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# Allocative Efficiency and Input Subsidy in Asian Agriculture

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In this paper, input subsidies (fertiliser subsidies to be exact) have been related to the allocative efficiency of fertiliser input. Fertiliser was singled out not to ignore other inputs but to emphasise the fact that fertiliser accounts for at least 30 percent of the total farm expenditure in most of Asia, and the rest of the expense is accounted for by labour (which is primarily family labour). The regression results are based on a sample survey data of 150 farms of Khulna Division (Bangladesh) for the year 1986–87. We have first estimated a production function based on Hoque (1991) and then calculated the efficiency indices based on the estimated parameters of the production function. In the second stage regression, different farm sizes were regressed on efficiency indices which showed an overall inverse relationship (that is, the smaller the farm size, the higher the efficiency). This tendency is observed upto the size of 10 acres in case of fertiliser input. Thus, the farms upto the size of 10 acres should be subsidised to promote efficiency in production. However, if the selective subsidy programme is difficult to administer, one hundred percent subsidy may be worthwhile. It is argued that the withdrawal of the fertiliser subsidy will reduce efficiency and have an adverse impact on employment and output in the rural sector of Asia. The IFPRI (1987) study on Indonesia also clearly indicates this. Some indicative discussions in Section II and Section V support the statistical results in favour of fertiliser subsidy.

## I. INTRODUCTION

Agriculture represents the most important sector of the LDCs, contributing between 30 and 70 percent of the GDP, employing between 50 and 90 percent of the labour force, and accounting for between 30 and 80 percent of the exports. Thus, given the overwhelming importance of agriculture in the economy, it is not surprising that agriculture has been an important area for policy intervention by the government. This intervention has taken many forms such as price support for agricultural commodities, input subsidies, institutional credit at subsidised interest rates, and so on.

In the present paper we shall mainly relate input subsidies (more specifically fertiliser subsidies) to the allocative efficiency of fertiliser input and relative risk

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aversion of the farmers. This does not mean that the subsidies on other inputs are not important. But fertiliser constitutes about 30 percent of the total expenditure and most of the rest is accounted for by labour (which is primarily family labour). This explains why we singled out fertiliser.

The statistical results are based on a sample survey data of 150 farms of Khulna Division, Bangladesh, for the year 1986–87. The results indicate that subsidies will increase output and employment and achieve self-sufficiency in food if the subsidy policy is properly designed, although the exact nature of the subsidy could not be derived from our statistical results and for various parts of Bangladesh. More detailed and time series data would be necessary for this.

So far as empirical work on efficiency relating to agriculture is concerned, the following two problems have received primary attention. The first relates to the possibility of raising output through re-allocation of inputs among the farms, thus confining to the concept of allocative efficiency and inferring about the so-called rationality of the traditional farmers [see, for example, Hopper (1965); Saini (1971); Wise and Yotopoulos (1969)]. The second relates to the study of the relationship between farm size and efficiency, the latter being defined as the productivity of land per acre [see, for example, Sen (1964); Mazumdar (1965); Rao (1967); Bhattacharya (1972); Bardhan (1973); Rudra (1968); Rudra and Chattapadhyay (1976) and Hoque (1988, 1991)]. In this paper we shall be primarily concerned with the first problem and use an index of efficiency for each individual farm based on the random coefficient model.

**Plan of the Paper**

In Section II, we shall describe the economic grounds for fertiliser subsidies. In Section III we shall briefly discuss the indices of allocative efficiency and estimation procedure. Section IV will contain the numerical results and interpretation. In Section V, we will indicate the adverse impact of withdrawal of the fertiliser subsidy on the economy. Section VI will contain the overall conclusion and policy implications.

## II. WHY FERTILISER SUBSIDY

It is well-known that in a first-best world there is no need for taxes or subsidies to promote efficiency. However, in the context of a second-best world (a world characterised by distortions and market imperfections) there is a role for taxes and subsidies for promoting efficiency. Now, we put forward the following arguments in favour of fertiliser subsidies.

