricted profit function is used to estimate profit and factor demand functions from farm-level, cross-sectional data for the food grain and jute crops in Bangladesh. The estimated elasticities are used to evaluate price support and fertilizer subsidy programs in terms of their costs to the government, foreign exchange effects, and producer surplus for the food grain and jute sectors.*

Keywords. *Food grains, jute, profit function, output price supports, fertilizer subsidies, elasticities, producer surplus, Bangladesh.*

Bangladesh has adopted food grain self-sufficiency as a national policy goal. Motives include the critical dependence of low-income consumers on adequate supplies of food grains, the need to boost agricultural incomes, and a desire to reduce foreign exchange outlays for food grain imports because of the limited scope for expanding exports. Bangladesh's past success in boosting food grain production at an annual rate of 2.5 percent between 1976 and 1988, coupled with its vast potential based on fertile soils and abundant supplies of labor and water, supports the feasibility of this strategy (*36*).[1] Although Bangladesh has made significant progress toward self-sufficiency since independence, wheat and rice imports remain large, having averaged close to 2 million tons per year during the 1980's (*27, 38*).

The policy problem addressed in this article evaluates the shortrun effects of producer-oriented price support and fertilizer subsidy policies that support Bangladesh's goal of reducing dependence on food grain imports. The policies are evaluated against criteria of government cost, foreign exchange savings, and producer welfare. Other possible forms of public expenditure are not evaluated. A sustained longrun growth in food grain production is dependent upon improvement in irrigation, credit, transportation, flood control, and institutional factors, if combined with output and input price interventions. Shortrun pricing interventions that stimulate output along existing production functions, such as supporting product prices and subsidizing inputs, are important policy instruments in Bangladesh.

Both price support and input subsidies exist in Bangladesh. And, as in many other Asian countries, Bangladesh faces a tradeoff between policies that emphasize high input subsidies and low food grain prices on the one hand and those that emphasize low input subsidies and high food grain prices on the other (*10, 20*). Increasing fertilizer prices by reducing fertilizer subsidies weakens the ability of Bangladesh to maintain food grain self-sufficiency under continuation of existing food grain security policies, which emphasize low food grain prices for consumers and minimal output price incentives to producers. Increasing fertilizer prices, by contrast, requires policymakers to raise food grain prices higher than before or to focus subsidies on other inputs, such as credit and irrigation, to encourage producers to invest in new technologies that boost production.

Food grain purchases have depleted foreign exchange reserves, exacerbated long-term balance of payments problems, dampened overall growth rates, and raised concern about the efficacy of price support and subsidized food grain distribution operations among the United States and other food donors. Although most imports are on concessional terms, commercial imports have become increasingly important in recent years. While net losses on food grains amounted to just $15 million in FY 1988, food budget subsidies soared to $200 million in 1989 due to higher import prices and record distributions of subsidized food grains (*36*). Food budget expenditures represented close to 8 percent of current expenditures during 1980-88 (*36*), and subsidized public food grain distributions continued on a large scale (*38*).

Government policies emphasizing fertilizer subsidies to encourage production have also raised questions among donors concerning the necessity and relative effectiveness of continuing large fertilizer subsidies. While fertilizer subsidies amounted to only $20 million in FY 1988, just one-fifth of the 1981 level, they increased sharply to $47 million in 1989 (*36, 37*). Nitrogen fertilizer subsidies were phased out in 1986, but large per unit subsidies on phosphates and potash fertilizers persist (*27*). And, the slowdown in food grain production in recent years has revived the debate on the need for increasing nitrogen fertilizer subsidies (*36*).

Available analyses of price policy in Bangladesh are limited by lack of a comprehensive model of policy

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[1] Italicized numbers in parentheses cite sources listed in the References section at the end of this article.

evaluation and inadequacies in estimating key parameters measuring responsiveness of farmers and consumers to price incentives This study focuses on measuring key parameters on the supply side and defining the costs and benefits of alternative pricing policies The results should interest policymakers and analysts who face decisions about appropriate subsidy policies in other less-developed countries, and donors who are concerned with the impact of their aid and how supply responsiveness can affect trade forecasts

Procedures for Policy Evaluation

Policymakers in Bangladesh generally accept the notion that government intervention in input and output markets is necessary to achieve food security objectives (*1, 7, 8, 10, 18 20, 22, 24, 26, 33, 34*) Thus, controlling input and output subsidies is an important policy issue because food grain and input subsidies annually constitute a significant proportion of the Bangladeshi budget and potentially divert resources from programs with higher returns (*33, 36*)

Despite the importance of the output-versus-fertilizer subsidy issue in Bangladesh, there is clearly a lack of consensus on the relative impacts of the two policies Tolley and others argue that the fertilizer subsidy policy is more expensive to the government than the output subsidy (*26*) Ahmed argues the opposite (*1*) With the continuing use of selected fertilizer subsidies to keep prices low for farmers, identifying how changes in the fertilizer subsidy will affect production remains an important issue Research indicates that eliminating the fertilizer subsidy would not substantially reduce food grain output (*1*) In general, previous studies did not use econometric estimates of key parameters (for example, the own-price elasticity of output supply and the elasticity of output supply with respect to the price of fertilizer) Instead, they relied on best estimates of such parameters Ignored are many of the competitive effects of key inputs (labor and animal power) and other outputs (wheat and jute)

The price support and input subsidy programs are evaluated for how a 1-percent increase in production influences government costs, foreign exchange savings, and producer welfare Costs are measured for each program by using frameworks developed in other research (*1, 5, 6, 13, 18, 26*) The effects of each of the two programs on consumer welfare are limited because the prices of subsidized cereals are held constant, and distributed ration quantities are adjusted to help stabilize open market prices at current levels

