

3 Liberalization of Agricultural Input Markets in Bangladesh

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As recommended by the Agricultural Commission of 1960, the East Pakistan Agricultural Development Corporation was established in 1963. Later known as the Bangladesh Agricultural Development Corporation (BADC), this public parastatal was responsible for procuring and distributing agricultural inputs such as fertilizers, seeds, agricultural equipment, and pesticides (Ahmed 1978a). BADC soon developed an elaborate national organization for delivering goods and services to farmers, establishing a virtual monopoly over fertilizer and agricultural equipment markets while conforming to government pricing and related policies. The corporation has since been replaced by liberalized and deregulated input markets. This chapter chronicles the process of liberalization, examines its impact, and draws lessons from the change.

Liberalization of Input Markets

The step-by-step liberalization of markets for modern inputs in agriculture was carried out under pressure from foreign donors and with the realization that various direct interventions were fiscally unsustainable and unproductive in the long run.

The Structure of Markets before Liberalization

FERTILIZER MARKET. In 1959/60, about 11,400 nutrient metric tons of chemical fertilizers were used in Bangladesh, primarily on tea estates.¹ The use of fertilizers spread incrementally to peasants about the time when BADC was established. By 1977/78, the corporation had sold 354,000 nutrient tons of fertilizers (equivalent to 725,000 material tons), consisting of 65 percent nitrogen, 25 percent phosphorus, and 8 percent potassium.

BADC was the sole organization procuring fertilizers from domestic factories and foreign sources. Fertilizers were first shipped to transit warehouses, then to intermediate warehouses at strategic points, and finally to *thana* sales centers (TSCs).² These intermediaries functioned as both wholesale and retail

1. All further references to tons indicate metric tons.

2. A *thana* is an administrative unit consisting of 80 to 90 villages.

points, selling fertilizer to licensed private dealers and directly to farmers. Between 1963 and 1978, there were 67 intermediate warehouses and 423 TSCs. The other category of wholesaler was the Thana Central Cooperative Association, which sold fertilizer to private dealers and village cooperatives for retail sales to farmers. The share of cooperatives in total sales was small, accounting for only 12 to 17 percent. Three or four private dealers would serve 7 to 10 villages. Dealers were not supposed to sell outside a defined area, procuring their fertilizers from specified TSCs and selling at government-fixed prices. The fixed price included a commission based on the distance from the TSC to the operation center. Dealers were required to maintain registers, which were subject to occasional inspection by BADC officers. Excluding the commission, fertilizer prices were supposed to be uniform throughout the country. The system suffered from numerous problems arising from excessive bureaucratic control.

IRRIGATION EQUIPMENT. BADC changed public irrigation policy from expensive, large-scale projects to low-cost, small-scale ones. It initiated low-lift pump irrigation (lifting water from surface sources to adjoining fields) using diesel engines and distribution pipes, mainly to reclaim the *haor* areas of the Sylhet and Mymensingh districts.³ Most of these engines had a capacity of 0.0566 cubic meters per second. Initially, BADC owned, maintained, and operated these pumping sets to supply water to groups of farms using a flat charge per hectare, a system that covered only about 60 percent of the operating cost. Rapidly expanding from the *haor* areas, the scheme spread throughout the country along riverbanks, large ponds, and lakes, eventually making operations unwieldy and expensive. Therefore, by the end of the 1960s BADC introduced some reforms. Farmers were required to organize into irrigation groups, supply all diesel fuel costs, and pay a share of the maintenance cost at flat rates per hectare of irrigated land. Farm groups were responsible for water management, obtaining diesel fuel, and collecting charges. By the mid-1970s a rental system was introduced so that BADC's only responsibility was to make available well-functioning pumping sets. Farm groups had to meet all costs of the service, including the wages of pump operators.

Tubewell irrigation is suitable for areas in which surface water is not available and underground water is the next best source. In the early 1960s the Bangladesh Water Development Board initiated the first tubewell program, drilling 90 tubewells, each with 0.0566 to 0.0849 cubic meter per second capacity engines, in northern Bangladesh. For many years, however, the project did not attract farmers, even with a 100 percent subsidy. BADC began a deep tubewell experiment (0.0566 cubic meter per second capacity) at about the time when its low-lift pump program had reached saturation. In the meantime, using cooperative societies, the Comilla Academy for Rural Develop-

3. A *haor* is a lake-like depression in a low-lying, marshy stretch of land.

ment was successfully experimenting with shallow tubewells with a capacity equivalent to one-eighth to one-half of BADC tubewells, drilling them at a price much cheaper than BADC's. The academy also implemented a training program to develop private-sector tubewell installation capacity. In 1970 BADC started a modest tubewell irrigation program for farmers based on engines with a 0.0566 cubic meter per second capacity, initially operating these wells on the same principles as low-lift pumps. In about 1978 the corporation was asked to install tubewells for farmers at subsidized (20–30 percent) rates. Except for these publicly initiated programs, however, there was hardly any private initiative in the development of modern irrigation until the mid-1970s.

Irrigation equipment (engines, pumps, and so on) had always been part of a small, private, nonagricultural market. Because domestic capacity for producing diesel engines and pumps was small, most of BADC's equipment was imported using foreign aid. Therefore, liberalizing the import trade became the key element of market liberalization in agricultural equipment. Before the mid-1980s, two import restrictions were in effect:

1. Private import of diesel engines for irrigation was not allowed except for makes and models approved by a standardization committee in the Ministry of Agriculture (MOA) and with special permission from the ministry.
2. Private import of pumps for irrigation was not allowed except with MOA permission, foreign exchange through a donor-funded project, and no objection from the Ministry of Industries.

CULTIVATION EQUIPMENT. At its inception BADC began a mechanized cultivation scheme based on tractors, but such experiments had limited success. In about 1968 the Pak-Japan (later known as Bangladesh-Japan) Co-operative Scheme on Agricultural Machineries successfully introduced power tillers for plowing. Nevertheless, no special public agency was created to market and distribute the tillers, as had been the case for other inputs. Instead, private importers and distributors performed this function. Medium to large farms purchased power tillers to meet their own requirements and rent to neighbors. While the domestic market was not publicly controlled, the import market was constrained. Before the mid-1980s, MOA had to approve the make and model of all power tillers to be imported (Guisselquist 1992).