(a) It is a common practice to impose export taxes on some export crops in the LDCs. Fertiliser subsidies can be used here to compensate for the loss of output and income that the farmers suffer because of the export tax. An export tax imposes a price distortion in the system and an input subsidy is an offsetting distortion which may eliminate some of the adverse effects of the export tax. However, one should have a notion of the level of subsidy at which tax revenues (from export tax) exceed the cost of subsidies.[1]

(b) Agriculture is essentially a risky operation. As agricultural production in the tropics is highly uncertain, the risk-averse farmers would be inclined to make a less than optimal use of fertiliser input.[2] To the extent that the risk aversion leads to underinvestment in fertiliser, the government should extend a subsidy to achieve self-sufficiency in food [Hoque (1985)].

(c) As long as fertiliser and labour are complementary to each other, the increased use of fertiliser will reduce overt unemployment in the rural sector. One might mention that if manure is used in place of or in

[1]The issue has been studied by Barker and Hayami (1976); Parish and Mclaren (1982) and Chambers (1985), among others. They find that input subsidies will be more cost-effective than output subsidies if

(i) The subsidised input has a high elasticity of supply;

(ii) It is a substitute for factors which are fixed in supply; and

(iii) It has a low substitutability for factors which are in elastic supply.

Applying the above results, the fertiliser subsidy is cost-effective if fertilisers are a good substitute for land and a complement (i.e., low substitutability) to other inputs. If the supply of other factors is not perfectly elastic, then subsidising fertilisers will be less expensive than an output subsidy as long as the supply elasticity of fertiliser exceeds that of labour. In most of Asia, where land is scarce, fertiliser is a good substitute for land. Hence fertiliser subsidies may often be more cost-effective than a policy of output-price support.

[2]This argument, of course, depends on the assumption that the farmers in the LDCs are risk-averse. They are indeed, as has been confirmed by a number of studies, like Rangaswamy (1980) and Bliss and Stern (1982) in India, and Grisley (1980) in Thailand. Binswanger (1980, 1981) suggested that the differences in investment behaviour observed among the farmers could not be explained primarily by the differences in their attitudes toward risk, but would have to be explained by the differences in their constraint sets such as access to credit, modern inputs, marketing, extension services, and so on. He also made a point that both absolute and relative risk aversion decline as wealth/pay off rises. The first point confirms Arrow (1971) while the second one does not. It should be noted that the degree of relative risk aversion is a function of the level of income and wealth of a farmer. The lower the level of agricultural development of the country, the higher the level of risk aversion; and, consequently, the greater the need for subsidy to induce the farmer to apply the required amount of fertiliser. This suggests that there should be higher subsidies for countries at a lower stage of agricultural development, like Bangladesh.

It is worth mentioning here that many OECD countries maintain agricultural subsidy to provide protection to the farmers from risk and uncertainty in the international as well as domestic markets. The developing countries are being discouraged mainly by the IMF/World Bank to continue subsidy on the ground that it will generate inefficiency. We have shown in Section IV that this is not the case.

addition to chemical fertiliser, it will have a marginal effect on overt unemployment but will reduce disguised unemployment to a large extent [Hoque and Inder (1991)]. This is because the production and application of manure are largely handled by family labour in the majority of farms [see Hoque (1987)].

(d) If successfully implemented, the subsidy policy will save a substantial amount of foreign exchange previously used to import food. These savings can be used to import intermediate and capital goods to be used as inputs in the industrial as well as agricultural sectors [see Hoque (1983)]. The result, of course, critically depends on the assumption that the subsidy will eventually achieve self-sufficiency in food. Now, self-sufficiency in food is a sensible goal in a country like Bangladesh because food imports cost about 18 percent of the total value of imports per year or about $370 million per year on the average for the last five years. And Bangladesh does not have comparative advantage for exporting industrial goods to make up for food imports [see Khan (1987)].

## III. INDEX OF ALLOCATIVE EFFICIENCY AND ESTIMATION

We use the following random coefficient production function to define allocative efficiencies.

$$Y_i = \alpha_i X_{1i}^{\beta_{1i}} X_{2i}^{\beta_{2i}}, \qquad i = 1, \ldots, n. \qquad \ldots \quad \ldots \quad \ldots \qquad (1)$$

where $Y_i$ represents output per acre of the $i$th farm and $X_1$ and $X_2$ represent fertiliser and labour per acre, respectively. We assume that the farmers aim at maximising their profits. This implies that they attempt to equate the marginal value products of the variable inputs to their respective market prices. The allocative efficiency with respect to fertiliser and labour for the $i$th farmer will be defined as

$$E_{1i} = X^0_{1i} / X^*_{1i} \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad (2)$$

$$E_{2i} = X^0_{2i} / X^*_{2i} \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad (3)$$

where $X^0_{1i}$ and $X^0_{2i}$ are the observed values of fertiliser and labour (per acre) for the $i$th farmer and $X^*_{1i}$ and $X^*_{2i}$ are the optimal levels of fertiliser and labour, respectively [see Hoque (1991) for details].