Effects of Higher Crop Prices

Increasing food grain production through higher price supports boosts government spending for procuring and handling the additional marketed supply of food grain and distributing procured food grains at subsidized prices to enforce the new support price Outlays for already existing fertilizer subsidies rise as the higher crop price results in more fertilizer use The net savings in foreign exchange associated with the price support program comes from the reduction in expenditures on food grain imports (as higher domestic production reduces import needs) minus the cost of larger fertilizer imports and the loss in revenues from jute exports

It is assumed that food grain imports will be reduced by the 1-percent increase in production used in the evaluation of the output support and input subsidy programs Fertilizer imports are assumed to continue to account for 40 percent of fertilizer consumption, which is comparable with the 1981-84 percentage Wheat will likely continue to account for 83 percent of imports Exportable supplies of jute will fall as higher food grain support prices lead to some diversion of jute area to rice The price support program leads to a producer welfare gain which equals the additional revenues generated by the higher selling price, less the additional cost of inputs used to increase production The government costs associated with higher price supports are also influenced by how much additional food grain must be procured and distributed at subsidized prices in order to prevent an increase in open market consumer prices I assume that the government enforces the support price by purchasing all additional marketed surplus and distributing these quantities during the procurement period

Farmgate prices were used in deriving the supply and demand estimates in the profit function analysis Government policymakers have set support prices at the same level for all rice crops despite the disparate supply and demand conditions that prevail across the three cropping seasons (*33*) Winter rice has a lower price at the farmgate because of the impact on rice supplies that is caused by harvest of the large fall rice crop (*19*) The impact that these differences in prices have on procurement was factored into the analysis by weighting the average procurement levels separately for each food grain crop (*26*)

A constraint to stronger food grain price incentives is the desire of Bangladeshi policymakers to maintain an appropriate relationship between the prices of rice and jute (*19, 33*) Jute and rice compete for some of the same land, and jute exports account for a significant proportion of Bangladeshi export earnings (*27*) Half of the 600,000 hectares annually devoted to jute usually compete with the summer and fall rice crops, which together occupy about 9 million hectares (*19*) Given little reliable econometric evidence in the literature the analysis arbitrarily assumed a cross-price elasticity of supply of 0 33 between rice and jute The cross-price elasticity of supply between rice and other crops, including wheat, was ignored

Effects of Higher Fertilizer Subsidies

Government costs associated with the fertilizer subsidy program include the cost of subsidizing the increased volume of fertilizer used by food grain and jute producers at the lower price, and the cost of producing and distributing enough of the additional marketed supply of food grains that are produced to maintain the existing support price The net foreign exchange savings associated with a larger fertilizer subsidy match the reduced cost of food grain imports, plus the gain in revenues from larger jute exports, minus the cost of additional fertilizer imports The change in producer welfare can be estimated as the additional revenues from selling the increased output, minus any change in costs resulting from using larger amounts of less expensive fertilizer The fertilizer subsidy, I assume, causes the procurement volume to increase consistent with historical rates, leaving the support price unchanged The quantity procured is therefore smaller than that for the price support program Likewise, the market displacement effect, due to an increase in the quantity of rationed distributions, resulting in increased welfare to ration recipients for the fertilizer program, is likely to be less than for the price support program

Gauging the responsiveness of Bangladeshi farmers to changes in crop and fertilizer prices is necessary to estimate the various program costs and benefits Output supply and input demand elasticities have been estimated assuming profit-maximizing behavior by Bangladeshi farm firms producing food grains and jute Well-behaved, normalized restricted profit functions are estimated, and supply and input response functions are derived The profit functions for each of the food grains and jute were estimated separately

The Profit Function Model

Diewert has suggested a translog form of the estimating equations for the normalized restricted profit function (*8*, *14*, *15*)

$$\ln G = \alpha 0 + \sum_{i}^{n} \alpha_i \ln V_i + 1/2 \sum_{i}^{n} \sum_{j}^{n} \gamma_{ij} \ln V_i \ln V_j \quad (1)$$

$$+ \sum_{i}^{n} \sum_{k}^{v} \delta_{ik} \ln V_i \ln U_k + \sum_{k}^{v} \beta_k \ln U_k$$

$$+ 1/2 \sum_{k}^{v} \sum_{t}^{v} \phi_{kt} \ln U_k \ln U_k + \sum_{d}^{r} \Theta_d D_d + e_i$$

$$\frac{\partial \ln G}{\partial \ln V_i} = \alpha_i + \sum_{j}^{n} \gamma_{ij} \ln V_j + \sum_{j}^{v} \delta_{ik} \ln U_k + e_i \,, \quad (2)$$

where G, the restricted normalized profit, is defined as total revenue less total costs of variable inputs normalized by P, the price of output, V_i is the price of variable input X_i, normalized by P, U_k is the kth fixed input, i, j=1,2, v are behavioral parameters (ln is the natural logarithm), α_0, α_i γ_{ij}, δ_{ik}, β_k, ϕ_{kt} are the behavioral parameters, and Θ_d is the coefficient of the dummy variable K accounting for r-1 regional differences and technical change The profit functions for