PESTICIDES. BADC was given the task of procuring plant protection materials, while the Agricultural Extension Department was supposed to implement crop protection schemes. By the end of the 1960s, however, procurement and distribution were liberalized for several reasons. There were numerous complexities in storing and handling the poisonous materials and in dispensing them to farmers. Moreover, the government recognized that a bureaucratic agency was not well suited to take timely measures against pests. Private importers began to import and distribute pesticides through private

dealers and general retailers of consumer goods, but such import was allowed only for brands and dealers approved by MOA. This approval process might have implied hidden costs for traders, and import only by brand names was potentially oligopolistic. Canada's agricultural sector team in Bangladesh found pesticide prices in 1991 to be as much as double the prices in Pakistan despite the absence of tariffs (CIDA 1991).

SEEDS. Traditionally, Bangladeshi farmers produce seed for their own use and sale to markets. Those who need seeds buy from the market, and it is common for some farmers to specialize in seed production. These traditional markets have been the primary distribution channel not only among farmers within the country but also between those in Bangladesh and India. To supplement traditional seed markets, since the late 1960s BADC has been operating 19 seed multiplication farms to produce and distribute improved seeds of various crops. The government has developed a seed certification mechanism to ensure quality. Nonetheless, complaints that publicly produced seeds are of poor quality and unavailable when needed are common.

In the past BADC has imported seeds to introduce high-yielding varieties (HYVs) of crops, such as Dutch potatoes and Mexican wheat. Liberalizing seed markets, aimed at promoting free and competitive international trade in seeds, would be a potent mechanism of technological progress in Bangladeshi agriculture.

Reforms in Input Markets

FERTILIZER. The chronology of reforms in the agricultural input markets is summarized in Table 3.1. The liberalization of the fertilizer and irrigation equipment markets was the dominant reform that boosted production. The fertilizer trade expanded rapidly, and by 1988 nearly 8,000 wholesalers and 50,000 retailers operated competitively in the fertilizer market (Infanger, Samad, and Hooker 1988). The share of private trade climbed quickly to 75 percent in 1989 and nearly 100 percent by 1992. The import trade was partially privatized, although there is an underlying fear that it may ultimately turn into an oligopoly because of economies of scale and differential access of traders to capital markets. Throughout the time of reform each process was monitored to identify problems and solve them as they emerged. The International Fertilizer Development Center (IFDC), through a network of field investigators, provided a useful service in this regard.

Although the distribution of fertilizers was privatized, most urea production stayed in the public sector. Between December 1994 and March 1995, a serious urea shortage shocked the fertilizer market, resulting in a partial reversal of the reform process that had worked so well before the crisis. Farmers reacted violently, and 17 died before order was restored. There are divergent views about what caused the crisis. The government believes that it resulted from the wholesale privatization of the fertilizer distribution system, arguing that the private sector created an artificial shortage by hoarding and selling at

TABLE 3.1 Step-by-step liberalization of agricultural input markets in Bangladesh

Actions	Time Span	Remarks
Fertilizer market		
1. BADC withdrew from retail and wholesale markets at <i>thana</i> levels, the primary distribution points.	1978–83	Done first at Chittagong Division, with vigorous response from traders
2. Licensing requirement was abolished and restriction on movement removed (except for eight-kilometer border zones with India).	1982–83	
3. Deregulation of fertilizer price took place.	1982–84	Beginning of real competition
4. Private traders directly purchased from factory gates and port points.	1987	Vigorous response from traders
5. Free import from world market began.	1992	Good response but persistent fear of oligopoly
6. Fertilizer crisis took place, with partial reversal of reform.	1994/95	Too early to assess full implications; large subsidy returns
Irrigation devices		
1. BADC sold all its low-lift pumps to private parties backed by special credit arrangement for purchasers.	1980–82	Good response from farmers
2. BADC sold all its tubewells for irrigation to farmers and cooperatives; sale was supported by special credit arrangement for purchasers.	1983–85	Good response from farmers
3. Restriction on import of engines and pumps was withdrawn.	1988	Drastic fall in prices of engines
4. Standardization restrictions limiting makes and models were removed.	1988	Drastic fall in prices of engines
Power tillers, pesticides, and seeds		
1. Restriction on power tiller import and the standardization requirement were removed.	1989	Modest response
2. Restriction on import by brand names was liberalized for pesticides.	±1989	Modest response
3. Except for rice and wheat, all seed imports were liberalized.	1990	Modest response

SOURCES: Computed from information in Mudahar (1984), Sidhu (1992), Guisselquist (1992), ADB (1990), Bangladesh Establishment Division (1992), and personal communications.

higher prices, smuggling across borders, and deliberately manipulating the allotment orders and lifting schedules formulated by the public production agency. The private fertilizer traders contend that the crisis erupted because the government took two contradictory steps at the same time: (1) reducing fertilizer prices in the domestic market (perhaps a preelection strategy), which boosted domestic demand, and (2) exporting fertilizer without considering the newly inflated demand. Moreover, the private traders believe that resorting to administrative controls worsened the market situation. A number of studies concluded that the crisis stemmed from the culmination of several factors. First, it occurred at peak seasonal demand. Second, the export of 554,000 tons of urea between June 1994 and January 1995 drastically reduced domestic availability during this peak period. Third, the introduction of administrative controls during the crisis destabilized the distribution system and hurt crisis management. There seems to be little evidence of private smuggling across borders.

EQUIPMENT. Perhaps the most significant effect of reform was realized in the case of irrigation equipment. By early 1989 the cost of a shallow tubewell (complete with sinking, pipe, pump, and engine) to irrigate four to five hectares of land had fallen below taka 20,000 (US\$600), which is about 60 percent of the subsidized price for such equipment through BADC.⁴ As a result, between 1988 and 1996 irrigated area expanded at a rate roughly twice as quickly as had been achieved between 1978 and 1986. Although the practice of using power tillers for cultivation was still uncommon, the price of a tiller had decreased to \$1,500 in 1989 from \$2,500 only a few months earlier, before the liberalization of imports (Guisselquist 1992). The use of power tillers is spreading faster now due to the removal of import restrictions. Thus far, the liberalization of markets for seeds and pesticides has had only a modest impact. In the long run, however, that impact, particularly for seeds, is likely to be large.