The efficiency indices $E_{1i}$ and $E_{2i}$ can be easily calculated once we estimate the parameters of the production function. $E_1$ and $E_2$ can be compared between two farms and one can see whether both are equally efficient or not in allocating either fertiliser or labour or both.

Now, Model (1) can be written as

$$y_i = \beta_{0i} + \beta_{1i} x_{1i} + \beta_{2i} x_{2i} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

where $y$ and $x$ are the natural logarithms of output and inputs respectively; and $\beta_{0i} = ln\alpha_i$. By McMillan *et al.* (1989) also justify – such a function in agriculture.

The above model requires $3n$ coefficients to be estimated with the help of only $n$ observations. Thus, we make certain simplifying assumptions about the probabilistic behaviour of the individual response coefficients. We assume that the individual response coefficient of output with respect to an input is random and fluctuates around its mean value. Following Hildreth and Houck (1968); Singh *et al.* (1976); Hoque (1991) and Hoque (1992, 1992a), we obtain the following estimable equation:

$$y_i = \bar{\beta}_0 + \bar{\beta}_1 x_{1i} + \bar{\beta}_2 x_{2i} \quad + u_i \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

## IV. NUMERICAL RESULTS

In the production function, we have productivity per acre (gross output/gross cropped area) as the dependent variable and two explanatory variables: (i) fertiliser per acre and (ii) labour per acre. The production function has been estimated both by the OLS (fixed coefficient) and the random coefficient (RC) methods. The results are given in Table 1. All the elasticity coefficients are positive and signifi-

Table 1

*Estimates of the Mean Elasticity Coefficients and Range for the Farm Level Elasticity Coefficients*

| | Elasticity Coefficients | | Range of Farm Level |
|---|---|---|---|
| Independent Variable | OLS Model | RC Model | Elasticity Coefficient |
| Labour | .48* | .51* | .35 to .62 |
| | (3.56) | (3.89) | |
| Fertiliser | .43* | .45* | .31 to .58 |
| | (4.73) | (5.17) | |

*Denotes significance at 5 percent level; figures in brackets are $t$ values.

cant at 5 percent level. After estimating the production function in (5), we can calculate $E_{1i}$ and $E_{2i}$ using (2) and (3). The Indices of allocative efficiency for fertiliser are presented in Table 2 for various farm sizes. We know that the closer $E$ is to unity, the higher the efficiency. We see that $E_1$ is higher for the smaller farms. Indeed, smaller farms up to 10 acres in size show considerable allocative efficiency with respect to fertiliser input .

Table 2

*Frequency Distribution of Farms Showing Different Levels of Allocative Efficiency of Fertiliser Inputs*

| Farm Size | Efficiency Level | | | | | |
|---|---|---|---|---|---|---|
| (in Acres) | .2 – <.3 | .3 – <.5 | .5 – <.7 | .7 – <.9 | ≥ .9 | Total |
| 1 - <3 | 5 | 3 | 6 | 8 | 3 | 25 |
| 3 - <5 | 4 | 6 | 7 | 9 | 4 | 30 |
| 5 - <10 | | 5 | 6 | 9 | 15 | 35 |
| 10 - <15 | 2 | 11 | 5 | 7 | 5 | 30 |
| 15 and Above | 4 | 10 | 5 | 6 | 5 | 30 |
| Total No. of Farms | 15 | 35 | 29 | 39 | 32 | 150 |

Now, the indices of allocative efficiency for human labour are presented in Table 3 for various farm sizes. Labour is employed above optimal level for both small and large farms. However, if we look at the market conditions of labour, the above results will not indicate irrationality in allocating labour by either group of farms [ for example, see Sen (1964) and Hoque (1988)]. Finally, the index of efficiency $E_1$ is regressed against farm size of different categories to see whether there is any relationship between the two. We have considered five piece-wise regressions for five categories of farm size and the results are presented in Table 4. It is seen that farm size and allocative efficiency for fertiliser are positively related for the categories 1 – <3 acres, 3 – <5, and 5 – <10, and all the regression coefficients are significant at the 5 percent level. This implies that the allocative efficiency for fertiliser increases with farm size up to 10 acres, but much more prominently at the lower levels of holding. The relationship is also positive for the category 10 – 15 and 15 acres and above but quite insignificant.

