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ESTIMATION OF JUTE HECTARAGE ALLOCATION FUNCTION FROM FARM-LEVEL DATA IN BANGLADESH

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I. INTRODUCTION

In general, supply response analysis for agricultural products has not received much academic interest in Bangladesh. But jute is an exception, because it is the major export commodity. Several studies have estimated the jute supply response function [1] [9] [12]. These studies used macro-level data for which there is a great demand, particularly from the policymakers. However, supply response functions estimated by using macro-level data do have some limitations, which Mujeri has put beautifully:

> Basically, the area under cultivation of jute, like that under any other agricultural commodity, rests on the micro-relationships within agriculture. Estimation of acreage functions from aggregate data leads to one of the most complex econometric problems which influences not only the choice of the explanatory variables but also the reliability of estimated parameters. [9, p. 3]

Paddy is the most important crop in Bangladesh which occupied about 75 per cent of the gross cropped area during 1987–88 [4]. It is also the staple food item of the Bangladeshis. Because jute is grown during the season when paddy (*aus*) is grown and both the crops utilize the same type of land, it is thought that jute-paddy price ratio would be a key determinant of the area under jute vis-à-vis paddy. Several studies found that jute-paddy price ratio or jute price had significant impact upon allocation of jute hectarage [1] [2] [5] [7] [11] [12] [13]. It is thought that this relationship has become increasingly weak in recent years. Mujeri [9, p. 3] has stated that "the true nature of the relationship between area under jute and jute and rice prices is a matter for conjecture and assumption." To investigate the exact relationship between jute hectarage allocation and jute-paddy price ratio, micro-level data need to be used. It may be mentioned that

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price is not an appropriate variable which influences supply response. This point is discussed below.

In the past, jute and paddy prices were used in supply equations for agricultural commodities. But prices are not appropriate barometers for change. Rational producers do not compare prices of commodities; they rather compare net returns which are functions of prices, costs of production, and yield rate [6] [9]. Because it is difficult to obtain accurate and representative data on net returns of commodities at the macro level, prices were used as proxies. Thus, for analyzing micro-level data, net returns can be used instead of prices in the supply equations.

The objective of this paper was to estimate jute supply response function (jute hectarage allocation function) from micro-level data so as to avoid the limitations of supply response functions estimated from macro-level data. The paper has been organized as follows. The next section describes the conceptual model of the study. Section III provides background information about the study area. The model estimation and results are discussed in Section IV. Finally, the summary and conclusions are given in Section V.

II. THE CONCEPTUAL MODEL

Area allocated to jute production by the ith farm at time t is assumed to be determined by three factors: (i) farm size; (ii) expected total net return from jute per hectare; and (iii) expected total net return from paddy production per hectare. The model can be written as:

$$AJ_{it} = a_0 + a_1FS_t + a_2TNRJ^*_{it} + a_3TNRP^*_{it} + U_{1it}, \qquad (1)$$

where

AJ = area allocated to jute,
FS = farm size,
$TNRJ$ = total net return from jute,
$TNRP$ = total net return from paddy,
U = disturbance term,
i refers to ith farm,
$*$ refers to expected value,
t refers to time.

Following the principle of Cobweb theorem, which assumes that producers base their production plan upon the recent past price [14], the model can be rewritten as:

$$AJ_{it} = b_0 + b_1FS_t + b_2TNRJ_{i(t-1)} + b_3TNRP_{i(t-1)} + U_{2it}. \qquad (2)$$

Equation (2) states that area allocated to jute at time t depends on farm size at time t, and total net returns from jute and paddy at time $(t-1)$. The expected signs of b_1 and b_2 are positive and that of b_3 is negative.

By-products of both jute and paddy are very important to farmers. Jute sticks are used for making walls of homes and houses as well as being used as fuel for cooking. Paddy straws are principal animal feed. Thus it is thought that jute and paddy by-products may have distinct effects upon jute hectarage allocation. So, the model can be written as:

$$AJ_{it} = c_0 + c_1FS_{it} + c_2NRJ_{i(t-1)} + c_3RJS_{i(t-1)} + c_4NRP_{i(t-1)} + c_5RPS_{i(t-1)} + U_{3it}, \quad (3)$$

where

NRJ = net return from jute,
RJS = return from jute stick,
NRP = net return from paddy,
RPS = return from paddy straw.

Equation (3) has decomposed total net return from jute and total net return from paddy respectively into net return from jute and jute stick, and net return from paddy and paddy straw. The expected signs of c_1, c_2, and c_3 are positive, while those of c_4 and c_5 are negative.

