PRODUCTION FUNCTION (AN EMPIRICAL STUDY ON DETERMINANTS OF OUTPUT IN AGRICULTURE)

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Introduction

The main thrust of this paper is to examine the production conditions in Indian agriculture. It is expected economic reforms in 1990s for the agrarian sector must have motivated the farmers for a better performance in crop production[1]. The neo-classical analysis of market behavior cannot be directly applied to study agricultural production. Existence of market imperfections is the important characteristic of the agricultural sector and farmers very often have to plan and carry out their production decision in peculiar complicated conditions.

A number of factors influence farmers' productions decisions as well as choice of crops and crop combinations. Household resource endowment in terms of land, labor and capital, availability of input and technology, etc., are the major factors involved in decision making. Household food and food security are also important considerations. Another set of factors is the incidence of insect, pests and diseases (witnessed in the recent past), rainfall uncertainty, and soil conditions. Among the more fundamental structure and institutional factors are the availability of infrastructure and marketing support. Furthermore, the degree of price response influences the farmer producing for the market and those engaged in subsistence farming. As Bharadwaj (1974) quotes, "*to identify the production methods or production conditions of Indian agriculture will lead to complications if the objectives of production are*

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[1]Since July 1991, the Indian economy has experienced a series of economic reforms, encompassing all major sectors of the economy (agriculture, industry, trade, foreign investment and technology, public sector, financial institutions and so on); it has marked a steady break from the past regime. It was of the view to improve India's competitiveness in the global market, i.e., the new policy was 'Laissez faire' inspirit as it reinforced the feeling that only liberalization and opining up of the economy to global competition can remove the shackles that chained the Indian economy.

Economic reforms in *agriculture* were mainly in the form of structural changes (the liberalization measure). Liberalization is from many angles. For example, sale and purchase of land except when its purchase makes the land holding move above the ceiling as imposed by law, is allowed. There is complete freedom to the farmers to produce anything they like, on their farms. Government regulation with regard to the movement of crops within the country has almost been abolished and it was also decided to liberalize the exports as well as imports of agricultural commodities, of course with some safeguards. Agriculture is been made completely free from direct taxes.

not the same for all producers (it is presumed all are not profit-maximisers)." The factors influencing production conditions are all the more daunting.

Survey of economic literature show, agricultural production/output is a function of land, labor, material inputs, irrigation, etc, that is, based on the idea that the amount of output in a production process depends upon the amount of inputs (viz., technical factors), used in the process[2] [Bharadwaj (1974); Bardhan (1973), etc].

The main objective of this present study is to examine the determinants of output in a post-reform period. As such, we too have formulated more or less the same idea/hypothesis. *Value of production/output is a function of land, labor, material inputs, tractors, irrigation, soil quality and cropping intensity.* Since, the sample study undertaken is for the total crop production, we tried to consider, along with the technical/institutional factors, the degree of utilization of the available land resource, that is, the *cropping intensity* for determining the total value of production or output[3].

Section II

Methodology

To examine the determinants of total crop output, we use the Cost of Cultivation data based on 600 cultivators of Andhra Pradesh state for the year 1994-95, a normal agricultural year after the introduction of economic reforms.The type of production function used to test the hypothesis is based on the pattern followed in Cobb-Douglas production function type (that is,agricultural output is a function of land, labor, inputs, etc**).**

An empirical model is set with different explanatory variables (depending upon the available sample information). It is presumed that they are the important factors to influence the production conditions. The *explanatory variables* are: The farm size (land holding), total human labor hours, total material inputs (seeds, chemical fertilizers, manures, etc), machine (tractor) hours, proportion of irrigated area, rental value per hectare (a proxy for soil quality), and cropping intensity. It is important to note, among the explanatory variables, the total animal labor hours and the proportion of high yield variety area have been excluded because of the multicolinearity problems.

We carry out regression analysis for total crop production (aggregated data) to investigate the hypotheses. The basic forms that have been tried in the literature are linear and log-linear. Here, we tried both linear and log-linear functions, in which log-linear estimations are found to be satisfactory. In order to capture regional effects and

[2] This type of technical relationship that is the empirical procedure is developed by M.J. Farwell (1957) to compare the technical performance of various size classes of holdings, which gives measures of technical efficiency with respect to multiple inputs. It is important to note, the similar approach is followed for *selected crops* in Bharadwaj (1974) for her study on 'production conditions in Indian agriculture'.