The Impact of Liberalization

The impact of liberalization is twofold, consisting of (1) its direct influence on agricultural production owing to changes in the level of input use and (2) its indirect influence on the production of both agricultural and nonagricultural products arising from reallocating budgetary savings achieved by reducing or eliminating input subsidies. These savings are likely to lower budget deficits and affect the price of foreign exchange, which in turn may influence production of tradable agricultural products. Measurement of the indirect impact warrants economy-wide modeling that is not attempted here. Nevertheless, this section considers some of the fiscal impact relating to the magnitude of the subsidies eliminated from the budget.

4. All further references to dollars indicate U.S. dollars.

Detailed calculations indicate that the budgetary subsidy on fertilizers dropped from taka 1,286 million (\$83 million) in 1979/80, to taka 1,426 million (\$57 million) in 1983/84, to taka 1,273 million (\$40 million) in 1988/89, to only about taka 25 million (\$0.6 million) in 1992/93 (Ahmed 1987; Renfroe 1991; and personal contacts in the Bangladesh Ministry of Agriculture). The small subsidy in 1993 was meant to correct minor and trace-element deficiencies in certain soils. In 1995/96, however, the new government reversed the subsidy policy so that the direct subsidy on fertilizer in 1996/97 is estimated at taka 4,725 million (\$105 million). The 1983/84 figure was equivalent to about 14 percent of total public development expenditure on agriculture and rural development, while the 1979/80 figure was equivalent to 28 percent of such expenditure (IFPRI 1985).

Although budgetary savings arising from liberalization of the fertilizer market are significant, comparable estimates of irrigation subsidies are not available. Nevertheless, the budgetary subsidy on BADC's low-lift and tubewell irrigation program was estimated at taka 1,035 million (\$66.7 million) in 1979/80 and taka 830 million (\$33 million) in 1983/84 (Rashid 1986). By 1986 almost the entire subsidy had been eliminated. These subsidies are indeed budgetary losses, but they also contributed to social gains. Their role in the development of markets for modern inputs and as a foundation for larger growth in production in the post-liberalization period cannot be ignored (Ahmed 1978b; Osmani and Quasem 1985).

Methodology

Model for Measuring Direct Impact on Rice Production

The impact of market reform on the use of inputs and the production of agricultural products depends on farmers' response to changes in prices and the availability of inputs resulting from reform. Although farmers' responses are rooted in household-level resource allocation decisions and motivation, price formation takes place at the aggregate level. Therefore, a model to determine the nationwide impact of reform on agricultural production should reflect farm-level behavior.

Consider a typical farm with a production function,

$$V = F(X_1 \dots X_m; Z_1 \dots Z_n), \quad (3.1)$$

where V represents output, X variable inputs, and Z fixed inputs and other shifter variables of the function. The farm is seeking maximization of profit,

$$\Pi = PF(X_1 \dots X_m) - \sum_m q_j x_j \quad (3.2)$$

where P is the unit price of output and q_j is the unit price of the j th variable input. Fixed costs are conveniently ignored. The profit maximizing level of input use is given by

$$\partial F / \partial X_j = q_j / P. \quad (3.3)$$

Equation (3.3) can be solved for optimal quantities of variable inputs denoted as a function of prices and Z :

$$X_j^* = F_j(P, q, Z). \quad (3.4)$$

Substituting equation (3.4) into equation (3.2), the restricted profit function becomes

$$\Pi = G(P, q_1 \dots q_m; Z_1 \dots Z_n). \quad (3.5)$$

This general function gives maximized values for the optimal sets of $(q_1 \dots q_m)$ so that

$$\Pi = G^*(P, q_1 \dots q_m; Z_1 \dots Z_n). \quad (3.6)$$

It is possible to derive output supply and input demand functions from equation (3.6) via Shepard's (1970) lemma. The output supply function is

$$V^* = \Pi(P, q, Z), \quad (3.7)$$

and input demand function is

$$X_j^* = F_j(P, q, Z). \quad (3.8)$$

The function is negative in input prices. Note that P and q can be expressed in relative terms, collapsing the two vectors into one of relative output and input.

The values of V^* and X_j^* relate to a typical farm: if there are n number of such farms (measured in efficiency units) in an economy, then aggregate values can be obtained by multiplying V^* and X_j^* by n :

$$\text{aggregate } V_a^* = nV^* \quad (3.9)$$

and

$$\text{aggregate } X_a^* = nX_j^*. \quad (3.10)$$

At the household level farms are assumed to be price takers. At aggregate levels the prices of outputs and inputs are determined in markets. The theoretical logic in the previous equations and the process of aggregation indicate the pace of adjustment at farm level and aggregate impact on production arising from a change in the incentive environment (such as market reform). Given a technical condition of production, and assuming that all farms are alike and there are no credit constraints, the adjustment and impact arising from a change in incentives occur faster and may appear to be one-shot affairs. In the real world, however, farms are not all alike, and there are constraints. Therefore, the

aggregate impact takes some time. The time span within which all adjustments are completed is primarily an empirical issue.