Many studies on jute supply response analysis used jute-paddy price ratio as the explanatory variable instead of price levels. The ratio is important information in that it measures relative changes. Thus, equations were specified which included ratios of returns from jute and paddy as explanatory variables as follows:

$$AJ_{it} = d_0 + d_1FS_{it} + d_2\frac{NRJ_{i(t-1)}}{NRP_{i(t-1)}} + d_3\frac{RJS_{i(t-1)}}{RPS_{i(t-1)}} + U_{4it}, \quad (4)$$

$$AJ_{it} = e_0 + e_1FS_{it} + e_2\frac{TNRJ_{i(t-1)}}{TNRP_{i(t-1)}} + U_{5it}. \quad (5)$$

Equation (4) shows that hectarage allocated to jute depends upon farm size, and ratios of net return of jute to that of paddy and return from jute stick to that of paddy straw. In equation (5) the ratio of total net return from jute to paddy has been included as an explanatory variable. The expected signs of all coefficients in equations (4) and (5) are positive.

III. BACKGROUND INFORMATION ABOUT THE STUDY AREAS

To estimate the models developed in the previous section, farm-level data on hectarage allocation and economic returns from jute and paddy were collected from two upazillas: Delduar in Tangail District and Chowhali in Serajganj District. From each upazilla, four villages were purposively selected which included two irrigated and two nonirrigated villages. One hundred samples were collected from each upazilla—fifty from irrigated villages and fifty from nonirrigated villages. It may be mentioned that shallow tube-wells were used for irrigation in the study areas.

The main reason for collecting data from irrigated and nonirrigated areas is that it is thought that introduction of mechanical irrigation has enhanced the

TABLE I

ALLOCATION OF CULTIVATED LAND AMONG COMPETITIVE CROPS, 1985–87

(Ha)

Crops	Irrigated Areas			Nonirrigated Areas		
	1985	1986	1987	1985	1986	1987
Jute	37.7	28.3	22.9	31.5	23.6	15.9
	(28)	(21)	(17)	(28)	(21)	(14)
Paddy	87.4	96.8	103.6	68.6	73.1	75.4
	(65)	(72)	(77)	(61)	(65)	(67)
Other crops	9.4	9.4	8.0	12.4	15.8	21.4
	(7)	(7)	(7)	(11)	(14)	(19)
Total cultivated area	134.5	134.5	134.5	112.5	112.5	112.5
	(100)	(100)	(100)	(100)	(100)	(100)

Note: Figures in parentheses represent the percentage of allocation.

degree of competition between HYV paddy and jute crops. This is because irrigated HYV paddy cultivation has substantially increased profitability from farming. Therefore, the impact of paddy may differ between irrigated and non-irrigated areas on jute hectarage allocation function.

Two upazillas were adjacent; there were not many differences in cropping pattern. In the nonirrigated areas, jute competed with local paddy (*aus*), while in the irrigated areas, jute competed with HYV paddy. Therefore, data analysis was based on the irrigated and nonirrigated areas and not on geographical areas.

Hectarage Allocation between Jute and Paddy and Economic Returns

Jute and paddy are two important crops in the subsistence agriculture of Bangladesh. The main product of jute (fiber) is used on farms for making jute string, an item required for making walls of houses, fences, bounding animals, etc. The by-product of jute (sticks) is the main material for building walls of houses, fences, etc. It should be noted that in Bangladesh villages, there are very few brick houses and fences surrounding homes, etc. The main product of paddy (rice) is the staple food item of rural people who make up more than 80 per cent of the population of country. Cereal constituted about 64 per cent of per capita daily food intake in rural Bangladesh in 1981–82 [8]. The by-product of paddy (straw) is the main feed item for animals used for tillage operations. It should be noted that mechanical cultivation is almost nonexistent in Bangladesh.

There are well-developed markets for jute fiber and rice. The bulk of jute fiber produced is marketed, because a minimal amount of fiber is required for home consumption. But most farmars cannot market their paddy, because they are unable to produce a marketable surplus due to small size of holding. Only large and medium farmers can produce some surplus. The average size of farm and family size in Bangladesh were 0.68 hectare and six respectively in 1983–84. The average size of large, medium, and small farms were 4.8 hectare, 1.67

TABLE II

AVERAGE RETURNS FROM JUTE AND PADDY, 1985–87

(1,000 taka)

Returns from Jute and Paddy	Irrigated Farm			Nonirrigated Farm		
	1985	1986	1987	1985	1986	1987
Jute:						
Net return from jute	12.5	−1.3	2.0	12.8	−1.1	0.6
Return from jute stick	2.1	2.6	3.6	2.3	2.6	3.5
Total return	14.6	1.3	5.6	15.1	1.5	4.1
Paddy:						
Net return from paddy	20.0	19.8	22.5	1.3	1.6	−2.1
Return from paddy straw	3.3	3.6	6.2	1.1	1.3	1.3
Total return	23.3	23.4	28.7	2.4	2.9	−0.8

Note: The exchange rate between taka (Bangladesh currency) and U.S. dollar was U.S.$1=30 taka in 1988.

hectare, and 0.38 hectare respectively. But large, medium, and small farms constituted 4, 18, and 51 per cent of rural households respectively [3].