Table 1—Descriptive statistics

Item	Unit	Spring rice	Summer rice	Winter rice	Wheat	Jute
Farm observations	(no)	222	95	100	95	222
Variable profits	(taka)[1]	707 35	1,507 10	1,108 47	898 82	1,276 35
Output	(maunds of paddy, grain, or fiber)	16 89	27 64	23 30	18 25	10 45
Labor	(workdays)	48 74	70 45	42 22	44 24	65 82
Fertilizer	(seers of nutrients)	17 52	46 01	36 45	42 73	10 11
Animal power	(bullock teamdays)	16 23	19 87	12 18	10 60	9 71
Land cultivated	(acres)	84	1 25	66	75	63
Crop price	(taka/maund)	74 24	84 47	78 09	83 64	146 23
Wage rate	(taka/day)	10 42	9 73	12 97	10 34	9 56
Urea	(taka/seer)	1 51	1 50	1 52	1 50	1 56
Irrigation cost	(taka)	27 66	29 86	131 57	44 93	—
Bullock hire	(taka/team)	14 35	11 07	20 39	11 89	13 10
Fertilizer share[2]	(percent)	- 04	- 08	- 09	- 10	- 02
Labor share[2]	(do)	- 74	- 42	- 56	- 46	- 62
Irrigation share[2]	(do)	—	—	09	03	—
Tenants	(do)	25 23	33 68	23 00	34 79	28 80
High-yielding varieties users	(do)	27 03	11 58	70 00	100 00	40 90
Fertilizer users	(do)	45 95	63 16	77 00	89 30	64 00

— = Not applicable

Note US$ = Taka 32 15 in 1988/89 One seer = 2 05 pounds One maund = 82 29 pounds

[1]Per farm actual variable profits, revenues from crop output and byproducts, less the cost of chemical fertilizer, hired labor, and irrigation

[2]—Input quantity multiplied by input price equals profit

Sources (*28*, *29*, *30*, *31*, *32*)

wheat and winter rice were specified with three variable inputs labor, fertilizer, and irrigation The profit functions for summer rice, fall rice, and jute were specified with only labor and fertilizer I measured the fixed inputs for each crop as the cost of capital (including the cost of hired bullock services, pesticides, seeds, organic fertilizer, and credit) and acres of land cultivated per farm

Table 2—Parameter estimates

Variable	Spring rice	Summer rice	Winter rice	Wheat	Jute
α0	26 728	6 250	−1 138	2 386	2 865
	(3 869)	(1 879)	(860)	(502)	(2 928)
αF	− 213	248	− 192	− 206	− 037
	(21 884)	(5 247)	(1 215)	(1 449)	(2 250)
αL	965	034	−1 410	146	− 879
	(5 917)	(034)	(3 928)	(388)	(4 380)
αI			− 270	198	
			(2 328)	(2 291)	
γFF	− 002	− 068	047	− 025	− 016
	(227)	(4 110)	(1 146)	(798)	(1 748)
γLL	169	− 169	− 323	− 346	− 490
	(1 163)	(9 632)	(3 198)	(7 742)	(10 284)
γII			026	− 007	
			(1 733)	(856)	
γFL	− 003	049	− 145	022	033
	(383)	(2 795)	(3 222)	(768)	(3 614)
γFI			003	− 003	
			(214)	(028)	
γLI			− 127	048	
			(4 097)	(3 415)	
δFT	− 010	011	002	− 032	− 002
	(5 203)	(1 847)	(074)	(1 532)	(671)
δFK	010	− 013	011	011	009
	(5 193)	(2 693)	(611)	(0 574)	(6 094)
δLT	124	093	− 049	325	174
	(1 652)	(4 820)	(613)	(5 337)	(3 531)
δLK	− 146	− 114	041	− 199	− 158
	(3 137)	(10 492)	(789)	(3 386)	(5 631)
δIT			− 022	− 023	
			(786)	(1 777)	
δIK			− 011	− 023	
			(647)	(1 913)	
βT	6 782	−1 569	464	2 380	2 311
	(4 269)	(1 687)	(813)	(2 000)	(5 038)
βK	−9 496	1 215	714	− 034	− 053
	(4 184)	(1 124)	(1 668)	(023)	(1 897)
ϕTT	− 432	026	− 145	652	330
	(2 420)	(184)	(843)	(3 062)	(2 044)
ϕKK	1 673	− 142	− 086	− 381	− 006
	(4 462)	(811)	(1 036)	(161)	(107)
ϕTK	−1 104	− 054	057	− 144	− 126
	(4 152)	(394)	(633)	(780)	(1 882)
ϕBO				− 634	
				(12 415)	
θCO	1 763				
	(6 708)				
θDA	1 692				
	(6 543)				
θDI		− 222			
		(3 380)			
θFA	1 862				
	(7 254)				
θMY	1 260			− 118	
	(4 824)			(2 093)	
θNO		201			
		(2 035)			
θJE				− 411	
				(7 633)	
θRA					− 017
					(237)
θHYV			7 39		
			(10 557)		

Figures in parentheses are the absolute values of the asymptotic t-statistics

Applying the Goldfield Quandt test for heteroskedasticity between users and nonusers of fertilizer (implying as seems reasonable greater variance of profits for users) using OLS estimation yielded F values of 2 20 with (103,103) degrees of freedom for spring rice and 3 93 with (40,40) degrees of freedom for summer rice Thus at the 0 5 percent level of significance there is indication of heteroskedasticity for spring and summer rice Consequently all observations for spring and summer rice are divided by the standard errors of the separate regressions for users and nonusers of fertilizer prior to obtaining estimates shown in table 2

The entire sample covered 9 regions BO = Bogra, CH = Chittagong, DA = Dhaka DI = Dinajpur FA = Faridpur JE = Jessore, MY = Mymensingh NO = Noakhali and RA = Rangpur The regions covered for each crop are indicated by dummy variables reported above