The household-level model just described could be used directly to measure the impact of liberalization if necessary data at household levels were available for all pre- and post-liberalization years—which is not the case. Nevertheless, models based on time-series aggregate data rooted to the behavioral logic at household levels can be formulated. Grounded in the micro-economics of production, an empirical aggregate model can be developed that simultaneously determines input use and crop production:

$$FC_t = (PFR_t/PR_t, AGR_t, NAR_t, CDS_t/P_t, D) \quad (3.11)$$

$$(PFR_t/PR_t) = f(PFD_t/PR_t, HYV, PFM_t/PR_t, D) \quad (3.12)$$

$$AGR_t = f(PD_t/PR_t, EG_{t-1} \neq P_{t-1}, CDL_{t-1}/P_{t-1}) \quad (3.13)$$

$$DAR_t = f(AGR_t, PR_t/PO_t, D) \quad (3.14)$$

$$QR_t = f(FC_t, AGR_t, DAR_t, D) \quad (3.15)$$

The algebraic symbols are defined as

FC_t = consumption of fertilizers (urea, triple superphosphate, and murate of potash) in year t (measured in thousands of tons),

PFR_t, PFD_t, PFM_t = respectively, retail, domestic factory gate, and border prices of fertilizer in year t , measured in taka per ton (with prices a weighted average of three types of fertilizer),

PR_t = wholesale price of rice in year t (taka per ton),

AGR_t = total irrigated area of rice in year t (thousands of acres),⁵

NAR_t = other crop area in year t (thousands of acres),

CDS_t = short-term crop loan advanced to farmers from banking institutions and public agencies in year t (10 × taka 1 million),

P_t = general price index

PD_t = price of diesel fuel in year t (taka per ton),

D = dummy variable that takes a value of 0 for 1975/76 to 1988/89 and 1 for 1989/90 to 1996/97,

EG_{t-1} = public expenditure on water control and irrigation development in year $t-1$ (10 × taka 1 million),

CDL_{t-1} = long-term loan to farmers from banks and public agencies in year $t-1$ (10 × taka million),

DAR_t = dry-land rice area in year t (thousands of acres),

HYV = area planted in high-yielding varieties of rice (thousand of acres),

5. The multiequation model, employing simultaneous system estimation, was estimated with acreage rather than hectorage as a land measure. Changing the measurement unit from acres to hectares may involve nonlinear transformation; therefore, this change was not made. It is not expected to make any difference, except in some nonuniformity of style.

PO_t = price of mustard oil seeds (taka per ton) as proxy for crop prices other than rice, and

QR_t = production of rice.

The impact of reform on rice production was chosen because of its importance to the economy. Rice contributes about 73 percent of GDP (gross domestic product) in the crop sector; 85 percent of fertilizers and 95 percent of irrigated areas are used to produce rice (Chowdhury 1993).

The following hypotheses are plausible in light of evidence from previous studies (Hossain 1988; Ahmed 1978a; Stone 1987):

1. Change in fertilizer consumption
 - due to increase in real price of fertilizer: negative
 - due to increase in irrigated area: positive
 - due to increase in other crop area: zero or positive
 - due to increase in volume of short-term credit: positive
2. Change in irrigated area
 - due to increase in real price of diesel fuel, which is critical for tubewells and low-lift pumps: negative
 - due to public expenditure on water control and irrigation: positive or zero
 - due to long-term credit to agriculture: positive
3. Change in retail price of fertilizer
 - due to increase in domestic factory-gate price: positive
 - due to increase in world price and exchange rate: positive
 - due to increase in HYV: positive
4. Change in dry-land rice area
 - due to irrigation expansion: negative or zero
 - due to increase in relative price of rice: positive
5. Change in rice production
 - due to increase in fertilizer use: positive
 - due to increase in irrigated area: positive
 - due to increase in dry-land rice area: positive

Most of these hypotheses may appear intuitive except for the effects of (1) other crop area on fertilizer consumption, (2) public expenditure for water control and irrigation on irrigated area, and (3) long-term credit to agriculture on irrigated area. Fertilizer use in nonrice crops, particularly nonirrigated ones, is patchy due to various risks associated with such land and underdeveloped technology for nonirrigated crops. In the case of public expenditure for water control and irrigation, the effect is hypothesized to be either zero or positive for two main reasons. First, the bulk of such expenditure is meant for flood control that does not influence irrigation. Second, the part of this expenditure that goes for irrigation is meant for large tubewells and surface irrigation structures.

Although farmers are unlikely to participate in either scheme, the indirect impact of such expenditures on tubewell irrigation could be significant. With the expansion of tubewell irrigation, the most suitable areas are covered first. Subsequent expansion may depend on the scope of flood-protected areas that such water-control projects tend to create. Long-term credit for agriculture in Bangladesh is largely meant for modern farm equipment—primarily tubewell and low-lift pump equipment for irrigation and power tillers for cultivation.

The most important and relevant hypothesis in the context of this analysis is the effect of the dummy variable D , which is designed to capture the complex effects of various changes induced by the liberalization measures on the levels of input use and production. There is no a priori presumption that the effect of the dummy will be positive or negative except that the coefficient of the dummy in equation (3.15) is expected to not differ significantly from 0. This is because the impact on production occurs through the impact on the levels of use of inputs, particularly the technology-embodied fertilizers, and irrigation. In equation (3.15) the actual levels of these inputs include any effect of market reform. A change in productivity may, however, influence the parameters of the production equation. The productivity of these inputs is not expected to be influenced by the liberalization measures because shifts in productivity are a function of technological change that does not pertain directly to liberalization measures, at least in the short term.

Using a dummy to capture the effect of unusual phenomena, structural change, spatial differences, and so on is not a new approach. Many researchers have adopted it for measuring the effect of structural reforms, particularly when direct and relevant data are difficult to obtain (Harris, Schiantarelli, and Sireger 1994; Alderman and Shively 1996; Devarajan, Swaroop, and Zou 1996; Khan 1996). Researchers have long faced the problem of impact measurements that require counterfactual information. Depending on their objectives and the degree of empirical problems, they have tried economy-wide, sectoral, or multimarket models that are capable of generating such information using “before and after” and “with and without” scenarios. None, however, has been completely satisfactory. Regardless of a model’s dimensions, its central challenge is to develop appropriate relationships that link the factors affected by reform to the defined objectives of analysis. The use of dummy variables in econometric models is one such way to attempt to capture “with and without” effects. Nevertheless, it is essential that the number of years in pre- and post-reform periods does not differ widely so that random effects have an equal chance of distribution between the two periods (Mill 1990).