The by-products of jute and paddy are usually not sold, because they are mostly used at home. However, recently, the area under jute cultivation has decreased, while due to introduction of HYV dwarf rice, production of paddy straw has decreased. Consequently, prices of by-products of jute and paddy have increased significantly (Appendix Table II). These products are sold at home.

Allocation of cultivated land among competitive crops in the jute season during 1985–87 period in both irrigated and nonirrigated areas is shown in Table I. It may be observed that the total cultivated land did not change over years in either irrigated or nonirrigated areas. But data showed that cultivated area of individual farms sometimes changed. Therefore, it is possible that land transfer occurred among the sample farms.

The following points may be gleaned from Table I. First, more than 60 per cent of cultivated land was allocated to paddy. Area under paddy cultivation increased over the years in irrigated and nonirrigated areas, but the rate of increase was significantly higher in irrigated areas than nonirrigated areas. Second, percentage of cultivated land allocated to jute decreased over time. Twenty-eight per cent of the land was allocated to jute in 1985 which decreased to 17 per cent in irrigated area and 14 per cent in nonirrigated area in 1987. Finally, the percentage of land allocated to other crops did not change in irrigated areas, whereas the same increased in nonirrigated areas.

Some explanations about the behavior of land allocation under different crops may be obtained from Table II which shows economic returns from jute and paddy cultivation. Total return from jute cultivation consistently declined over the years in both irrigated and nonirrigated areas. Although there was a significant increase in total return from paddy in irrigated areas, the same declined in the nonirrigated areas. Thus, in the irrigated areas, land released from jute cultivation was allocated to paddy cultivation; but in the nonirrigated areas, land released from jute cultivation was allocated to other crops. Finally, although net return from jute decreased over time, returns from jute sticks increased in both irrigated and nonirrigated areas.

IV. MODEL ESTIMATION AND RESULTS

Linear functional forms were estimated in this study. Log linear functional form could not be estimated, because some observations of the explanatory variables were negative. Semi-long functional form was estimated but gave poor fit.

Although data were collected for three consecutive years from 1985 to 1987, two-year data could be used, because the structural model was specified in log form. The jute hectarage and farm-size data were for the years 1986 and 1987, while the return data were for the years 1985 and 1986. Since cross-section panel data were available, the pooling method was used for data analysis. There are several alternative schemes by which the data might be pooled. The technique used here was to combine all cross-section panel data and perform ordinary least-squares (OLS) regression on the entire set for the case of computation [10].

Equations (2), (3), (4), and (5) were estimated. Table III shows the jute hectarage allocation equations estimated for the nonirrigated areas. Equation (T_{11}) shows that *NRP* and *RPS* have inconsistent signs and small *t*-values. Equation (T_{12}) also shows that *TNRP* has inconsistent sign and small *t*-values. These equations imply that return from paddy (*aus*) and its by-product either separately or together had no significant impact upon jute hectarage allocation. Equation (T_{13}) was estimated excluding *NRP, RPS,* and *TNRP* which exhibits better statistical fitness. It is interesting to note that the *t*-value of *RJS* is more than double of that of *NRJ* and the elasticity of *RJS* is more than four times higher than that of *NRJ*. This indicates that the returns from jute sticks were relatively more important than the returns from jute in determining jute hectarage allocation.

Equation (T_{14}) implies an important result. The coefficient of the ratio of net return from jute (*NRJ*) to net return from paddy (*NRP*) has a small *t*-value, but the coefficient of the ratio of returns from jute sticks (*RJS*) to returns from paddy straw (*RPS*) has large *t*-value. This implies that it was the ratio of returns from by-products from jute and paddy which influenced farmers' decision with respect to jute hectarage allocation, not the ratio of net return from jute and paddy. The coefficient of the ratio of *TNRJ* to *TNRP* had wrong sign and small *t*-value [equation (T_{15})]. Comparing all equations, equation (T_{13}) exhibits the best statistical fitness, with all explanatory variables significant and the highest R^2.

