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ANATOMY OF INPUT DEMAND FUNCTIONS FOR INDIAN FARMERS ACROSS REGIONS

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Abstract

This study models the optimum use of production inputs and analyse the behaviour of input demand functions of agricultural production through restricted transcendental logarithm profit function for four different regions in India using rural economic and demographic survey (REDS) data. The Seemingly Unrelated Regression (SUR) method of estimation reveals that the level of productivity of farms is significantly influenced by output prices, inputs like labour, fertilizer, pesticides. The results of own-price elasticities for the demand of variable inputs are negative and price elastic. Fertilizer prices and area planted had a significant impact on the profit function altogether. The effect of output prices in eastern region is larger. Whereas, wage rate and other input prices are more effective for other regions. The cross-price elasticities for input indicated imperfect complementary relationships among the inputs. A well designed input distribution policy can mitigate the problem of low factor productivity and lack of technological improvements in agriculture.

Keywords: *Agriculture, Restricted Translog Profit function, Input Demand, Seemingly Unrelated Regression, India*

JEL Codes: *C30, D61, I38*

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INTRODUCTION

A PRELUDE

Agriculture sector, in India, is considered at the core of the economy's purchasing power as it accounts 14 percent of the nation's GDP and about 11 percent of its exports[1]. About half of the population still considers agriculture as its principal source of income. The prices of agricultural commodities differ with the input demand elasticities across different parts of the country. It has long been realised in price policy formulation that the farmers typically respond to relative prices than just the prices received or prices paid. Reliable estimates of input demand elasticity are the outcomes for predicting farmers' responsiveness to changes in input-output prices and government taxes and thereby for formulating successful agricultural incentive programs consistent with national requirements of food, development and exports. In fact, robust estimates of the coefficients of such elasticities can serve as a tool in determining effective policy relevance for promoting production, equity, efficiency, and finally egalitarian income distribution in the farm sector of the economy. Many non-behavioural factors like seed quality, fertilizer and chemical usage, irrigation and harvesting intensity can also influence yields thus input demand. Our purpose in this paper is to determine how behavioural and qualitative inputs affect the profit efficiency of farmers in different regions of India.

Input demand functions with farm level data from developing countries have been estimated through different production functions, profit functions and cost functions in numerous past studies (Taru *et. al.*, 2011; Ojo *et. al.*, 2006; Rahman, 2003; Ekpebu, 2002; Abdulai and Huffman, 2000; Kalirajan and Obwona, 1994; Battese and Hassan,

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[1] State of Indian Agriculture, 2012-13. http://agricoop.nic.in/Annual%20report2012-13/ARE2012-13.pdf
India has 170 million hectares under food grain cultivation, producing 220 million tons of food grains in a year. Whereas China has only 60 percent of this arable land area, but it is able to produce twice the extent of food grains that India produces (Hussain, 2015).

1999). Farmers' input factor demand and output supply elasticity have earlier been derived with direct or indirect application of the Cobb-Douglas production function to farm survey data Despite the restrictive nature of Cobb-Douglas function researchers found it useful. Ekpebu (2002) argued that this particular functional form is useful in analysis of surveys where many variable inputs are involved and it is needed to determine returns to scale, intensity of factors of production and overall efficiency of production. However, there are differences in opinion in this regard.

Mawa, Mutuku, Poole (2014) assessed profit efficiency of smallholder dairying in Kenya using stochastic frontier analysis for estimating farm level profit efficiency and identifying the specific determinants of efficiency. The results showed that the farmers are fairly profit efficient with an average of about 68 percent. Cost of fodder produced on farm significantly improved profit efficiency among farmers. Restricted normalized translog profit function is used as it can represent input demand and output supply simultaneously. Moreover, translog profit function is a flexible functional form to estimate the input demand as it can take out the problems related to the restrictive as required by Cobb-Douglas profit function. Wijetunga (2016) estimated the output supply and input demand elasticities of rice production using the restricted normalized translog profit function for the four major paddy producing districts in Sri Lanka. The results suggest that the changes in market prices of inputs and output significantly affect the farmers` profits, rice supply and the use of resources in paddy cultivation. The supply elasticity of rice with respect to its own price is 0.5 and the supply elasticity of output with respect to fertilizer price is -0.05 on an average. Fertilizer demand in the country is inelastic but significant to its own price. Therefore, fertilizer subsidy is one of the main factors to increase fertilizer demand as well as paddy supply in the country. In addition, the low elasticity of substitution between labour and fertilizer and other inputs indicates that there is a complementary relationship among these inputs hence their combined application increases paddy production synergistically.