[3]Ahmed (1981) in his study of Bangladesh tries to assess production function involving cropping intensity or the degree of multiple cropping to witness the social efficiency of resource utilization.

seasonal effects, three additional empirical models are estimated by including tehsil dummies, zone dummies and season dummies.

Before we proceed with the analysis, a brief specification of the *variables* presented is discussed.

***Farm size* (FS):** One of the important production units in agriculture is 'land', that is the most commonly used classificatory basis, namely, the 'size of land holding' or 'farm size'. 'Farm size' is defined as the 'physical area of the cultivator', which is used wholly or partly for agricultural production. Farm size being the principle productive resource and the level of utilization of this crucial resource is closely correlated with the ability to command other productive inputs and facilities. Farm size is also called as institutional factor influencing the total value of production.

***Rental value per hectare* (RV):** For crop production, the basic requirement is the fertile land, whereas the quality of soil is of various types (for example, loamy, sandy, etc). In the literature, we find one among the determinants of farm productivity or total value of production, is the quality of land or the soil factor which plays an active role in increasing the total output [Reddy, V. Ratna (1993), etc]. The quality of soil is measured by its rental value (we cannot measure the quality of soil). It is assumed fertile land fetches a better price. Therefore, it is of our interest to include rental value per hectare (proxy measure for soil factor) in the analysis to see its impact upon total value of production.

***Total human labour hours* (HL):** In the crop production process, involvement of labor is of different categories. Here in the analysis, as per the available statistical information, we tried to consider only the pattern of family labor, casual labor, attached farm servants and exchange labor. Therefore, total human labor hours is calculated as the *total* of family labor hours, casual labor hours, attached labor hours and exchange labor hours irrespective of laborer's age and sex in consideration.

***Machine hours (MH*):** Over a period of time, with the technological changes, modernization, easy access to credit facilities, etc, in agricultural economy, it is normally expected, machines and implements play a pivotal role in crop production activity. They are also called as fixed capital assets. For instance, to have a better yield at the proper time agricultural operations are to be speeded up and it is possible only if mechanization is adopted. Machines unlike men and bullocks do not get easily fatigued and work faster than men and animals. Machines (especially tractors) help us in keeping to the time schedule of sowing and harvesting, and therefore to have a better yield (land productivity), to rise multiple cropping pattern and also in raising the employment level.

***Material Inputs(INP)*:** The basic and critical factor affecting the productivity of land along with the farm size is material inputs. The better quality seeds, manures and fertilizers with the help of timely irrigational facilities not only increases the crop output, but also favors for multiple cropping and brings in new area under cultivation. For

traditional variety crops, fertilizer application is very low, for high yield variety crops it is used in quite large quantities. Similarly, manures are used only on lands, which are not flooded. It is to be noted, we have considered only the value measurement of all the material inputs instead of quantity measurement due to statistical bias in measuring the quantities of different inputs.

Irrigation **(PIA):** Irrigation plays an important role in crop production, that is, it increases the labour input via an increase in cropping intensity. Irrigation improves the relative economic position of the farming community and generates dynamism of growth and productivity. This however, depends on the type or source of irrigation. Above all, the proportion of irrigated area has the potential for higher cropping intensity and an increase in total value of production. It is of expectation that large farmers hold more proportion of irrigated area. To examine the effects of irrigation by combining all sources of irrigation in one heading is likely to give misleading results because they have a varying degree of importance. To quote, the major sources of irrigation are canals, tanks, wells and tube wells. The most dependable source is canal and tube well irrigation because tank and well irrigation is extremely sensitive to rainfall conditions (being essential rain fed). Even within one type of irrigation there are wide differences in quality. As such, in the analysis of cost of cultivation studies, we have computed 'Proportion of Irrigated Area'. It is defined as 'the ratio of gross irrigated area to gross cropped area' separately to avoid the misleading results, irrespective of the type of irrigation used.

Cropping Intensity **(CI):** Cropping Intensity' is defined/measured as a '*ratio of gross cropped area to land holding in percentages*'. One of the important factor through which value of production and labour use, etc could be increased is the cropping intensity and it depends on the type and source of irrigation. The study on cropping intensity helps us to assess the degree of utilization of available land resource of a region.