In the case of fertilizers the complex changes induced by liberalization measures that are not explicitly included as explanatory variables concern real costs of fertilizer to producers and availability of the input at the right time and place because of a greatly enhanced competitive market after privatization, deregulation of the market, and decontrol of prices. The price of fertilizer included as an explanatory variable does not include various discounts that the

dealers are known to provide to purchasers to reap quick profits through high turnover. Similarly, fertilizer dealers sometimes resort to sales on informal credit to their subordinate retailers and farmers (Chowdhury 1993; World Bank 1992). Moreover, increasing the access of fertilizer dealers to factory-gate deliveries instead of controlled delivery from BADC stores must have enhanced the speed and volume of overall supply in the market. As discussed, in the case of irrigation the price and supply of low-lift pump and tubewell engines suddenly changed (price decreased and supply increased) because of market reforms, which included the withdrawal of import restrictions. These price and supply data are not systematically recorded and therefore cannot be used as explanatory variables in the model; the dummy variable is designed to pick up these effects.

Three other considerations also need a brief explanation. The first concerns the selection of 1988/89 as the splitting point between the pre- and post-liberalization periods.⁶ The process of liberalizing fertilizer markets proceeded gradually; deregulation and privatization of the market and decontrol of prices were effectively completed by 1984 but partially reversed in 1995. A crucial event occurred in 1988: the deregulation and withdrawal of all restrictions on the import of irrigation equipment. Since irrigation is the leading factor for growth based on seed-fertilizer technology, this year was selected as the effective separating point between the pre- and post-liberalization production periods (see Table 3.1). Cheaper irrigation equipment fueled the process of expansion in tubewell irrigation.

The second consideration concerns the fact that HYVs of rice do not appear in any equation that also includes irrigated rice area. Analysis of HYV area and irrigation indicated that the correlation between the changes in HYV area and changes in irrigated area was very high (0.91). Thus, the effect of irrigation must be viewed as inclusive of the effect of HYVs. Although fertilizer and irrigation are also positively correlated, the correlation is not as strong as between irrigation and HYVs.

The third consideration is that the variable *NAR* and a few others have not been endogenized in the model because the type of information (for example, the relative profitability of crops in a time-series framework) was not available. Moreover, given the known high profitability of irrigated rice crops, *NAR* remains primarily a function of weather conditions (rainfall, drought, and so on). *CDS*, *PD*, and *CDL* were not endogenized because they are hardly influ-

6. A simple comparison of growth rates in production between the two periods may give misleading conclusions about the impact of modern inputs and liberalization of their markets. Splitting the years from 1975/76 through 1996/97 into two periods, each with an equal number of years, shows that in the first period the annual logarithmic growth rate in rice production is 2.1 percent—the result of 1.6 percent growth in yield and 0.5 percent growth in rice area. In contrast, the 1.7 percent logarithmic growth rate in production in the second period is caused by a 2.3 percent growth rate in yield and 0.5 percent annual decline in rice area.

enced directly by input market liberalization and because such an extension of the model would ultimately devolve into a general equilibrium framework that is beyond the scope of this chapter.

The final consideration relates to the labor market. No variables on supply and demand for labor are included in the model. In a generally labor-surplus economy such as Bangladesh, and with a relatively undistorted rural labor market, the exclusion of labor from the model is not likely to influence the measurement of the contribution of input market reform to production. Rural labor markets are generally not as distorted as urban labor markets are. Moreover, annual data on labor services (as opposed to stock of labor) used in production are not available to incorporate such variables as explanatory factors in the equations. Therefore, the effect of reforms in fertilizer and agricultural equipment on labor use in agricultural production remains a primary concern. In terms of labor's contribution to production in equation (3.15), the implication is that such a contribution is mixed with the contribution of land and other inputs.

Data

The data set used to estimate the model is presented in Table 3.2. These time series data were collected from various sources, mostly government organizations. Certain data, such as credit, production and areas of nonrice crops, and even the use of major inputs, have certain degrees of unreliability. Even rice production statistics, once considered to be the most reliable, have been questioned (see Mitchell 1998). Although such skepticism tends to weaken this type of analysis, the conclusions derived here should hold, if not in precise magnitude at least in approximate order and direction.

Estimation and Results

The system of equations (3.11) through (3.15) was estimated using Zellner's Seemingly Unrelated Regression (SUR) model, with annual data from 1975/76 to 1996/97. This model is efficient in situations in which the equations are closely interrelated, with the possibility of the error term of one equation being correlated with the error term of another. Before using the SUR model, the equations were estimated using the simple Ordinary Least Squares (OLS) model. The adjusted R^2 s were generally high.

As Table 3.3 shows, results indicate that most of the hypotheses about input use are true, with the overall conclusion that the story of market liberalization is primarily one of irrigation-driven success in rice production. Liberalization of markets for irrigation equipment had both a direct and indirect impact *on not only irrigated rice but also fertilizer use and rainfed rice area—hence, total rice production.*

TABLE 3.2 Time-series data used to estimate models for measuring the impact of liberalization