The effect of input prices and other factors on the cost efficiency of agricultural production have been explored earlier (Binswanger, 1974; Ray, 1982; Bravo-Ureta, Evenson, 1994; Coelli, *et. al.*, 2005) finding that cost inefficiency either through different frontier based analyses or by non parametric approaches. There are number of studies (Sidhu and B.anante, 1979; Sidhu and Baanante, 1981; Chand, 1986; Kumar *et. al.*, 1981; Goyal, 1992) which have estimated the changes in input resource use to produce output, and profit as a function of input prices and output prices using a primal production function, a dual cost function, and a dual profit function. The duality approach was extensively used as it is able to provide a complete relationship among inputs and output (Beccera, 1992; Siregar, 2007). Duality approach states that both production and profit function can describe the behavior of input demand and output supply equally well if both functions satisfy standard properties. This was preferred to be utilized since it can overcome the problem of solving first order condition by directly specifying suitable maximum profit function rather than production function.

However, the production function, the profit function involves only input/output prices and quantity of quasi fixed inputs which are not endogenous. By the duality approach, the assumption of profit maximization and competitive market are assured because the derived input demand and output supply equation are obtained from the profit function. However, past studies have focused on the estimation of the production, cost, and profit function using the traditional OLS procedure. Cost efficiency, however, is only a part of whole response to the factors. A more complete scenario of the effects is obtained from a profit function which reflects the joint impact of revenue as well as cost effects. Moreover, cost efficiency measures derived from a profit function can differ from those obtained from a cost function if the output quantities (taken as given in the cost function) are observationally inconsistent with profit maximization, so that revenue inefficiency exists.

There are few studies have examined the elasticity of substitution of inputs used for agricultural sector India. However, there are no proper elasticity estimates for input demand and output supply in agriculture using recent input output data. Although it has been considered as important area to keep track time to time for policy perspective, there is dearth of recent investigation in this area. Hence, our study seems to fill the knowledge gap in India using a normalized translog profit function approach. Further, this study differs from earlier research as its main objective is to estimate the restricted translog profit function for different regions using SUR model in simultaneous equation framework. The data set has been collected from different parts of India which approves a detailed disaggregated analysis of farm production structure which permits the measurement of the different impacts that exogenous variables have within and across input demand and output supply functions.

MODEL STRUCTURE

A restricted profit function, that includes only variable costs, is assumed to be homogenous of degree one in factor prices (Bergman, 1997). In the adopted model, let p_Y and p_I be the price vectors corresponding to the variable outputs and inputs, respectively with profits. Assume that a function $c(w, y)$ has all the properties of a cost function.

Then the function $f(x) := max\{y \geq 0 | w \cdot x \geq c(w, y) \, \forall w \;\; 0\}$, has the properties of a production function. If a firm is a price taker on its input markets, we can use a cost function to model the firm's technology. Under our assumptions, this is equivalent to modeling the firm's technology with a production function.

If the firm uses inputs x with prices (w , 0) to produce output y with price $p > 0$ its profit (revenue minus cost) is $py - w\,x$. The maximal profit that the firm can achieve at the output price p and the input prices $w: \pi(p, w) := max\ (x, y) \geq 0\ p\ y - w \cdot$ x, $s.t. f(x) \geq y$. Using the fact that the production function is strictly increasing, we can simplify the profit maximization problem appearing in the definition of the profit function.

$\pi(p, w) = max\ y \geq 0, p\ f(y) - c(w, y)$.

Properties of profit function: $\pi(p, w) \geq 0$

Profit is non-decreasing in *p* and non-increasing in *w.*

If $p^1 \geq p^2$, then $\pi(p^1, w) \geq \pi(p^2, w)$; If $w^1 \geq w^2$, then $\pi(p, w^1) \leq \pi(p, w^2)$ ();

$\pi(p, w)$ is convex and continuous in (*p*,*w*); $\pi(tp, tw) = t\pi(p, w)$ *t*>0 (positive linear homogeneity). It leads into a discussion of Hotelling's lemma (a profit function counterpart to Shephard's lemma. If the profit maximization problem has a solution x> 0, then this solution satisfies the first order condition, equalizing the marginal revenue product with the price of each input:

$p\ \partial\ f(x)\ \partial\ x_i = w_j$ i = 1,...,n. This implies the first order condition for optimization.

The profit maximizing output $y^* = f\ (x^*)$ and input choices x depend on the input prices w and the output price p. The function $y^* = y(p; w)$ is called the firm's output supply function. The function, $x^* = x(p; w)$ is called the firm's input demand function.

For those input prices w and output price p for which it is well-defined the profit function p(p, w) is continuous and differentiable, increasing in p. The first derivatives of the profit function with respect to prices and costs gives the optimal allocations, i. e. the aggregate supply and factor demand equations. Equations for profits and demand for factors can be directly estimated.