Table IV shows jute hectarage allocation equations estimated for the irrigated areas. Coefficient of *NRP* has inconsistent sign and small *t*-value, while the coefficient of *RPS* has consistent sign but small *t*-value [equation (T_{21})]. However, equation (T_{22}) shows that total net return from paddy (*TNRP*) has inconsistent size but significant *t*-value. Equation (T_{24}) shows that both ratios *NRJ* to *NRP* and *RJS* to *RPS* have consistent signs and large *t*-values. The coefficient of the ratio *TNRJ* to *TNRP* has consistent sign and is significant. Equation (T_{23}) shows the best statistical fitness with the highest R^2 and all explanatory variables significant.

TABLE III

ESTIMATED JUTE HECTARAGE ALLOCATION EQUATIONS FOR NONIRRIGATED AREAS

Equation Number	
T_{11}	$AJ_t = -0.01 + 0.03FS_t + 0.00002NRJ_{t-1} + 0.0002RJS_{t-1} + 0.000002NRP_{t-1} + 0.00002RPS_{t-1}$
	(1.57) (4.82)* (8.80)* (0.10) (0.42)
	[0.18] [0.16] [0.64] [0.005] [0.05]
	$R^2=0.72$, $F=47.20$*
T_{12}	$AJ_t = 0.06 + 0.07FS_t + 0.00003TNRJ_{t-1} + 0.000008TNRP_{t-1}$
	(3.37)* (8.90)* (0.51)
	[0.39] [0.40] [0.05]
	$R^2=0.53$, $F=34.76$*
T_{13}	$AJ_t = -0.005 + 0.04FS_t + 0.00002NRJ_{t-1} + 0.0002RJS_{t-1}$
	(2.53)* (4.95)* (9.49)*
	[0.21] [0.15] [0.65]
	$R^2=0.72$, $F=80.12$*
T_{14}	$AJ_t = -0.0009 + 0.11FS_t + 0.0006\frac{NRJ_{t-1}}{NRP_{t-1}} + 0.07\frac{RJS_{t-1}}{RPS_{t-1}}$
	(5.20)* (0.94) (5.09)*
	[0.64] [0.01] [0.34]
	$R^2=0.34$, $F=15.52$*
T_{15}	$AJ_t = 0.19 + 0.09FS_t - 0.009\frac{TNRJ_{t-1}}{TNRP_{t-1}}$
	(3.73)* (−1.41)
	[0.60] [−0.08]
	$R^2=0.14$, $F=7.67$*

Notes: 1. Figures in parentheses are t-values.
2. Figures in branckets are elasticities. Elasticities were calculated at the mid-values.

* Indicates significant at 1 per cent.

TABLE IV

Estimated Jute Hectarage Allocation Equations for Irrigated Areas

Equation Number	
T_{21}	$AJ=-0.002+0.03FS_t+0.00002NRJ_{t-1}+0.0002RJS_{t-1}+0.000003NRP_{t-1}-0.000007RPS_{t-1}$ FS_t: (2.28)* [0.18]; NRJ_{t-1}: (4.03)* [0.11]; RJS_{t-1}: (9.28)* [0.68]; NRP_{t-1}: (0.56) [0.06]; RPS_{t-1}: (−0.49) [−0.03] $R^2=0.77$, $F=61.94$*
T_{22}	$AJ=-0.04+0.09FS_t+0.00003TNRJ_{t-1}+0.00001TNRP_{t-1}$ FS_t: (6.13)* [0.05]; $TNRJ_{t-1}$: (8.71) [0.32]; $TNRP_{t-1}$: (3.29)* [0.26] $R^2=0.60$, $F=47.42$*
T_{23}	$AJ=0.006+0.04FS_t+0.00001NRJ_{t-1}+0.00023RJS_{t-1}$ FS_t: (2.78)* [0.20]; NRJ_{t-1}: (4.23)* [0.11]; RJS_{t-1}: (10.65)* [0.69] $R^2=0.77$, $F=15.00$
T_{24}	$AJ=0.13+0.08FS_t+0.11\frac{NRJ_{t-1}}{NRP_{t-1}}+0.08\frac{RJS_{t-1}}{RPS_{t-1}}$ FS_t: (3.84)* [0.43]; $\frac{NRJ_{t-1}}{NRP_{t-1}}$: (4.48)* [0.12]; $\frac{RJS_{t-1}}{RPS_{t-1}}$: (3.41)* [0.18] $R^2=0.41$, $F=21.53$
T_{25}	$AJ=0.13+0.10FS_t+0.16\frac{TNRJ_{t-1}}{TNRP_{t-1}}$ FS_t: (5.32)* [0.54]; $\frac{TNRJ_{t-1}}{TNRP_{t-1}}$: (4.93)* [0.19] $R^2=0.36$, $F=26.84$*

Notes: 1. Figures in parentheses are t-values.
2. Figures in branckets are elasticities. Elasticities were calculated at the mid-values.