Total value of production (A Dependent Variable)**:** In our study *total output* is defined as *total value of production*. Value of Production is measured in both gross cropped area as well as net sown area[4]. Value of production in a net sown area captures the impact of multiple cropping**.**

In the following section we examine the determinants of value of production (total output is defined as gross value of production) with totally eight equations in the estimation. The first four sets of equations were estimated taking log of value of production per unit of gross cropped area (GCA) as a dependent variable. The other four sets of equations were estimated taking log of value of production per unit of net cropped area (NSA) as a dependent variable. In order to capture regional effects and seasonal effects, empirical models are estimated by including tehsil dummies, zone dummies and season dummies.

[4]***Gross Cropped Area*** is Total cultivated area under all crops grown during the year and ***Net sown area*** is the Total cultivated area minus current fallows.

The estimated equations for the production function are:

1. Log Value of Production/GCA = $\alpha + X_1 \log FS + X_2 \log HL/GCA + X_3 \log INP/GCA + X_4 \log MH/GCA + X_5 \log RV + X_6 \log PIA$.

2. Log Value of Production/GCA = $\alpha + X_1 \log FS + X_2 \log HL/GCA + X_3 \log INP/GCA + X_4 \log MH/GCA + X_5 \log RV + X_6 \log PIA + b_i\Sigma$ tehsil dummies.

3. Log Value of Production/GCA = $\alpha + X_1 \log FS + X_2 \log HL/GCA + X_3 \log INP/GCA + X_4 \log MH/GCA + X_5 \log RV + X_6 \log PIA + b_i\Sigma$ zone dummies.

4. Log Value of Production/GCA = $\alpha + X_1 \log FS + X_2 \log HL/GCA + X_3 \log INP/GCA + X_4 \log MH/GCA + X_5 \log RV + X_6 \log PIA + b_i\Sigma$ season dummies.

5. Log Value of Production/NSA = $\alpha + X_1 \log FS + X_2 \log HL/NSA + X_3 \log INP/NSA + X_4 \log MH/NSA + X_5 \log RV + X_6 \log PIA + X_7CI$.

6. Log Value of Production/NSA = $\alpha + X_1 \log FS + X_2 \log HL/NSA + X_3 \log INP/NSA + X_4 \log MH/NSA + X_5 \log RV + X_6 \log PIA + X_7CI + b_i\Sigma$ tehsil dummies.

7. Log Value of Production/NSA = $\alpha + X_1 \log FS + X_2 \log HL/NSA + X_3 \log INP/NSA + X_4 \log MH/NSA + X_5 \log RV + X_6 \log PIA + X_7CI + b_i\Sigma$ zone dummies.

8. Log Value of Production/NSA = $\alpha + X_1 \log FS + X_2 \log HL/NSA + X_3 \log INP/NSA + X_4 \log MH/NSA + X_5 \log RV + X_6 \log PIA + X_7CI + b_i\Sigma$ season dummies.

Abbreviations: **FS** - farm size (land holding); **RV**-rental value; **CI**-cropping intensity; **PIA**-proportion of irrigated area; **HL/GCA**-total human labor hours per gross cropped area; **HL/NSA**-total human labor hours per net sown area; **MH/GCA**-machine hours per gross cropped area; **MH/NSA**-machine hours per net sown area; **INP/GCA**-total material inputs value per gross cropped area; **INP /NSA**-total material inputs value per net sown area; $\mathbf{b_i}$are parameters

The findings of our empirical analysis are presented in Table 1.

Section III

The Determinants of Output

In this section, we present the findings of the log-linear regression model, which is found to be a satisfactory fit in explaining the determinants of output. The *R bar square* values vary from 0.60 to 0.84 and the F-statistics for overall regression is statistically significant in all the estimations**.**

As per the findings (table 6.1), the coefficients of the variable *farm size* (FS) are positive and statistically significant. The positive impact of farm size on output survives irrespective of output measured either per unit of gross cropped area or net sown area. This is observed even when zonal and seasonal factors are controlled in the estimations. The output coefficients vary from 0.10 to 0.25. The elasticity of output increases at a higher percentage when the estimation is done for controlling regional and seasonal factors. This implies farm size is one of the important determinants when controlled for other factors in influencing the output.