Assume that the production function is strictly concave. Then $(p, w) \geq 0$. The input demand function can be calculated from [following Hotelling's Lemma]

$$x_i(p, w) = \frac{-\partial \Pi(p, W)}{\partial w_i}$$

The output supply function can be calculated from

$$y_i(p, w) = \frac{-\partial \Pi(p, W)}{\partial p}$$

We thus have a very simple and convenient way to calculate the firm's choice of inputs and its output from the profit function. Assuming a farmer maximizes profit subject to a given state of technology and a mix of fixed inputs, and marginal conditions hold, the normalized restricted Translog Profit function is estimated for one output. This profit function contains sufficient information to completely describe the production technology and hence the production possibility set. These properties of the profit function correspond generally to the more familiar properties of the dual production possibility set.

The generalized translog profit function can be written as follow

$$\Pi_i = p_Y \Sigma \beta_{ij} \ (p_{Iij})^{(1/2)} + \mu_i \tag{1}$$

Where $i = 1 ....N$ (households); $\Pi_{i=}$ Profit of the household, $\mathbf{p_I}$ = Input prices and $\boldsymbol{\mu}$= the error terms. The above profit function can be expanded in the following form.

$$\prod_i = \beta_0 + \beta_y \ln\left(p_{Y\,i}\right) + \beta_L \ln(p_{L\,i}) + \beta_F \ln(p_{F\,i}) + \beta_M \ln(p_{M\,i}) + \beta_N \ln(p_{N\,i})$$

$$+\frac{1}{2}\ln(p_{Y\,i})\left[\beta_{yy}\ln(p_{Y\,i}) + \beta_{yL}\ln(p_{L\,i}) + \beta_{yF}\ln(p_{F\,i}) + \beta_{yM}\ln(p_{M\,i}) + \beta_{yN}\ln(p_{N\,i})\right]$$

$$+\frac{1}{2}\ln(p_{L\,i})\left[\beta_{Ly}\ln(p_{Y\,i}) + \beta_{LL}\ln(p_{L\,i}) + \beta_{LF}\ln(p_{F\,i}) + \beta_{LM}\ln(p_{M\,i}) + \beta_{LN}\ln(p_{N\,i})\right]$$

$$+\frac{1}{2}\ln(p_{F\,i\,i})\left[\beta_{Fy}\ln(p_{Y\,i}) + \beta_{FL}\ln(p_{L\,i}) + \beta_{FF}\ln(p_{F\,i}) + \beta_{FM}\ln(p_{M\,i}) + \beta_{FN}\ln(p_{N\,i})\right]$$

$$+\frac{1}{2}\ln(p_{M\,i})\left[\beta_{My}\ln(p_{Y\,i}) + \beta_{ML}\ln(p_{L\,i}) + \beta_{MF}\ln(p_{F\,i}) + \beta_{MM}\ln(p_{M\,i}) + \beta_{MN}\ln(p_{N\,i})\right]$$

$$+\frac{1}{2}\ln(p_{N\,i})\left[\beta_{Ny}\ln(p_{Y\,i}) + \beta_{NL}\ln(p_{L\,i}) + \beta_{NF}\ln(p_{F\,i}) + \beta_{NM}\ln(p_{M\,i}) + \beta_{NN}\ln(p_{N\,i})\right]$$

$$+u_i$$

In such estimation procedure, the error terms in each equation are assumed to satisfy all the classical assumptions of well-behaved function but correlated across the equations within the system. A restricted profit is obtained by subtracting the cost of variable inputs from total revenue. The restricted profit is then normalized by the output price. Factor demand equations are derived from the FOC of the Profit function as follows:

$$\frac{\partial \prod}{\partial p_L} = -\frac{pL \bullet L}{\prod} = \beta_L + \beta_{LY}\ln(P_Y) + \beta_{LF}\ln(P_F) + \beta_{LM}\ln(P_M) + \beta_{LN}\ln(P_N) \qquad (2)$$

$$\frac{\partial \prod}{\partial P_F} = -\frac{pF \bullet F}{\prod} = \beta_F + \beta_{FY}\ln(P_Y) + \beta_{FL}\ln(P_L) + \beta_{FM}\ln(P_M) + \beta_{FN}\ln(P_N) \qquad (3)$$

$$\frac{\partial \prod}{\partial p_M} = -\frac{pM \bullet M}{\prod} = \beta_M + \beta_{MY}\ln(p_Y) + \beta_{ML}\ln(p_L) + \beta_{MF}\ln(p_F) + \beta_{MN}\ln(p_N) \qquad (4)$$

$$\frac{\partial \Pi}{\partial p_N} = -\frac{pN \bullet N}{\Pi} = \beta_N + \beta_{NY} \ln(p_Y) + \beta_{NL} \ln(p_L) + \beta_{NF} \ln(p_F) + \beta N_{NM} \ln(p_M) \qquad (5)$$

Where p_Y is output price, p_L is wage rate, p_F is price of the fertilizer, p_M is rental price of machinery and p_N the price of manure. Here output supply and input demand functions both are considered as homogeneous of degree zero in all prices. Supply is assumed as increasing in the output price and demand for each input is decreasing in its own price. The following symmetric restrictions are imposed on the coefficients in the estimated system of equations. $\beta_{LF} = \beta_{FL}$; Coefficient of wages and price of fertiliser = Coefficient of price of fertiliser and wages. Similar symmetric restrictions are imposed on the coefficients for other factors of production.