Year	FC	PFR	PFD	PFM	PR	P	PO	PD	AGR	NAR	HYV	EG	CDS	CDL	DAR	QR
1975/76	451	1,361	1,368	2,222	3,382	160	6,650	2,075	3,008	9,851	3,833	608	625	795	22,516	12,763
1976/77	509	1,633	1,437	1,711	3,023	167	5,920	2,107	2,242	10,864	3,162	716	687	1,205	22,175	11,752
1977/78	725	1,633	1,437	1,843	3,877	188	7,330	2,164	2,868	10,122	2,975	851	1,085	1,539	21,291	12,970
1978/79	698	1,905	1,749	2,268	4,216	201	7,160	2,164	2,916	10,111	3,392	1,028	967	747	22,075	12,849
1979/80	797	2,450	2,147	2,719	5,657	237	7,840	2,776	3,038	7,166	4,936	1,423	1,354	1,415	21,769	12,740
1980/81	820	2,994	2,537	3,592	4,770	258	8,920	5,043	3,110	7,048	5,421	1,632	1,976	2,092	22,363	13,882
1981/82	772	3,605	3,328	3,828	6,060	298	8,370	5,499	3,309	6,786	5,745	2,016	2,186	2,710	22,542	13,631
1982/83	885	3,945	3,594	3,409	6,700	327	9,130	7,574	3,607	6,746	6,498	1,989	3,511	4,008	22,552	14,215
1983/84	1,032	4,007	3,658	3,599	7,450	355	12,040	7,574	4,711	6,677	6,499	2,840	5,110	3,749	21,354	14,508
1984/85	1,247	4,749	4,020	3,940	8,250	395	12,210	7,575	3,909	7,233	6,860	3,508	5,148	3,432	21,354	14,622
1985/86	1,152	4,995	4,399	3,693	6,620	439	11,680	7,643	3,987	7,764	7,126	3,571	1,247	2,344	21,708	15,041
1986/87	1,317	4,931	4,530	3,609	9,160	487	12,550	8,828	4,244	8,668	7,738	3,311	2,527	1,944	21,971	15,456
1987/88	1,505	4,924	4,557	4,405	9,970	532	13,890	8,192	4,835	9,987	8,239	4,459	2,743	1,525	20,156	15,661
1988/89	1,645	4,639	4,320	4,394	9,810	571	15,170	8,245	4,958	7,333	9,645	5,187	3,537	1,992	21,516	15,794
1989/90	1,968	4,648	4,197	5,013	9,600	616	15,090	8,064	5,944	8,859	10,549	5,328	3,571	1,668	19,947	17,462
1990/91	1,984	4,725	4,150	5,937	10,650	668	15,940	8,572	6,124	8,794	11,358	5,932	3,199	1,085	19,462	17,852
1991/92	2,124	5,004	4,194	5,806	9,720	701	15,970	8,715	6,681	9,436	12,003	6,376	4,464	1,528	18,633	18,252
1992/93	2,234	5,390	5,039	4,854	9,637	708	16,410	8,802	6,690	9,859	12,488	7,010	4,821	1,309	18,461	18,495
1993/94	1,921	5,679	4,869	5,021	9,719	735	17,280	9,845	6,709	10,322	12,347	6,330	5,151	2,161	17,954	18,041
1994/95	2,368	5,972	4,975	7,041	12,371	772	17,910	9,245	7,011	10,158	12,283	5,650	5,912	4,345	17,506	16,833
1995/96	2,305	5,821	4,711	8,294	12,172	799	18,040	8,317	7,266	9,768	12,182	6,279	6,505	4,005	17,291	17,687
1996/97	2,414	5,659	4,739	7,157	9,935	809	17,950	8,325	7,492	9,866	12,622	8,498	7,416	3,074	17,657	18,883

SOURCES: BBS (1991, 1993), Khalil (1989), IFDC, DAM, and Planning Commission of Ministry of Planning.

TABLE 3.3 SUR estimates of fertilizer consumption, fertilizer price, irrigated area, and rice production

Function	Model 1			Model 2		
	Coefficient	<i>t</i> -Statistic	<i>R</i> ²	Coefficient	<i>t</i> -Statistic	<i>R</i> ²
Fertilizer consumption (<i>FC</i>)			0.95			0.95
Intercept	-145.432	-0.351		-501.636	-1.224	
Fertilizer price (<i>PFR/PR</i>)	-162.551	-0.395		-133.460	-0.310	
Irrigated rice area (<i>AGR</i>)	0.435	9.223		0.410	8.873	
Other crop area (<i>NAR</i>)	-0.023	-0.823		0.007	0.241	
Short-term credit (<i>CDS/P</i>)	-26.383	-2.079		—	—	
Dummy (<i>D</i>)	-129.134	-0.782		-92.184	-0.545	
Retail fertilizer price (<i>PFR/PR</i>)			0.92			0.92
Intercept	-0.087	-2.158		-0.086	-2.111	
Factory-gate price (<i>PFD/PR</i>)	1.120	15.726		1.122	15.662	
HYV area (<i>HYV</i>)	0.000	0.805		0.000	0.765	
World price (<i>PFM/PR</i>)	0.125	2.493		0.123	2.379	
Dummy (<i>D</i>)	-0.001	-0.035		0.000	0.002	
Irrigated rice area (<i>AGR</i>)			0.87			0.87
Intercept	886.791	1.275		936.504	1.346	
Diesel price (<i>PD/PR</i>)	-760.518	-0.693		-829.307	-0.755	
Public expenditure (<i>EG/P</i>), lagged one year	509.050	3.264		524.341	3.363	
Long-term credit (<i>CDL/P</i>), lagged one year	79.241	1.251		66.641	1.059	
Dummy (<i>D</i>)	2,024.292	4.32		1,943.962	4.166	

(continued)

TABLE 3.3 *Continued*

Function	Model 1			Model 2		
	Coefficient	<i>t</i> -Statistic	<i>R</i> ²	Coefficient	<i>t</i> -Statistic	<i>R</i> ²
Dry-land rice area (<i>DAR</i>)			0.89			0.89
Intercept	22,840.000	22.221		22,869.000	22.198	
Irrigated rice area (<i>AGR</i>)	-0.626	-3.462		0.622	-3.440	
Rice price (<i>PR/PO</i>)	1,968.157	1.257		1,900.933	1.211	
Dummy (<i>D</i>)	-1,484.394	-2.369		-1,495.939	-2.386	
Rice production			0.95			0.95
Intercept	-1,903.471	-0.421		-1,916.240	-0.422	
Fertilizer (<i>FC</i>)	1.661	2.142		1.536	1.974	
Irrigated rice area (<i>AGR</i>)	0.993	2.881		1.039	3.003	
Dry-land rice area (<i>DAR</i>)	0.490	2.646		0.488	2.633	
Dummy (<i>D</i>)	553.040	0.978		556.235	0.983	

SOURCE. Author's estimations.