Seventy percent of winter rice producers reported using high-yielding varieties

Information on Producer Surplus from the Restricted Profit Function

The welfare impact on producers of input and output price interventions in the associated input and output markets may be determined from supply and demand functions derived from the normalized restricted profit function (*13, 18*) Producer welfare from such price changes may be analyzed by measuring producer surplus (PS), defined as the excess of gross receipts (TR) over total variable costs (TVC), PS = TR − TVC Producer surplus is defined as the area above the supply curve and below the price line of the corresponding firm or industry (*13*) The welfare impact of a price change for a single input can be completely measured in the associated factor market, or the welfare impact of change for a single output can be completely measured in the associated output market, even though the price change induces a shift not only in output supply but other factor demands (*13*) All input markets for which prices are unchanged need not be considered in calculating the change in welfare

The restricted profit function by definition represents producer surplus and may be used to derive the effect on producer welfare from government price interventions in input and output markets (*11*) The total change in producer surplus, $\Delta\Pi$, from initial output and input price (P^0, V^0) to final prices (P^1, V^1) may be expressed as

$$\Delta\Pi = P^0 G(V^0, U) - P^1 G(V^1, U), \tag{3}$$

which is the change in output-market producer surplus associated with the change in output price from P^0 to P^1, plus the sum of changes in the input market consumer surpluses associated with changes in the respective input prices from V_i^0 to V_i^1

Derivation of Allen Elasticities from the Profit Function

The output effect may dominate the substitution effect for the profit function, obscuring the true relationships among the inputs The defect may be remedied by expressing the compensated factor demand effects associated with changes in factor prices in terms derived directly from the profit function Sakai showed that a factor demand's response to changes in output price, P, and input prices, V_j, can be decomposed as follows

$$\frac{\partial X_i(V,U)}{\partial V_j} - \frac{\partial X_i(V,Y,U^*)}{\partial V_j} + \frac{\partial X_i(V,Y,U^*)}{\partial Y}\,\frac{\partial Y(V,U)}{\partial V_j}, \tag{4}$$

where $X_i(V,U)$ is derived from the normalized restricted profit function using Hotelling's lemma, and embodies the substitution and profit-maximizing effects of an input price change (*16, 21*) Y^* is the profit-maximizing level of output

The Allen elasticity of substitution, in terms derived directly from the normalized restricted profit function, can be developed by manipulating the above decomposition First, solve for the substitution effect Second, convert the factor demand decomposition into an elasticity form and divide by factor j's contribution to cost These two manipulations yield

$$\sigma_{ij} = \frac{\dfrac{\partial \ln X_i(V,U)}{\partial \ln V_j}}{\dfrac{V_j X^j}{C}} - \frac{\dfrac{\partial \ln X_i(V,Y^*,U)}{\partial \ln Y}\,\dfrac{\partial \ln Y(V,U)}{\partial Y \ln V_j}}{\dfrac{V_j X^j}{C}} \tag{5}$$

We can rewrite this as

$$\sigma_{ij} = \frac{-\dfrac{1}{p}\dfrac{\partial^2 G}{\partial V_i \partial V_j}}{-\dfrac{\partial G}{\partial V_i}\,-\dfrac{\partial G}{\partial V_j}} - \frac{-\dfrac{1}{p}\displaystyle\sum_{k=1}^{m}\dfrac{\partial^2 G}{\partial V_i \partial V_k}\;\dfrac{1}{p}\displaystyle\sum_{k=1}^{m}\dfrac{\partial^2 G}{\partial V_i \partial V_k}V_k}{-\displaystyle\sum_{i=1}^{m}V_i\sum_{i=1}^{m}\dfrac{\partial^2 G}{\partial V_i \partial V_j}\dfrac{\partial V_j}{\partial p}\;-\dfrac{\partial G}{\partial V_i}\dfrac{\partial G}{\partial V_j}\dfrac{\partial G}{}}\,C \tag{6}$$

Letting $G_{ij} = \dfrac{-\partial^2 G}{\partial V_i \partial V_j}$, $G_i = \dfrac{-\partial G}{\partial V_i}$, $G_j = \dfrac{-\partial G}{\partial V_j}$,

$Y_j = \dfrac{\partial Y}{\partial V_j}$, $Y_p = \dfrac{\partial Y}{\partial P}$, $G_{ip} = \dfrac{\partial^2 G}{\partial V_i \partial P}$,

and collecting terms, we can compactly write

$$\sigma_{ij} = \frac{G_{ij}}{G_i G_j} - \frac{G_{ip} Y_j}{Y_p G_i G_j}\,C, \tag{7}$$

as our measure for the Allen elasticity of substitution, where C is the cost level for the profit-maximizing level of output All elements can be derived from the profit function using Hotelling's lemma, and from information in the Hessian of the normalized restricted profit function, appropriately weighted by P and V

Data, Estimation, Validation

The data used in this study were collected in 1978 by the U S. Agency for International Development (USAID) in Dhaka in a sample survey of 222 farmers growing summer rice, 95 farmers growing fall rice, 100 farmers growing winter rice, 95 farmers growing wheat, and 222 farmers growing jute Analysts identified constraints on adoption of high-yielding varieties (*28, 29, 30, 31, 32*) Table 1 provides a description of selected variables, important in specifying the profit function models Where appropriate, survey data, such as yields per acre, were compared with aggregate data These checks suggested that the survey data are consistent with secondary data (*34*)