An error term of the profit function and share equations are likely to be correlated contemporaneously due to large number of common explanatory variables. Thus Ordinary Least Square (OLS) is not applicable to estimate the equation in the system. The Seemingly Unrelated Regression (SUR) method of estimation is used to find out the correlations in the error terms (and hence the name) and provides estimates that are unbiased and efficient. The SUR model is a generalization of a linear regression model in simultaneous equation system. Each equation is a valid linear regression on its own and can be estimated separately, which is why the system is called seemingly unrelated. The SUR model is viewed as either the simplification of the general linear model when certain coefficients in coefficient matrix, β are restricted to be equal to zero, or as the generalization of the general linear model where the regressors on the right-hand-side are allowed to be different in each equation.

DATA DESCRIPTION AND SUMMARY STATISTICS

The present study is based on 'Rural Economic and Demographic Survey (REDS)' data collected by the National Council of Applied Economic Research (NCAER), India. These data have been collected for rural households of the major 17 states in India in 2006-07. Approximately two-thirds of the entire samples were selected from villages covered by the Intensive Agricultural Development Programme (IADP) or the Intensive Agricultural Area Programme (IAAP). It has three parts. The first part is the "listing sheet", where information on household income and a few demographic variables is collected. The second part is the "village questionnaire". The third part is the "household questionnaire" which is used for collecting data on a range of variables relating to household behavior. The listing sheets are typically used to select the households to be surveyed. This study estimates the input demand and output supply functions in four selected regions in India for the period of 2006-07. As the crops grown differ from State to State and not all crops are common in all the States and Union Territories and climate and farming pattern are, mostly, same according to geographical locations we have divided the whole area into four distinct regions, viz., North, East, West and South. For this analysis, major Indian states have been clubbed into the following four regions. North region comprises Uttar Pradesh, Punjab, Haryana, Himachal Pradesh, Madhya Pradesh and Chhattisgarh. Eastern region includes Bihar, Jharkhand, Orissa and West Bengal. West region consists of Rajasthan, Maharashtra and Gujarat. Southern region includes Andhra Pradesh, Tamil Nadu, Karnataka and Kerala.

Amount of total profit, output, disaggregated costs and prices of inputs (wage rate, rent, price of fertiliser, price of manure) along with household level characteristics for four mentioned regions separately and at India as a whole are presented in table 1. Northern part and Western part of India showed better performance in terms of agricultural profit generation compare to other parts. This is, basically, northern and western zone stood ahead because of enormous crop yielding capacity since beginning. The table shows the cost of production and profit in the eastern region is lower compared to other regions. This is due to the low labour cost cloud not made it profitable and this is the case of law of diminishing returns to scale. The results also find that the high cost of labour and fertiliser prices reduces the profit in the southern region.

Table 1: Summary Statistics of the Variables

Region	North	East	West	South	Total
Total profit (Rs.)	88942.63	33950.40	73622.71	43171.80	64941.62
Value of output (Rs.)	98064.92	39606.40	82995.52	52490.90	73712.97
Total cost (Rs.)	9122.29	5656.00	9372.81	9319.10	8771.36
Wage rate (Rs.)	44.73	40.49	42.93	59.40	50.48
Machinery rental (Rs.)	2297.48	1573.01	3060.41	2531.20	2440.85
Price of fertiliser (Rs.)	6.38	8.29	11.02	17.12	9.48
Price of output (Rs.)	20.56	20.42	17.35	24.22	19.58
Price of manure (Rs.)	5.58	6.42	7.63	6.29	6.72
Average household size	5.85	5.44	5.13	4.50	5.24
Uneducated (percent)	34.35	32.24	38.40	33.75	34.85
Primary (percent)	17.89	21.62	23.42	19.45	20.14
Secondary (percent)	30.81	29.71	27.09	34.35	30.79
Higher Secondary (percent)	9.34	7.71	6.63	6.28	7.61
Undergraduate/Graduate (percent)	5.11	6.45	3.31	4.67	4.74
Post Graduate	2.51	2.28	1.15	1.50	1.87

Note: Author's calculation using the REDS data, 2006.