If any part of the farm is cultivated twice in a given year, with the improvement in new technology there is a significant increase in land productivity. Therefore, one can reasonably expect a positive relationship between productivity/output and cropping intensity. Our findings reveal that the elasticity coefficients of *cropping intensity* (CI) in a net sown area are positive and statistically significant as expected. The cropping intensity coefficient increases by 4.3 percent (equation 5) in determining the total value of production. The inclusion of regional and seasonal dummies in the estimation confirms the positive impact of cropping intensity with total crop production (the coefficients of zonal and seasonal dummies in the estimations are jointly significant). It implies that regional (zones) or seasonal factors also influence the variation in cropping intensity with value of production.

As one among the determinants of farm productivity, we examine the influence of *rental value per hectare* (RV) with value of production. This is the measurement taken for soil quality. The findings reveal positive coefficients of rental value per hectare in explaining variations in value of production per gross cropped area and net sown area. The coefficient of rental value per hectare is positive and significant when value of production is measured per unit of gross cropped area as well as per unit of net sown area. (equation 1 and equation 5). The coefficients of rental value per hectare in gross cropped area and net sown area measurement are 0.16 and 0.08 respectively. Both the coefficients are statistically significant. The inclusion of dummies in the estimations does not change the direction of the relationship between rental value per hectare and output. We find stronger evidence of soil quality to influence output when seasonal factors are controlled for in both the measure of value of production in respect of gross cropped area and net sown area (equation 4 and 8).

Though, we find soil quality (rental value per hectare) as one of the determinant of output, in actual sense, with the advent of new technology (material inputs and irrigation), it is no more considered a determinant, that is, the endogenous factors improve the quality of land/soil. (ManabenduChattopadhyay&AtanuSengupta (1997), etc).

Total value of *material inputs*has an uncontroversial positive relationship with output in both the measurement that is, either defined as total value of production per unit of gross cropped area as well as per unit of net sown area. Inclusion of regional and seasonal dummies is jointly significant. Output increases by 4.3 percent per unit of net sown area with every increase in total material inputs.

Irrigation has been the key factor in the use of the HYV seed - fertilizer package by the farmers. Apart from providing favorable conditions for exploiting the new technology, assured irrigation also facilitates multiple cropping by enabling the farmers to raise crops even in the dry season. Therefore, irrigation is expected to have a positive impact on output. Here, in the analysis the explanatory variable, *proportion of irrigated area* (defined as a ratio of irrigated area to gross cropped area) has a positive influence on the value of production both as per gross cropped area and per net sown area. We find the coefficient of proportion of irrigated area is statistically significant only when value of production is measured per unit of net sown area (The observed coefficient is 0.22 in equation 5)). The influence of cropping intensity is found in the estimations (equation 5 to 8), on the other end, proportion of irrigated area is found to be invariant as per gross cropped area measure of total output.

Unlike irrigation, we do also assume high yield variety area to play a pivotal role in influencing the productivity, that is, they facilitate multiple cropping, contribute to an increase in labour demand indirectly via an increase in cropping intensity and finally on the productivity. In our analysis, because of multi-co linearity problems, the *proportion of high yield variety area* is not included in the model. Since the coefficient of irrigation (PIA) is positive, it is assumed, irrigation is picking up the effect of high yield variety area.

In our findings, there is an interesting observation. The *total machine hours* (MH) or *total tractor hours* does not show any strong evidence of explaining the variations in determining the value of production. Therefore, it is necessary to do further research on this issue.

The relation between the agricultural output and labor input is of great prominence in the study of production conditions. Normally it is expected if the higher labor intensity is not associated with the corresponding higher output (value of production) increase in labor intensity is not desired. In the finding, we find positive coefficients of total human labor hours (HL) in explaining the variations in value of production. The results in both gross cropped area and net sown area measure are statistically significant and robust. The coefficients of human labor hours are 0.38 (3.8 percent) and 0.49 (4.9 percent) when labor intensity is defined per unit of gross cropped area and per unit of net sown area respectively in determining the output or value of production. Even after controlling for tehsil, zonal and seasonal differences through dummy variables, the results remain more or less the same. From this observation,

it is quite reasonable to expect that high labor intensity may be the result of labor using technological change or the cropping pattern undertaken by the farmers are of labor-using type. The elasticity of labor intensity varies from 0.38 to 0.84 when alternative equations are estimated. The above observations confirm us that human labor hours are one among the most important factor in determining the output or total value of production.