To estimate a profit function, farmers must face different vectors of prices (*12*) The data exhibit substantial variability in the input price variables, normalized by the output price and in the fixed inputs (*18*) The coefficients of variation of prices across farms are close to or greater than 10 percent for labor, fertilizer, and irrigation for all crops, and 7 9 percent for summer rice output, 11 1 percent for fall rice, 4 6 percent for winter rice, 3 3 percent for wheat, and 8 3 percent for jute This variability suggests that the data may in some sense be suitable for estimation of parameters econometrically and for computing price and other elasticities Although some price variability may be due to transport or other costs, farmers producing each crop still face the same production functions They are competitive within geographically distinct locations where prices are significantly related to the state of development of infrastructure (*3*) Nonprice factors, such as soil and climatic differences, are accounted for in district dummies Nonparametric tests for profit maximization also support the profit function approach (*9, 18*)

The system of profit and share equations in equations 1 and 2 were estimated using the iterative, seemingly unrelated, regression method (*25*) Symmetry and parametric constraints were imposed in estimating the parameters of the profit and input demand equations The monotonicity and convexity conditions were satisfied at the means of the data Estimated own-price elasticities were computed using simple averages of input shares at the sample means of the independent variables (*23*) Allen own- and cross-price elasticities of substitution were computed as shown in equations 4-7

All own-price effects shown in table 2 are in accord with the usual hypotheses on sign, and most are statistically significant, and therefore useful for predicting adjustments to changes in price and exogenous variables and in formulating government policy Table 3 indicates that food grain and jute supply are positively related to increases in the price of rice and exogenous increases in land quantity and the input of capital, primarily bullock power, and are quite inelastic with values substantially less than 1 0, though less inelastic than the 0 10- to 0 25-range suggested by the work of other researchers (*1, 2, 20, 26*) The own-price elasticities of supply are also much higher relative to the elasticity of supply with respect to fertilizer price than reported by other researchers (*11, 26*) Food grain and jute supply are negatively related to increases in the price of each of the variable inputs

The effectiveness of higher price supports depends largely on how responsive producers are to a change in price, or the crop's own-price elasticity of supply The higher the supply elasticity, the greater the output response and the smaller the price increase needed to evoke a given change in production The estimated own-price elasticities of supply shown in table 3 range from 0 371 for jute to 0 877 for summer rice The result for summer rice is contrary to *a priori* expectations that relatively traditional crops exhibit low supply elasticities However, among the food grain crops, the response to output price, at 0 406, is lowest for the fall rice crop, the most traditional crop, and, at 0 473, next to highest for the most commercialized food grain crop, winter rice Thus the results are generally close to what one would expect *a priori* The reported elasticities are relatively inelastic (*20*) The impact on output of an adjustment in the procurement prices is adjusted using Ahmed's results, which indicate that a 1-percent increase in procurement price results in a 0 85-percent increase in output price (*2*)

The effectiveness of the fertilizer subsidy program depends primarily on the size of the elasticity of output supply with respect to the fertilizer price The more negative the elasticity the less fertilizer prices have to be reduced to stimulate a given increase in output The elasticities of output supply with respect to the fertilizer price range from –0 032 for jute to –0 097 for wheat, indicating that crop production is largely unresponsive to a change in fertilizer price alone (table 3) And, comparison of the crop own-price elasticities with those for outputs with respect to fertilizer prices indicates that producers generally respond more strongly to crop price changes than they do to changes in fertilizer prices

The costs of supplying additional fertilizer to farmers are determined by the degree to which farmers change their use of fertilizer as fertilizer prices change These elasticities range from –0 218 for fall rice (the least commercialized crop) to –1 529 for winter rice (the most commercialized crop), indicating significant variability in the extent to which producers of different crops respond These are results one would expect *a priori* The changes in fertilizer use resulting from a change in crop price are measured using the elasticity of fertilizer demand with respect to the output price For food grains, these elasticities range from 1 049 for winter rice to 1 554 for wheat and indicate that fertilizer use is relatively responsive to changes in crop prices

The results indicate that a fertilizer subsidy can stimulate an increase in production in the short run However, the complementarity between fertilizer and irrigation in winter rice production in table 3 suggests that sustained long-term growth depends on an im-

Table 3—Elasticity estimates for supply and demand for variable and fixed inputs of food grain and jute production

Item	Price of output	Price of labor	Price of fertilizer	Price of irrigation	Land	Capital
Output supply						
Summer rice	0 877	-0 838	-0 039	—	0 456	0 817
Fall rice	406	- 340	- 066	—	934	- 012
Winter rice	473	- 342	- 063	-0 069	901	119
Wheat	437	- 289	- 097	- 074	607	240
Jute	371	- 339	- 032	—	999	456
Labor						
Summer rice	2 010	-1 972	- 038	—	254	927
Fall rice	1 213	-1 018	- 196	—	782	174
Winter rice	984	-1 165	108	072	939	079
Wheat	991	- 716	- 147	- 152	073	539
Jute	2 413	- 825	- 075	—	822	621
Fertilizer						
Summer rice	1 192	- 674	- 994	—	758	053
Fall rice	1 259	-1 040	- 218	—	863	068
Winter rice	1 049	626	-1 529	- 148	846	044
Wheat	1 554	- 685	- 847	- 045	1 980	221
Jute	906	-2 118	- 295	—	1 195	- 044
Irrigation						
Winter rice	1 080	541	- 138	-1 336	1 046	141
Wheat	2 435	-2 160	- 093	- 902	1 254	588

— = Not applicable

provement in irrigation infrastructure because high-yielding varieties are dependent on irrigation for efficient use of fertilizer (*3*, *33*, *36*) These elasticities, however, involve producer adjustments of output levels and input levels in response to output and input price changes and are not the input substitution along an isoquant By separating the substitution and expansion effects, I can provide this information and estimate the substitution effects in the Allen elasticity sense directly from the profit function (*16*)