RESULTS AND DISCUSSION

We have estimated restricted translog profit functions using iterative seemingly unrelated technique and corresponding input demand functions for all-India and separately for four different regions. Table 2 represents estimated profit function, functions of share of labour, share of machinery and share of fertiliser for all India. Subsequent tables (3, 4, 5 and 6) correspond to the estimated functions for Northern, Eastern, Western and Southern zones respectively. The results vary across regions.

The signs of the coefficients of output price revealed a positive and significant relation with agricultural profit in all the cases. All the input prices have positive impact on agricultural profit. The price of fertilizer is found to have a negative impact on profit thereby indicating a heavy dependence of the profitability of the farm household in the Western India on fertilizer price as an important input. The dependency on fertilizers is linked to the cropping patterns in these states that are involved the production of pulses (particularly in Maharashtra) that require nitrogen fertilizers and certain cash crops such as cotton (Gujarat and Maharashtra) and groundnut (Gujarat) that require phosphate fertilizers. The wage rate has less impact on profit in eastern region compared to other regions and also the coefficient of squared wage rate shows the diminishing returns to scale. There is a significant relation between profitability and the size of the farm household, thus indicating higher profitability of larger farmer in western states. Coefficient of higher level of education shows negative relation, with the higher secondary education as the only exception, possibly reflecting migration of educated workforce away to non-agricultural activities. However, the results for these co-efficient are statistically insignificant.

The results of the factor demand equations can be used to infer the impact of various factors on the demand of a particular factor. The results from Model (2) support that even as the wage rates increase the labour demand is likely to go up by as much as 7.6 per cent thereby supporting the higher labour absorption in the agriculture sectors of these states. There appears to a substitution between labour and fertilizer thereby indicating that the farmer tends to replace costly fertilizer with labour. However, labour is complementary to the rent of machinery paid by the farmer that is to say greater the mechanisation of the household is likely to show up in higher employment in the farm activity. A decline in the price of manure would lead to increase in the manure usage, thereby increasing the labour required for its application. Smaller households tend to employ more hired labour. The results of the estimation equation for the rental of machinery show that the famer tends to replace costly labour for machinery, though the result is not statistically significant. Smaller household tends to be more capital intensive. The third factor demand equation suggests very high substitution of fertilizer by manure. A small farmer tends to use more fertilizer to compensate for labour required for tilling.

Table 2: Translog Profit Function Using Iterative Seemingly Unrelated Technique (Total)

VARIABLES	Profit	Share of Labour	Share of Machinery	Share of Fertilizer
Price of output	1.548***			
	(0.0912)			
Wage rate	0.992***	0.0344***	-0.0146***	0.0413***
	(0.234)	(0.00732)	(0.00443)	(0.00718)
Price of fertilizer	1.055***	0.0413***	0.0169***	-0.357***
	(0.128)	(0.00718)	(0.00495)	(0.0127)
Rental rate of machinery used	0.323***	-0.0146***	0.0114*	0.0169***
	(0.0653)	(0.00443)	(0.00603)	(0.00495)
Price of manure	0.668***	-0.0611***	-0.0137	0.299***
	(0.197)	(0.0146)	(0.0131)	(0.0180)
Household size	0.730***	-0.703***	-0.585***	-0.622***
	(0.0980)	(0.0360)	(0.0462)	(0.0392)
Primary	0.0738	-0.118**	0.000878	-0.0898
	(0.137)	(0.0514)	(0.0660)	(0.0560)
Secondary	0.253**	-0.0756*	-0.0403	-0.0875*
	(0.123)	(0.0456)	(0.0584)	(0.0497)
Higher Secondary	0.854***	-0.0929	-0.276***	-0.241***
	(0.197)	(0.0737)	(0.0944)	(0.0802)
Undergraduate/Graduate	0.458*	-0.146	-0.135	-0.179*
	(0.241)	(0.0902)	(0.116)	(0.0982)
Post Graduate	-0.238	0.0443	-0.181	-0.0343
	(0.369)	(0.138)	(0.177)	(0.150)
Price of output^2	-0.0694***			
	(0.0169)			
Wage rate^2	-0.273***			
	(0.0567)			
Rental rate of machinery used^2	-0.0128			
	(0.00797)			
Price of fertilizer^2	0.0671**			
	(0.0315)			

(contd… Table 2)