Our findings on the factors influencing the crop output does corroborate with the studies ofBharadwaj (1974), Bardhan (1973), Ahmed (1981), etc. However, it is important to mention here, the above-mentioned studies are related to individual crop analysis. Our findings are reported for the total crop production.

Section IV
Summary and Conclusions

The main objective of this paper is to examine the factors determining the total crop production. This is based on the reasoning that neo-classical analysis of market behavior does not exist in agriculture.

As per the survey of literature identified on agriculture, agricultural output is a function of land, labor, material inputs, irrigation, etc. Therefore, we too have formulated similar hypotheses to examine the determinants of output in post-reform period and carried out the regression analysis. As per the results, it is observed, the coefficients of farm size, cropping intensity, human labor, material inputs, rental value and proportion of irrigated area (in net sown area) are all positive and significant in influencing the output. With the inclusion of cropping intensity in the estimation, it is found the coefficients are significant and higher in most of the observations. Whereas, the important input, machine hours does not show any significant impact in influencing the total crop production. This is even found in alternative estimations. Inclusion of dummies is jointly significant, which implies the factor influencing the value of production survives even when controlled for regional and seasonal factors. To conclude, there are no changes in the factors affecting the total crop production in post-reform period.

However, our study has few limitations. The individual crop production function is not estimated, and moreover, the factors affecting production conditions or output is likely to be confounded also with some other factors which is not considered in our scope of study.

TABLE 1

DETERMINANTS OF OUTPUT

Equation No.→	1	2	3	4	5	6	7	8
Independent Variables↓	O/gca	o/gca (T)	o/gca (Z)	o/gca (S)	O/nsa	o/nsa (T)	o/nsa (Z)	o/nsa (S)
Constant	1.43* (4.73)	1.97* (5.06)	1.82* (5.40)	0.85* (2.50)	-0.22 (-0.82)	-1.01 (-2.42)	0.46 (1.38)	-1.05* (-2.95)
FS	0.10* (5.36)	0.14* (8.94)	0.11* (5.53)	0.12* (5.86)	0.19* (8.07)	0.25* (12.0)	0.19* (7.99)	0.23* (8.83)
HL/GCA	0.38* (11.2)	0.59* (12.0)	0.38* (10.1)	0.41* (11.6)	-	-	-	-
INP/GCA	0.49* (12.6)	0.29* (6.90)	0.51* (12.7)	0.48* (12.5)	-	-	-	-
MH/GCA	0.02 (1.73)	0.02 (1.22)	0.02 (1.28)	0.03 (1.97)	-	-	-	-
HL/NSA	-	-	-	-	0.49* (12.2)	0.84* (13.2)	0.52* (11.6)	0.54* (12.6)
INP/NSA	-	-	-	-	0.43* (9.46)	0.14* (2.76)	0.41* (8.66)	0.40* (8.90)
MH/NSA	-	-	-	-	0.03 (1.65)	-0.007 (-0.36)	0.007 (0.37)	0.03 (1.91)
RV	0.16* (8.02)	0.12* (3.03)	0.11* (4.24)	0.18* (8.03)	0.08* (3.01)	0.03 (0.79)	0.02 (0.68)	0.10* (3.51)
PIA	0.06 (2.67)	-0.05 (-2.29)	0.06 (2.61)	0.03 (1.26)	0.22* (6.35)	0.14* (3.85)	0.22* (6.10)	0.20* (5.88)
Cropping Intensity	-	-	-	-	0.43* (8.71)	0.54* (9.98)	0.41* (8.14)	0.47* (9.06)
ΣX_i	1.2	1.1	1.2	1.2	1.9	1.9	1.8	2.0
F-statistics	154.0*	33.4*	98.3*	86.9*	253.8*	47.5*	165.6*	152.2*
R^2	0.61	0.80	0.62	0.62	0.75	0.86	0.76	0.76
R^{-2}	0.60	0.77	0.61	0.61	0.75	0.84	0.75	0.75

Note: a) Figures in parentheses are t-values &**(*)** - Statistically significant.
b) Alphabet T, Z, & S in brackets denote estimations done with Tehsil, Zone and Season Dummies.

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