The Allen own-price elasticities in table 4 imply the following conclusions All have the correct sign Labor demand seems to be very inelastic, as one would expect in a country like Bangladesh with low wages and surplus agricultural labor However, the factor demand decompositions reveal that the total negative effects of a change in wages on the demand for labor are elastic, but are only slightly larger than the positive effects of profit maximization due to a change in the price of labor In general, fertilizer and irrigation demand appear to be very elastic, reflecting the growing use of modern inputs

The Allen cross-price elasticities present a mixed picture (table 4) Strong substitutability seems to exist between the labor-fertilizer pair in the production of summer and winter rice Very little interaction appears to exist in wheat and jute production A strong complementarity between the labor-fertilizer pair is suggested only in the production of spring rice These are noteworthy results Bangladesh, characterized by severe underemployment, may not have to pay a high price in employment if it raises fertilizer prices to reduce fertilizer subsidies This relationship can perhaps be partly explained by the use of hired labor and animal labor to produce and apply manure Therefore, an increase in the fertilizer price gives farmers an incentive to substitute manure for chemical fertilizer, and to hire the labor needed to produce and apply it

Prices significantly influence farmer demand for fertilizer, although nonprice factors such as irrigation and credit availability are undoubtedly important Thus, one of the ways the government may influence demand for fertilizer is by the fertilizer and output price policies it follows

Table 4—Allen elasticities

Factors	Labor	Fertilizer	Irrigation
Labor			
Summer rice	-0 050	-0 793	—
Fall rice	- 004	1 375	—
Winter rice	- 392	1 320	0 987
Wheat rice	- 412	- 057	3 937
Jute	- 004	096	—
Fertilizer			
Summer rice		-23 422	—
Fall rice		- 094	—
Winter rice		-8 184	- 118
Wheat		-2 266	6 514
Jute		-2 677	—
Irrigation			
Winter rice			-5 556
Wheat			-59 489

— = Not applicable

Analysis of Policy Alternatives

Incremental cost calculations require base-level estimates of several variables. Averages of crop production, crop prices, and fertilizer prices for FY 1979-81 are taken as the base level (table 5). However, numerous changes in 1979-81 base variables occurred in recent years. World fertilizer prices fell close to 15 percent during the early 1980's compared with the late 1970's. At the same time, to fulfill its goal of reducing subsidies, the government increased fertilizer prices to farmers by more than 60 percent (*19*). On average, world food grain and jute prices fell nearly 20 percent. Government-subsidized prices of rice and wheat were raised to achieve a closer alignment with procurement prices, eliminating some of the consumer subsidy historically provided for ration recipients. Significant changes in fertilizer use among crops occurred: use on wheat and winter rice rose relatively, while use on summer rice, fall rice, and jute fell relatively. These changes in variables are recorded in table 6.

Given the estimated elasticities, a 1-percent increase in total food grain production can be expected to result from a 2.22-percent increase in rice support prices for all three crops, coupled with a 2.69-percent increase in wheat support prices, or a 16.20-percent drop in fertilizer prices to food grain and jute producers. The estimated incremental government costs, net foreign exchange savings, and changes in producer welfare associated with using price support and fertilizer subsidy programs to stimulate a 1-percent increase in food grain production are computed following a variation of the model described in (*26*, pp. 139-62). The base results indicate that the major differences between the two programs are in the areas of government costs and foreign exchange savings (table 7). The budgetary cost of the fertilizer subsidy program is about 11 percent lower than the cost of the price support program (primarily because issue prices are reduced 8 percent to compensate consumers for welfare losses due to higher price supports), while producer welfare gains are only slightly higher for the fertilizer subsidy program. The net foreign exchange savings are, on the other hand, 17 percent higher for the price support program. Based on these criteria, and particularly if minimizing combined foreign exchange and budgetary cost is a key objective, enhanced price supports may be the better policy option for stimulating production for Bangladesh.

Table 5—Estimated base level of variables used in analysis, FY 1979-81 averages

Crop	Production	Procurement	Domestic price support	Trade price	Handling cost	Issue price	Market surplus	Use	Farm price	World price
	Procurement/distribution							Fertilizer		
	---1,000 tons---		*-----------Dollars/ton-----------*				*Percent*	*1,000 tons*[1]	*--Dollars/ton--*	
Rice										
Summer	3,161	36	255	363	40	211	25	74	298	539
Fall	7,643	299	255	363	40	211	25	140	298	539
Winter	2,352	130	255	363	40	211	50	15	298	539
Wheat	803	116	176	197	40	162	50	15	298	539
Jute	1,033	—	214	383	40	—	80	22	296	539

— = Not applicable.
[1]Nutrient tons of nitrogen, phosphates, and potash.
Source: (*11*).

Table 6—Estimated base level of variables used in sensitivity analysis, FY 1982-84 averages

Crop	Production	Procurement	Domestic price support	Trade price	Handling cost	Issue price	Market surplus	Use	Farm price	World price
	Procurement/distribution							Fertilizer		
	---1,000 tons---		*-----------Dollars/ton-----------*				*Percent*	*1,000 tons*[1]	*--Dollars/ton--*	
Rice										
Summer	3,185	11	237	311	50	228	25/30	81	344	458
Fall	7,600	99	237	311	50	228	25/30	173	344	458
Winter	3,366	93	237	311	50	228	50/85	144	344	458
Wheat	1,087	55	151	195	50	158	50/85	27	344	344
Jute	892	—	211	303	50	—	80	14	344	458

— = Not applicable.
[1]Nutrient tons of nitrogen, phosphates, and potash.
Source: (*11*).