VARIABLES	Profit	Share of Labour	Share of Machinery	Share of Fertilizer
Price of manure^2	0.0378			
	(0.0334)			
Price of output * Wage rate	-0.0132			
	(0.0240)			
Price of output * Price of fertilizer	-0.445***			
	(0.0379)			
Price of output * Rental rate of machinery	-0.0529***			
	(0.0104)			
Price of output * Price of manure	-0.143***			
	(0.0469)			
Wage rate * Rental rate of machinery	-0.0101			
	(0.00720)			
Wage rate* Price of fertilizer	0.00306			
	(0.0353)			
Wage rate* Price of manure	-0.0540			
	(0.0350)			
Rental rate of machinery * Price of fertilizer	-0.0104			
	(0.0165)			
Rental rate of machinery * Price of manure	-0.0336**			
	(0.0147)			
Price of fertilizer * Price of manure	-0.123			
	(0.0845)			
Constant	4.215***	-0.217***	-0.441***	-0.598***
	(0.190)	(0.0646)	(0.0819)	(0.0702)
Observations	5,885	5,885	5,885	5,885

Note: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Translog Profit Function Using Iterative Seemingly Unrelated Technique (North)

VARIABLES	Profit	Share of Labour	Share of Machinery	Share of Fertilizer
Price of output	1.830***			
	(0.226)			
Wage rate	2.465***	0.0618***	0.0162**	0.0628***
	(0.529)	(0.0138)	(0.00824)	(0.0134)
Price of fertilizer	1.418***	0.0628***	0.0124	-0.267***
	(0.324)	(0.0134)	(0.00887)	(0.0225)
Rental rate of machinery used	0.276**	0.0162**	0.0359***	0.0124
	(0.110)	(0.00824)	(0.0109)	(0.00887)
Price of manure	0.379	-0.141***	-0.0645***	0.192***
	(0.514)	(0.0280)	(0.0242)	(0.0330)
Household size	0.601***	-0.639***	-0.427***	-0.535***
	(0.153)	(0.0647)	(0.0810)	(0.0684)
Primary	0.563**	-0.231**	0.131	-0.204**
	(0.226)	(0.0972)	(0.122)	(0.103)
Secondary	0.382**	-0.245***	-0.0111	-0.267***
	(0.193)	(0.0832)	(0.104)	(0.0878)
Higher Secondary	0.560*	-0.0772	-0.104	-0.194
	(0.286)	(0.123)	(0.154)	(0.130)
Undergraduate/Graduate	0.503	-0.300*	-0.162	-0.284*
	(0.369)	(0.159)	(0.198)	(0.168)
Post Graduate	-0.0575	-0.0882	-0.496*	-0.290
	(0.509)	(0.219)	(0.273)	(0.231)
Price of output^2	-0.158***			
	(0.0448)			
Wage rate^2	-0.635***			
	(0.134)			
Rental rate of machinery used^2	-0.0154			
	(0.0135)			
Price of fertilizer^2	-0.0446			
	(0.0812)			
Price of manure^2	0.0230			
	(0.0534)			
Price of output * Wage rate	-0.0496			
	(0.0488)			
Price of output * Price of fertilizer	-0.530***			
	(0.0895)			
Price of output * Rental rate of machinery	-0.0293			
	(0.0193)			
Price of output * Price of manure	-0.0352			
	(0.0985)			

(contd… Table 3)

VARIABLES	Profit	Share of Labour	Share of Machinery	Share of Fertilizer
Wage rate * Rental rate of machinery	-0.0169			
	(0.0126)			
Wage rate* Price of fertilizer	-0.0570			
	(0.0896)			
Wage rate* Price of manure	-0.0727			
	(0.0692)			
Rental rate of machinery * Price of fertilizer	-0.00884			
	(0.0342)			
Rental rate of machinery * Price of manure	-0.0309			
	(0.0245)			
Price of fertilizer * Price of manure	-0.0147			
	(0.242)			
Constant	4.820***	-0.755***	-1.154***	-1.045***
	(0.328)	(0.124)	(0.154)	(0.131)
Observations	2,035	2,035	2,035	2,035

Note: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Translog Profit Function Using Iterative Seemingly Unrelated Technique (East)

VARIABLES	Profit	Share of Labour	Share of Machinery	Share of Fertilizer
Price of output	2.376***			
	(0.331)			
Wage rate	0.995***	0.109***	0.0198**	0.119***
	(0.230)	(0.0146)	(0.00985)	(0.0169)
Price of fertilizer	0.891*	0.119***	0.105***	-0.124***
	(0.472)	(0.0169)	(0.0129)	(0.0332)
Rental rate of machinery used	0.186	0.0198**	0.0593***	0.105***
	(0.184)	(0.00985)	(0.0158)	(0.0129)
Price of manure	0.348	-0.248***	-0.184***	-0.101**
	(0.469)	(0.0299)	(0.0319)	(0.0435)
Household size	0.993***	-0.451***	-0.500***	-0.521***
	(0.228)	(0.0802)	(0.125)	(0.103)
Primary	0.0672	-0.183	-0.611***	-0.418***
	(0.321)	(0.115)	(0.178)	(0.148)
Secondary	0.842***	-0.249**	-0.858***	-0.317**
	(0.301)	(0.106)	(0.164)	(0.136)
Higher Secondary	1.520***	-0.386**	-1.134***	-0.699***
	(0.467)	(0.165)	(0.257)	(0.213)