Table 3

*Frequency Distribution of Farms Showing Different Levels of Allocative Efficiency of Labour*

| Farm Size (in Acres) | Efficiency Level .6 – <.7 | .7 – <.9 | .9 – <.1 | ≥ 1 | Total |
|---|---|---|---|---|---|
| 1 – <3 | | 4 | 7 | 14 | 25 |
| 3 – <5 | | 5 | 9 | 16 | 30 |
| 5 – <10 | 4 | 4 | 15 | 12 | 35 |
| 10 – <15 | 5 | 5 | 10 | 10 | 30 |
| 15 and Above | 6 | 8 | 10 | 6 | 30 |
| Total No. of Farms | 15 | 26 | 51 | 58 | 150 |

Table 4

*Regression Results: Allocative Efficiency ($E_1$) as Dependent Variable*

| Independent Variables (Farm Size) | | Regression Coefficient | $R^2$ | *DW* |
|---|---|---|---|---|
| 1 – <3 | (n = 25) | .55* (3.8) | .86 | 1.91 |
| 3 – <5 | (n = 30) | .63* (4.3) | .89 | 1.87 |
| 5 – <10 | (n = 35) | .79* (6.91) | .96 | 2.03 |
| 10 – <15 | (n = 30) | .23 (1.3) | .92 | 1.96 |
| ≥15 | (n = 30) | .15 (1.2) | .75 | 1.81 |

A similar pattern can be found in connection with the allocative efficiency of labour ($E_2$) as presented in Table 5. The $R^2$ values are close to unity, showing a high degree of goodness-of-fit and DW values are close to 2, showing absence of auto-correlation in the disturbances.

Table 5

*Regression Results: Allocative Efficiency ($E_2$) as Dependent Variable*

| Independent Variables (Farm Size) | | Regression Coefficient | $R^2$ | *DW* |
|---|---|---|---|---|
| 1 – <3 | (n = 25) | .93* (8.1) | .98 | 1.99 |
| 3 – <5 | (n = 30) | .85* (8.6) | .96 | 1.96 |
| 5 – <10 | (n = 35) | .79* (6.5) | .91 | 2.05 |
| 10 – <15 | (n = 30) | .65* (6.1) | .89 | 1.89 |
| ≥15 | (n = 30) | .23 (1.5) | .72 | 1.83 |

*Denotes significance at 5 percent level; figures in brackets are *t* values.

## V. THE IMPACT OF SUBSIDY WITHDRAWAL

### (a) Impact on Output, Employment, and Balance of Payments

The withdrawal of subsidies on chemical fertiliser would entail an increase in the price of fertiliser. With agricultural output prices remaining the same, this will lead to a decline in the demand for fertiliser. Thus, even if the application of other inputs remains the same, there would be a consequent fall in the agricultural output when the farmers will use less fertiliser.

In a recent study by the International Food Policy Research Institute [IFPRI (1987)] on Indonesia, it was reported that a complete phase-out of fertiliser subsidies by 1991 will have a substantial negative impact on rice and corn production. It further noted that the phasing out would cause a 3 percent decline in the rice growing area by 1995 and 8 percent decline in yield, giving rise to about 10.5 percent decline in the total production or about 5 million metric tons of paddy.

In this connection, one may also mention that the contribution of fertiliser to increase agricultural production is widely acknowledged. The FAO (Food and Agricultural Organisation) study, *Agriculture : Toward 2000,* suggests that fertilisers were responsible for some 55 percent of the increase in production in the developing countries between 1965 and 1976. According to another study, by Herdt and Capule (1983), fertiliser contributed from 10 to 30 percent of the total growth in output in eight Asian countries, as shown below.