Sensitivity of Results

Results are highly sensitive to the base levels used for marketable surplus, procurement level, domestic prices, and import prices of crops and fertilizers This will be demonstrated in the policy scenarios that follow

To calculate the impact of such changes on government cost, foreign exchange savings, and producer welfare due to a 1-percent change in output induced by price supports or fertilizer subsidies, the model was re-evaluated under six additional scenarios, incorporating variables from a 1982-84 base (table 7) To simplify the analysis, the initial price elasticities were left unchanged, although the elasticity estimates are likely to be biased (*18*) All scenarios using 1982-84 food grain prices reflect the government's current policy to more closely align issue and procurement prices

- Scenario one the model was re-evaluated using 1979-81 base level values for all variables except for fertilizer prices, which were set at 1982-84 levels
- Scenario two only food grain prices were set at 1982-84 values
- Scenario three both fertilizer and food grain prices were set at 1982-84 values
- Scenario four the model was re-evaluated, incorporating variables using 1982-84 as a base, assuming a 35-percent upward adjustment in nonfertilizer input prices to reflect input price trends (*27*, *36*)
- Scenario five the basic model for 1982-84 was re-evaluated, allowing for increases in marketable surplus and procurement This scenario assumes that implementation of a more effective price support program may raise the level of marketable surplus because maintenance of previous price levels, as assumed for both programs, may require an upward adjustment in procurement levels I assumed that marketable surplus for wheat and winter rice, induced by an effective price support program, was 75 percent compared with the previous 50 percent, and 30 percent for summer and fall rice compared with the previous 25 percent In this scenario, I assumed that procurements would constitute 10 percent of the food grain crop, rather than the lower historical levels In scenario six (not shown in table 7), the model was re-evaluated using 1982-84 as a base but using the actual cost of fertilizer As stated previously, the government does not pay world market prices for fertilizer

Results

Scenario one (current fertilizer prices) the new assumptions do not alter the initial conclusions pertaining to the 1979-81 base case The budgetary cost of the price support program remains lower than for the fertilizer subsidy program, but the advantage is narrowed At the same time, the level of producer welfare gains increases sharply for both programs These results are as expected An increase in price supports or fertilizer subsidies, as higher domestic fertilizer prices and lower world fertilizer prices, implies relatively lower economic subsidies and higher producer welfare gains compared with the base case Foreign exchange savings, which are more strongly influenced by changes in world grain prices than fertilizer prices, remain slightly higher for the price support program

Scenarios two (higher food grain prices) and three (higher food grain and fertilizer prices) the new assumptions improve the producer welfare advantage for the fertilizer subsidy program, and substantially so in scenario three Budgetary results remain basically unchanged compared with the 1979-81 base case Net foreign exchange savings, because of higher food grain prices, are drastically reduced for both programs In scenario two, real input prices of all inputs decline sharply, leading to higher producer surpluses for most crops as the result of price supports or fertilizer subsidies The major crop-specific changes for scenarios two and three compared with the 1979-81 base case are large gains in producer welfare for summer rice producers under the fertilizer subsidy program, and a reduction in producer welfare gain for winter rice producers under the price support program

Scenario four (base level, 1982-84) producers realize a slight welfare advantage for the price support program compared with the 1979-81 base case The foreign exchange advantage of the price support program also improves In this scenario, reduced food grain and fertilizer prices imply reduced foreign exchange expenditures, although this factor is offset partially by higher base-level food grain production and, therefore, a somewhat larger food grain import requirement The level of producer surplus resulting from a 1-percent change in production remains close to the 1979-81 base levels, reflecting increases in the real price of inputs offsetting increases in output price

Scenario five (price support adjustment 1982-84 base) the new assumptions enhance the producer welfare advantage of the price support program compared with the 1982-84 base case because of the assumed increase in marketable surplus (which influences costs only in the price support program) The new assumptions also drastically raise the budgetary cost of the price support program, which is now only 32 percent lower than the fertilizer subsidy program Producer

Table 7—Estimated benefits and costs of price support and fertilizer subsidy programs in Bangladesh[1]