(contd… Table 4)

VARIABLES	Profit	Share of Labour	Share of Machinery	Share of Fertilizer
Undergraduate/Graduate	1.136**	-0.566***	-1.195***	-0.836***
	(0.514)	(0.178)	(0.277)	(0.230)
Post Graduate	1.076	-0.279	-0.314	-0.285
	(0.799)	(0.284)	(0.442)	(0.365)
Price of output^2	-0.157**			
	(0.0618)			
Wage rate^2	-0.774***			
	(0.242)			
Rental rate of machinery used^2	-0.0187			
	(0.0234)			
Price of fertilizer^2	-0.0750			
	(0.145)			
Price of manure^2	-0.0311			
	(0.0827)			
Price of output * Wage rate	-0.00564			
	(0.0833)			
Price of output * Price of fertilizer	-0.549***			
	(0.128)			
Price of output * Rental rate of machinery	-0.0622*			
	(0.0352)			
Price of output * Price of manure	-0.139			
	(0.120)			
Wage rate * Rental rate of machinery	0.0278			
	(0.0188)			
Wage rate* Price of fertilizer	0.0166			
	(0.106)			
Wage rate* Price of manure	0.102			
	(0.0712)			
Rental rate of machinery * Price of fertilizer	0.0333			
	(0.0472)			
Rental rate of machinery * Price of manure	-0.000550			
	(0.0380)			
Price of fertilizer * Price of manure	0.0968			
	(0.177)			
Constant	3.734***	-0.315**	-0.250	-0.914***
	(0.462)	(0.144)	(0.223)	(0.185)
Observations	791	791	791	791

Note: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Translog Profit Function Using Iterative Seemingly Unrelated Technique (West)

VARIABLES	Profit	Share of Labour	Share of Machinery	Share of Fertilizer
Price of output	1.511***			
	(0.184)			
Wage rate	1.320***	0.0758***	-0.0101	0.0117
	(0.531)	(0.0174)	(0.00884)	(0.0158)
Price of fertilizer	2.152***	0.0117	0.0129	-0.585***
	(0.296)	(0.0158)	(0.00899)	(0.0280)
Rental rate of machinery used	0.0639	-0.0101	0.0182	0.0129
	(0.124)	(0.00884)	(0.0118)	(0.00899)
Price of manure	0.601	-0.0774**	-0.0210	0.561***
	(0.605)	(0.0312)	(0.0253)	(0.0372)
Household size	0.392**	-0.717***	-0.667***	-0.527***
	(0.194)	(0.0735)	(0.0959)	(0.0729)
Primary	-0.00603	-0.204**	0.00117	-0.0237
	(0.251)	(0.0971)	(0.127)	(0.0959)
Secondary	0.194	-0.0988	0.301**	0.00108
	(0.242)	(0.0927)	(0.121)	(0.0916)
Higher Secondary	0.879**	0.205	0.437**	0.156
	(0.403)	(0.156)	(0.203)	(0.154)
Undergraduate/Graduate	-0.305	0.346	0.693**	0.127
	(0.551)	(0.212)	(0.277)	(0.210)
Post Graduate	-0.223	0.729**	0.987**	0.617*
	(0.906)	(0.349)	(0.456)	(0.345)
Price of output^2	-0.0375			
	(0.0311)			
Wage rate^2	-0.0137			
	(0.191)			
Rental rate of machinery used^2	0.00799			
	(0.0151)			
Price of fertilizer^2	0.0209			
	(0.0746)			
Price of manure^2	-0.0287			
	(0.0913)			
Price of output * Wage rate	-0.0694			
	(0.0680)			
Price of output * Price of fertilizer	-0.790***			
	(0.0997)			
Price of output * Rental rate of machinery	-0.0334			
	(0.0238)			
Price of output * Price of manure	-0.00344			
	(0.153)			

(contd… Table 5)

VARIABLES	Profit	Share of Labour	Share of Machinery	Share of Fertilizer
Wage rate * Rental rate of machinery	-0.0262*			
	(0.0158)			
Wage rate* Price of fertilizer	0.0527			
	(0.0980)			
Wage rate* Price of manure	-0.116			
	(0.106)			
Rental rate of machinery * Price of fertilizer	0.000168			
	(0.0366)			
Rental rate of machinery * Price of manure	0.0160			
	(0.0355)			
Price of fertilizer * Price of manure	-0.312			
	(0.224)			
Constant	5.065***	-0.426***	-0.765***	-0.666***
	(0.371)	(0.128)	(0.166)	(0.127)
Observations	1,388	1,388	1,388	1,388