NOTE: *R*² relates to separate OLS estimation

The results in Table 3.3 represent two models: one with a short-term credit variable (*CDS*) in the fertilizer consumption function, the other without this variable. Contrary to the hypotheses, the variable *CDS* produced a significantly negative coefficient. This perverse relation was puzzling, but it appears to be due to a failure to endogenize *CDS*. Short-term credit supply from public institutional sources is often driven by political concern about helping farmers in bad crop situations. Therefore, a negative correlation between fertilizer use and credit becomes germane in the time-series data. Endogenizing *CDS* was not possible because of inadequate data, so *CDS* was dropped to show whether the omission affected R^2 and coefficients of other variables of interest. As the comparison shows, the results are not substantially distorted. The fertilizer function demonstrates that irrigated rice area is the dominant influence in fertilizer consumption. The relative price of fertilizer has the right sign, but the coefficient is not significantly different from 0, implying that the price effect on demand falls within the margin of error. The coefficient of the dummy variable in the fertilizer consumption function is also not significant, implying that liberalizing the fertilizer market did not make any significant difference in consumption. This liberalization began much earlier than that of irrigation equipment and was completed by 1984/85. Any effect should have been fully realized within six to seven years. Accordingly, a separate regression treating 1975/76 through 1984/85 as the pre-liberalization period and 1985/86 through 1992/93 as a post-liberalization period yielded results that showed a modestly positive impact of liberalization: that is, the coefficient of the dummy was significant at the 10 percent level. The size of the dummy coefficient and that of the production coefficient implies that the liberalization of the fertilizer market contributed only 280,000 tons of rice. Squeezing the adjustment period further by one year (that is, taking data up to 1991/92) produced a significant coefficient of the dummy and a larger impact (350,000 tons) of liberalization. It may be possible to conclude that fertilizer market liberalization did not create any negative impact on rice production. Moreover, the positive impact that may have been realized during the late 1980s and early 1990s was of a small order of magnitude. This conclusion does not, however, deny the considerable budgetary savings that occurred due to liberalization of the fertilizer market.

The fertilizer price equation demonstrates that the supply-side factors, particularly the pricing policy at the factory gate (which is administratively determined) and world price levels, dictate the retail prices. This is not surprising. But given the present composition of various fertilizers, particularly of domestic versus import, a taka increase in factory-gate prices seems to raise the average retail price by taka 1.12. On the other hand, a world price increase of the same magnitude causes the average retail price to increase by taka 0.13. This reflects the small share of imports in the total fertilizer consumption rather than the extent of transmission of world price to retail levels. The dummy variable in the price equation is not, as expected, significant.

The equation with irrigated rice area (*AGR*) as an independent variable indicates that the price of diesel fuel relative to rice has the correct negative sign but is significant only at the 30 percent level, which is traditionally a case of not being significantly different from 0. The statistical significance improves substantially, however, when the regression is run with data up to 1992/93 and the breaking point for the dummy is 1984/85. This could reflect the fact that, during the 1990s, irrigation tubewells have been partly electrified; therefore, the price of diesel may be of lesser consequence. Interestingly, the coefficient of annual public expenditures on water development measures is significant in influencing the change in irrigated area. This is surprising because such public projects are generally considered to be ineffective, a perception that seems to be erroneous. The flood protection, drainage, and other activities may indeed create congenial conditions for the expansion of tubewell irrigation. Long-term credit (*CDL*) does appear to have a positive but weakly significant influence on irrigated rice area.

Perhaps the most important coefficient in this equation is that of the dummy variable. It is significant and positive, and the underlying effect of forces is large. Without liberalization of the market for agricultural equipment, deregulation, and the privatization of tubewell installations, the irrigated area could have been about 0.81 million hectares smaller than its size in 1996/97. As in the case of fertilizer, repeated estimations of parameters and shortening the time period indicate that most of the effects of liberalization, as proxied by the size and significance of the dummy variable, have been realized in the 1990s.

The equation on rainfed rice area yields some interesting results that were previously overlooked. Changes in the rainfed rice area are negatively influenced by irrigation and positively by price factors—the former influence being significant, the latter moderately so. An increase of 1 hectare of irrigated rice area decreases rainfed rice area by about 0.6 hectare. This is the direct effect of irrigation and supports the general perception that an increase in irrigated rice comes at the cost of local varieties of rainfed rice and other crops. Similarly, a higher rice price relative to other prices tends to increase hectares of rainfed rice. The indirect effect of irrigation, in addition to the direct and price effects, is especially interesting and is captured by the coefficient of the dummy variable, which is highly significant, has a negative sign, and is large. Even though market liberalization has directly contributed to increased irrigated area, it generated a large negative impact indirectly on the area of rainfed rice. What might the underlying forces for this effect be, which are independent of direct effects of irrigation and price factors? Initially, this result appeared to be a misleading correlation, but discussion with a few agronomists and knowledgeable persons corrected that perception. The rapid expansion of irrigation and HYV rice has forced farmers to change the crop rotation involving all crops. Because irrigated rice is of longer duration (about 120–140 days compared to

60–100 days in other crops) and because of labor constraints in the peak season, farmers generally make changes by cutting down on area of rainfed rice. Farmers often produce other short duration crops on the rainfed rice area that has been dropped from rotation. Further research on this subject would contribute to our understanding of Bangladesh's crop agriculture.

Finally, the production equation seems to be well behaved in all respects. The coefficients of all variables (except the dummy) are significant, of the right sign, and of appropriate magnitude. The coefficient of the dummy is not, as expected, statistically significant. This implies that the measure of the contribution of market liberalization is not distorted by effects of unusually good weather or similar extraneous forces. The coefficient values seem close to what is generally perceived as marginal contributions of factors. Thus, adding a unit of fertilizer generates an additional 1.7 units of rice. Similarly, adding an area equivalent to 0.40 hectare of irrigated rice area results in an additional ton of rice production, but the same increase in rainfed area yields only half a ton of rice.