Scenario	Summer rice		Fall rice		Winter rice		Wheat		Jute		Total	
	Price support	Fertilizer subsidy	Price support	Fertilizer subsidy	Price support	Fertilizer subsidy	Price support	Fertilizer subsidy	Price support	Fertilizer subsidy	Price support	Fertilizer subsidy
Base level 1979-81												
Government cost increase	3.9	7.4	6.0	9.1	3.8	13.1	1.4	1.7	—	1.4	15.1	32.7
Foreign exchange savings	12.2	2.0	12.5	17.5	4.3	-.2	1.7	2.4	2.8	1.8	27.9	23.5
Producer welfare gain	2.5	2.4	5.6	9.8	6.3	3.0	1.0	.3	-.8	.3	15.5	15.8
Current fertilizer prices												
Government cost increase	3.7	6.5	5.6	9.6	3.5	10.7	1.3	1.6	—	1.4	14.1	29.8
Foreign exchange savings	11.5	2.3	12.6	17.7	4.3	.6	1.7	2.5	-2.8	1.9	27.3	25.0
Producer welfare gain	1.9	2.2	5.9	10.1	19.7	15.3	1.3	.4	-.8	.5	28.0	28.5
Current grain prices												
Government cost increase	4.1	7.3	6.2	9.2	4.1	13.1	.9	1.7	—	1.4	15.1	32.7
Foreign exchange savings	9.2	3.1	10.0	13.7	3.4	-1.2	1.3	1.9	-2.7	1.8	21.2	17.3
Producer welfare gain	4.0	3.6	10.0	15.1	3.1	2.8	2.0	—	-.8	.3	18.3	21.8
Current fertilizer and grain prices												
Government cost increase	4.0	6.5	5.8	9.6	3.7	10.8	1.3	1.2	—	1.4	14.8	29.5
Foreign exchange savings	9.2	1.5	10.1	14.1	3.4	-.4	1.4	1.9	-2.7	1.9	21.4	19.0
Producer welfare gain	3.7	3.4	9.0	17.0	3.4	3.7	1.9	.1	-.8	-.5	17.2	24.7
Base-level 1982-84												
Government cost increase	4.0	6.7	5.0	10.3	5.0	14.0	1.4	2.3	—	.8	15.4	34.1
Foreign exchange savings	10.0	1.3	9.9	13.6	5.0	-.2	1.8	2.4	-1.9	1.2	24.8	18.3
Producer welfare gain	3.2	2.8	6.2	9.7	6.2	2.2	1.9	.1	-.8	.9	16.7	15.7
Price support adjustment												
Government cost increase	6.1	7.1	8.8	12.3	8.2	14.7	2.2	2.4	—	.8	25.3	37.3
Foreign exchange savings	10.0	1.3	9.9	13.6	5.0	-.2	1.8	2.4	-1.9	1.2	24.8	18.3
Producer welfare gain	3.9	3.4	7.5	11.6	9.3	3.3	2.9	.2	-.8	.9	22.8	19.4

— = Not applicable

[1]Estimated incremental costs and benefits of inducing a 1-percent increase in total food grain production through each policy

welfare results in both scenarios four and five are dominated by changes within the summer rice and winter rice crops

Scenario six (cash flow, 1982-84) the budgetary cost advantage of the price support program is not appreciably altered even though increases in costs for fertilizer are now based on actual costs to the government rather than donor costs The largest component of change in fertilizer costs (increased costs of subsidizing existing volume) consists of increased subsidies on domestic production and reduced revenues on imported fertilizers and remains unchanged compared with the 1982-84 base The assumption of actual costs indicates, however, that the price support program has no advantage over the subsidy program in terms of foreign exchange savings compared with the 1982-84 base

The government may not need to procure as much food grain under the fertilizer subsidy program to support the output price, which could fall due to a decline in fertilizer price To evaluate this assumption, procurements under the fertilizer subsidy program were reduced 20 percent for both the 1979-81 and 1982-84 base cases The results indicate that costs to the government for the fertilizer subsidy program fall less than 2 percent in the 1979-81 base case and less than 1 percent in the 1982-84 base case Changes in subsidy costs due to increased fertilizer consumption are clearly much larger than costs related to larger procurements

The results of using more current fertilizer and food grain prices suggest that recent drops in world fertilizer and food grain prices either reduce or remove the cost advantage of the fertilizer subsidy program but improve the producer welfare advantage of the program In the case of either current food grain or fertilizer prices, the price support program has an advantage over the input subsidy program

Conclusions

This analysis shows that changes in the procurement prices for food grains have a relatively greater impact on output supply and input demand than do changes in the level of fertilizer subsidies, and, given the current levels of output prices and input subsidies, output price supports may involve somewhat higher foreign exchange savings and slightly less government spending than fertilizer subsidies to induce the same percentage impact on output The two programs appear to be largely neutral in terms of producer welfare Although the total costs of the two programs are very similar, enhanced price supports may be the better policy option for stimulating production, particularly if reducing the combined foreign exchange and budgetary costs of Bangladesh and donor nations is a key goal Clearly, the government faces a difficult policy choice between fertilizer subsidies and price supports on the basis of criteria evaluated in this article

Although these results should be interpreted cautiously given the limitations of the cross-section data used, they seem to suggest that shortrun food grain supply elasticities in Bangladesh may be somewhat higher than previously thought (*1, 11*) More recent results support these conclusions Using 1982 for 330 farms, Ahmed and Hossain (*3*) estimated a Cobb-Douglas profit function specified with output measured as variable profits from crops, livestock, and other income, labor and fertilizer as variable inputs, and capital and land as fixed inputs The results on all variables are highly significant and imply an output elasticity with respect to price of 0 56 and an own-price elasticity of demand for fertilizer of –1 12 However, nonprice factors, including technological change and increases in irrigation inputs, have played a large role in boosting Bangladesh's production of food grains in recent years Ideally, one would estimate a multioutput profit function from panel data collected over a period of years A profit function analysis using a time series cross-section data set could more completely capture how producers, given the technology, adjust output and input levels in response to price changes Nonetheless, with all its limitations, the profit function analysis used in this study (which included irrigation in the specifications for winter rice and wheat and high-yielding varieties in the specification for winter rice) appears to have captured a significant response to price changes

The availability of donated imported fertilizer that can be resold at a higher price to farmers makes the fertilizer subsidy program attractive to the Government of Bangladesh because most costs are actually incurred by donors In fact, revenue generation from the sale of donated fertilizer has made it easy for the government to maintain a high level of subsidy on fertilizer by keeping prices low, thereby achieving popular support by passing a part of the grant to farmers The revenues received from resale of concessional food grain imports, in contrast, are not sufficient to produce an overall net surplus on the food account Therefore, an increase in price supports raises government costs Disaggregation of the budgetary and foreign exchange costs of the two programs into costs paid by the government and costs paid by donor nations is a worthwhile topic for more research

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