* Indicates significant at 1 per cent.

Several inferences may be drawn from the analysis. First, mechanical irrigation, which is usually used for HYV paddy cultivation, has enhanced competitiveness between HYV paddy and jute crops. This is because, profitability of HYV paddy is much higher than that of local paddy. Hence return from jute and its by-products must be high enough to coax farmers to grow jute in lands where HYV paddy can be grown.

Second, the study lends support to the idea that returns from jute by-products may have significant influence upon farmers' decision to grow jute. In the rural areas, jute sticks are principal materials for making walls for homes and houses. They are also important items of fuel for cooking. Thus, in farmers' decision matrices, the jute by-product is an important variable. This indicates the weakness of the jute supply response functions estimated from macro-level time-series data which included the price of jute as an explanatory variable, but did not consider the price of jute sticks.

Third, comparing equations (T_{13}) and (T_{23}), it can be seen that the elasticities are fairly similar between irrigated and nonirrigated areas. But there are significant differences among elasticities in equations (T_{14}) and (T_{24}), and (T_{15}) and (T_{25}), indicating the impact of irrigation on the competitiveness between HYV paddy and jute crops.

Finally, the study confirms that returns from jute and paddy and their by-products are appropriate variables for supply response analysis at the farm level. Farm size and returns from jute and jute sticks were found to be the most significant variables. Moreover, return from jute and jute sticks should be specified as separate variables to measure their separate effects.

V. SUMMARY AND CONCLUSIONS

Jute supply response functions have been estimated by several studies using macro-level time-series data. The major limitations of these studies include exclusion of appropriate variables due to non-availability of data, such as net returns from jute and paddy, and their by-products and lack of reliability of estimated parameters. This study was undertaken to estimate jute hectarage allocation function using micro-level data in order to avoid the limitations of supply response functions estimated from macro-level time-series data.

Some important conclusions can be drawn from the study. First, farm size, net return from jute, and return from jute sticks were found to be the most significant explanatory variables. But returns from paddy and paddy by-product were not significant variables in equations estimated for irrigated or nonirrigated areas. Additionally, the ratio of net return from jute to net return from paddy and the ratio of total net return from jute to total net return from paddy were not significant variables in equations estimated for nonirrigated areas. This raises some question about the reliability of coefficient of jute-paddy price ratio or paddy price estimated by studies using macro-level time-series data. However, introduction of mechanical irrigation seems to have increased the competitiveness of paddy.

Second, return from by-product of jute was found to be the most significant variable in equations estimated for both irrigated and nonirrigated areas and its elasticity is much higher than that of the net return from jute.

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APPENDIX

CALCULATION OF NET RETURN

The net returns of the main products of jute and paddy were calculated as follows:

$$NR_i = P_i Y_i - p_j x_j,$$

where

NR_i = net return of jute or paddy,

P_i = average price of the main product of jute or paddy,

Y_i = total quantity of the main product of jute or paddy,
p_j = price of jth input,
x_j = quantity of jth input.

The return from by-product of jute and paddy was calculated as follows:

$$RB_i = P_i B_i,$$

where
RB_i = return from by-products of jute or paddy,
P_i = average price of by-product of jute or paddy,
B_i = quantity of by-product of jute or paddy.

To calculate net return, average price was used, because it was assumed that farmer's decision with respect to jute hectarage allocation was guided by expected net return.

APPENDIX TABLE I

AVERAGE PER HECTARE YIELD OF JUTE AND PADDY, AND THEIR BY-PRODUCTS

(Ton/ha)

Year	Jute	Jute Stick	Paddy	Paddy Straw
		Irrigated area		
1985	1.95	1.85	7.05	3.40
1986	1.90	1.85	6.95	2.85
1987	2.20	1.87	7.15	4.60
		Nonirrigated area		
1985	1.95	1.90	1.25	1.10
1986	1.90	1.85	1.25	1.10
1987	1.85	1.85	0.70	0.85

APPENDIX TABLE II

AVERAGE FARM GATE PRICE OF JUTE AND PADDY, AND THEIR BY-PRODUCTS

(Taka/ton)

Year	Jute	Jute Stick	Paddy	Paddy Straw
1985	9,777	1,133	5,351	994
1986	3,416	1,400	5,663	1,350
1987	4,833	1,891	6,189	1,794