*Percentage Contributions of Various Factors to Rice Production Increases, 1965–1980*

| Country | Fertiliser | HYV | Irrigation | Other |
|---|---|---|---|---|
| Bangladesh | 23.1 | 7.5 | 19.6 | 49.8 |
| Burma | 19.1 | 34.5 | 37.0 | 9.4 |
| China | 22.8 | 26.2 | 32.0 | 19.0 |
| India | 30.9 | 22.7 | 31.9 | 14.5 |
| Indonesia | 19.7 | 23.2 | 20.3 | 36.8 |
| The Philippines | 30.8 | 25.9 | 24.4 | 18.9 |
| Sri Lanka | 20.0 | 23.0 | 27.0 | 30.0 |
| Thailand | 10.6 | 12.8 | 13.5 | 63.1 |

How this decline in output affects the price of agricultural output depends on price policy. If the government is committed to maintaining a given domestic price level, this decline in output will lead to higher imports for a deficit country and a reduced level of exports for the surplus country. In other words, the withdrawal of the fertiliser subsidy is likely to cause an adverse impact on the balance of payments of the country insofar as it adversely affects the import/export of the agricultural output of the country. Again, we can quote the IFPRI study which found that the withdrawal of the fertiliser subsidy in Indonesia (which presently enjoys self-sufficiency in food) would lead to a projected increase in imports of rice to 3.4 million metric tons in 1995 and 4.1 million tons in 2000.

### (b) Impact on Rural-Urban Wages

To the extent that the withdrawal of the fertiliser subsidy reduces the usage of fertiliser, there will be a corresponding fall in the marginal product of other factors including labour. Assuming no change in labour supply and no change in output prices, both the nominal and real wage in agriculture will tend to decline with the decrease in rural labour demand. If rural wages are slow to adjust or are inflexible, the result will be larger rural unemployment. If the prices of agricultural output are allowed to rise with the withdrawal of subsidies, the cost of living of the urban residents will increase. If the urban wage is nominally fixed, the real wage of the urban sector will fall. On the whole, the standard of living of the working class in both the urban and the rural areas of will fall as a result of the withdrawal of fertiliser subsidies [see Hoque (1986)].

## VI. POLICY IMPLICATIONS

Given the indicative discussions in favour of fertiliser subsidy in Section II, and further discussion on the adverse impact of fertiliser withdrawal in Section V, it is worthwhile to subsidise fertiliser. This conclusion is supported by our empirical finding in connection with Bangladesh. We have calculated the allocative efficiency indices for fertiliser and have found that larger use of fertiliser, especially in small and medium farms, does make a significant contribution to raising agricultural output (see Tables 2 and 4). Given that fertiliser constitutes an important item in the total outlay of farmers (for example, in Bangladesh, it is about 30 percent, and given that there is a capital shortage for the majority of farmers, withdrawal of subsidy will mean an immediate reduction in fertiliser use and, hence, a decline in output and employment. The IFPRI (1987) study on Indonesia clearly indicates this. Other countries that are following Indonesia in this respect might face the same consequences. Afghanistan, Bangladesh, and Sri Lanka are following this policy, as can be observed from the following Table.

*Fertiliser Subsidy in Asia*
*Subsidy as Percent of Current Government Expenditure*

| Country | 1981–82 | 1982–83 | 1983–84 | 1984–85 |
|---|---|---|---|---|
| Afghanistan | 0.32 | 0.31 | 0.16 | 0.12 |
| Bangladesh | 6.56 | 4.63 | 4.76 | 2.51 |
| India | 1.37 | 2.27 | 3.05 | 3.51 |
| Indonesia | 3.80 | 3.86 | 3.13 | 2.97 |
| Nepal | 4.18 | 2.01 | 3.03 | 5.99 |
| Sri Lanka | 5.20 | 3.99 | 3.14 | 2.93 |

*Source: FAO Fertiliser Yearbook, 1985. International Financial Statistics, IMF, 1987.*

One might wonder what type of subsidy – selective or universal – should be adopted. Given the politico-economic reality in many Asian countries, it will be almost impossible to successfully implement a selective subsidy policy in favour of small and medium farms which show higher allocative efficiency. Some experts, therefore, suggest a hundred percent subsidy (i.e., all farms, small and big, pay the same subsidised price of fertilisers) which is primarily an administrative viewpoint. Our finding just suggests that there is a need for subsidy if the level of output has to be raised. The actual extent of subsidy will depend basically upon the objective functions of the policy-makers.

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