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 6: Translog Profit Function Using Iterative Seemingly Unrelated Technique (South)

VARIABLES	Profit	Share of Labour	Share of Machinery	Share of Fertilizer
Price of output	1.584***			
	(0.156)			
Wage rate	1.185***	0.0366***	-0.0129	-0.0129
	(0.357)	(0.0117)	(0.00795)	(0.0120)
Price of fertilizer	0.909***	-0.0129	0.0361***	-0.452***
	(0.208)	(0.0120)	(0.0100)	(0.0213)
Rental rate of machinery used	0.440***	-0.0129	0.0224**	0.0361***
	(0.149)	(0.00795)	(0.0113)	(0.0100)
Price of manure	0.454	0.0624***	-0.0455**	0.429***
	(0.321)	(0.0233)	(0.0230)	(0.0312)
Household size	0.203	-0.431***	-0.244***	-0.368***
	(0.216)	(0.0596)	(0.0762)	(0.0727)
Primary	-0.349	0.0504	0.136	0.0394
	(0.294)	(0.0811)	(0.104)	(0.0989)
Secondary	0.0525	0.0698	-0.0870	0.0211
	(0.256)	(0.0701)	(0.0887)	(0.0851)
Higher Secondary	1.045**	-0.196	-0.595***	-0.426***
	(0.447)	(0.125)	(0.159)	(0.152)

(contd… Table 6)

VARIABLES	Profit	Share of Labour	Share of Machinery	Share of Fertilizer
Undergraduate/Graduate	0.748	-0.194	-0.131	-0.0727
	(0.508)	(0.142)	(0.180)	(0.172)
Post Graduate	-1.409*	-0.0243	-0.264	0.0533
	(0.849)	(0.238)	(0.304)	(0.290)
Price of output^2	-0.0966***			
	(0.0305)			
Wage rate^2	-0.271***			
	(0.0827)			
Rental rate of machinery used^2	-0.00422			
	(0.0185)			
Price of fertilizer^2	0.0821			
	(0.0500)			
Price of manure^2	0.0495			
	(0.0781)			
Price of output * Wage rate	0.0443			
	(0.0386)			
Price of output * Price of fertilizer	-0.354***			
	(0.0609)			
Price of output * Rental rate of machinery	-0.0738***			
	(0.0217)			
Price of output * Price of manure	-0.178**			
	(0.0810)			
Wage rate * Rental rate of machinery	-0.0349**			
	(0.0158)			
Wage rate* Price of fertilizer	-0.0584			
	(0.0525)			
Wage rate* Price of manure	-0.0733			
	(0.0685)			
Rental rate of machinery * Price of fertilizer	-0.0483			
	(0.0330)			
Rental rate of machinery * Price of manure	-0.0274			
	(0.0372)			
Price of fertilizer * Price of manure	-0.0354			
	(0.146)			
Constant	4.013***	-0.0687	-0.338***	-0.429***
	(0.386)	(0.102)	(0.127)	(0.123)
Observations	1,671	1,671	1,671	1,671

Note: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1, * p<0.1.

CONCLUSION AND POLICY IMPLICATIONS

This study analyzed some aspects of agricultural production in India through an estimated normalized restricted profit function. Empirical findings put forward the issue that agricultural productivity, input demand functions, input price elasticity vary across regions. Our detailed empirical estimation reveals that the farmer is more sensitive to input prices across regions. It is may be because of existing regional disparity in the distribution of institutional credit to the farmers and the distribution of subsidised fertilizer and other inputs as well. Fertiliser price has significant impact on agricultural profit and other input demands too. In eastern region of India output price is the main determinant of farm's profit function whereas, in northern region, labour demand function becomes highly elastic. In southern region, capital prices and price of manure are the two main determining factors in input demand function. Moreover, the role of education in making agricultural productivity has been captured explicitly. Result shows that level education expedites use of technology in agriculture. However, it didn't bring significant results at the time of disaggregated analysis. Another interesting fact came out from analysis positive and significant correlation between the household size and profit on one hand and negative significant relation between the household size and labour which indicates that the high labour demand by the small household is likely to impact upon the profitability thereby suggesting for adoption of mechanised inputs. The cross-price elasticities for input indicated imperfect complementary relationships among the inputs. By and large, we found degree of substitutability among inputs varies across regions. The disparity arises derived, partly, from the character of technological change which is function of the mechanism of surplus capital germination and partly, from regional differences in resources allocation, physical and institutional infrastructure. Therefore it can be claimed that if we put stress on demand based distribution of subsidised inputs it can uniformly make high agricultural growth across regions.

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