Net Effect on Rice Production

The net impact of input market liberalization on rice production between 1976 and 1997 is shown in Table 3.4. The effects consist of two factors: irrigation and rainfed rice. The effect of fertilizer market liberalization is small (about 300,000 tons of rice) and realized mostly before 1992/93 and coming to a steady state at about that time.⁷

The gross effect of the liberalization of agricultural equipment markets appears to be large—about 2 million tons. But the indirect effect of expansion of irrigated rice on rainfed rice via the change in crop composition also appears to be large and negative. This effect of irrigation has been realized mostly during the 1990s. It was not possible to infer whether the effect had reached a steady state by 1996/97. The net effect of irrigation-related changes is about 1.3 million tons of rice, meaning that the rice production during the post-liberalization period would have been 1.3 million tons less had market reforms not been undertaken. Another way of expressing the result is to note its impact on the growth rate of rice production or the share of the net effect of total increase in production. Based on the comparison of estimated trend production levels in 1988/89 and 1996/97 (15.67 and 19.09 million tons), the annual average growth rate in production was 2.5 percent and the absolute amount of

7. The dummy variable captures the difference between the average levels of fertilizer use in post- and pre-liberalization periods. This difference seemed to peak positively in about 1992/93 and then fell back to pre-liberalization levels. It has, however, not become negatively significant. The steady state, therefore, means a steady state in reference to the pre-liberalization period. The fall in the significance of the dummy variable after 1992/93 may imply a negative impact of reversals in some liberalization measures, an exhaustion in the scope of incentives for fertilizer use originally created by the liberalization, or a mixed effect of both factors.

TABLE 3.4 Estimated contribution of liberalization to rice production, 1976–97

Significant Factors	Coefficient of Dummy Variable		Production Coefficient		Contribution	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
					(thousand metric tons)	
Irrigated area (<i>AGR</i>)	2,024.29	1,943.92	0.993	1.039	2,010	2,020
Dry-land area (<i>DAR</i>)	-1,484.39	-1,495.94	1.490	0.498	-727	-730
Net contribution					1,283	1,290

SOURCE: Computed from Table 3.3.

NOTE: Model 1 includes short-term credit as an explanatory variable. Model 2 does not.

increase 3.42 million tons. The net effect of 1.3 million tons implies that the net effect is 38 percent of total incremental production and suggests that the growth rate would have been 0.9 percentage points lower without liberalization.

These conclusions warrant a few cautionary words lest the results are interpreted wrongly to suit various purposes. First, market reform is not a substitute for sustained growth in foodgrain production. For sustained growth the continual development of technology, institutions, and infrastructures (the shifter variables in the equations) is essential. Second, the focus of the impact measurement in the chapter was on rice production. The impact on income distribution and consumer welfare was not the focus, even though these are important. Third, the approach adopted is not comprehensive enough to include crops other than rice. The impact on other crops might augment or reduce the overall impact. For example, the reduction in rainfed rice area shown in the analysis might have caused an increase in areas of other crops so that the net gain in the crop sector might have been larger than that indicated by rice alone.

Finally, attributing success entirely to market liberalization would be shortsighted. While the measurement of the impact of liberalization warrants a distinction between pre- and post-reform periods, the government's role in the pre-liberalization period (creating fertilizer and irrigation markets and nurturing them to maturity) must not be underrated. The efforts of research and extension departments and the construction of rural infrastructure accumulated over time to build a foundation for growth in agricultural productivity. The impact of market liberalization could have been smaller or even negative without the cumulative effects of market development in the pre-liberalization period, as is observed in many developing countries, particularly in Africa.

Conclusions and Lessons

Although BADC contributed markedly to the infusion of modern inputs into Bangladesh's traditional agriculture, a competitive distribution system eventually became necessary for efficiency and effectiveness. Liberalization and privatization of input markets began gradually but have substantially influenced the growth of rice production; about 1.3 million tons of rice (about 38 percent of the trend incremental production between 1988/89 and 1996/97) may be credited to market liberalization. Without it the growth rate could have been 0.9 percent lower. This net effect, however, is mostly the result of irrigation-related development and the influence of irrigation on fertilizer use, which the liberalization process induced. The effect of fertilizer market liberalization was small (about 300,000 tons)—realized before 1992/93 and achieving a steady state at about that time.

Many developing countries are also attempting to liberalize their input markets. Therefore, lessons from Bangladesh may have international relevance, except perhaps for former Communist countries.

1. At first farmers are generally unfamiliar with modern inputs such as fertilizer, power-driven equipment, HYV seeds, and pesticides. Such markets do not exist and need to be created. This initial period of market failure is quite different from when modern inputs become reasonably well known and market size becomes adequate for a viable competition. The “one-size-fits-all” principle frequently pushed by donors can be harmful, as can wholesale condemnation of public parastatals such as BADC, whose role in the development of infant and missing markets is a remarkable success story.
2. Consider the evolution of the forces that drove public marketing out of circulation in Bangladesh. Donor conditionality was a powerful force but so were other compelling factors, such as budgetary burden and political will. The rapid removal of subsidies followed by privatization and liberalization of import restrictions demonstrates the government’s eagerness to change its mode of agricultural development. But as the fertilizer crisis of 1994/95 has shown, unless the process of change is closely watched for problems, setbacks are likely to imperil reforms.
3. Sudden liberalization of markets (the shock therapy approach) and liberalization in phases (the gradual approach) have been much debated in both the literature and policy circles. Because one-shot approaches are rare, the sequencing of reform measures generally plays a strategic role in liberalization. If phasing is unavoidable, the question of how to sequence becomes relevant. One order is to introduce competitive trading in various layers of the marketing channel involving external trade: from grass-roots retailing, to wholesaling. Generally, the public sector gains efficiency as it withdraws from retail, to wholesale, to the apex; it loses efficiency as it moves in the reverse order. In contrast, the degree of competition in private trade generally diminishes as one moves from retail, to wholesale, to the apex. Thus, the best strategy of sequencing is to privatize the retail market first and then gradually move to the apex level—the sequence followed in Bangladesh (see McKinnon 1993).

Another order might be gradual geographical coverage of markets by reform measures, as in the case of the privatization and price decontrol of fertilizers in Bangladesh. This sequence is generally chosen to avoid a risky failure at the beginning in the event that country-wide privatization and liberalization create turmoil or have unforeseen side effects that a weak administration cannot handle. If no side effects are observed, then reform measures can be extended to all regions. Such gradual coverage, however, should be considered only when the risk of failure is high and vested interests seem to be working against reform. When adopting this approach, reformers should begin with the region that has a relatively strong demand for the input in question.

4. Complementary support for the principal program of liberalization is almost always critical for success. Monitoring changes in supply, demand, prices, and emerging situations is essential. Without a well-considered support plan, the process often falters. In the case of fertilizer in Bangladesh, IFDC's monitoring role has been a profound factor in the success of liberalization.

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