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Abstract

The main objective of this paper is to estimate the technical, economic and allocative efficiency of Indian agricultural farmers in both cross section and panel year of 1982, 1999 and 2007 using production and cost frontier model. We have estimated this for the crops level such as paddy, wheat, serials, pulses, oil seeds and other crops by appropriate season and for all across crops. We identify the factors affecting the production efficiencies. Here we try to identify the important factors such as household characteristics such as age and education level of the households, land characteristics such as land reforms, land size, land fragmentation and share of modern area to total village area, infrastructure variables such as distance to pucca road and wholesale market, proportion of irrigated area covered by canals, tanks and wells, the government agricultural prices to market prices, the government agriculture extension services, rainfalls, the governance variables such as participation of gram sabha meetings, agricultural expenditure by local government and women reservations. These factors may suggest to identify the policy and investment priorities that will accelerate sustainable agricultural productivity and efficiencies.

Key words: Production function, cost function, technical and allocative efficiency, India

JEL classification code: C33, D20

[#] The findings, interpretations and conclusions expressed here are those of the authors and do not necessarily reflect the views of NCAER or its Governing Body.

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I. Introduction

Over the past decade and a half, the Indian economy has started to grow very rapidly. Despite increases in public and private investment in agriculture, the accelerating economy-wide growth has not resulted in an acceleration of agricultural output growth, which remains below three percent per annum. In Binswanger-Mkhize and d'Souza (2012), they showed that over the past 20 years, economic growth has been driving a rapid decline in the share of agriculture in GDP that is now less than 15 percent, but the share of labor in agriculture has declined much more slowly, with a widening gap between the two. Despite the rapid growth in the productivity differential between the nonagricultural economy and the agricultural sector, consumption levels in the rural economy have not declined sharply relative to urban consumption and the poverty differential has narrowed a bit. The question pursued in this paper is why the farm economy has not responded to the demand side forces that have been unleashed on it from the rapid economy-wide growth, and what policy changes could bring about an acceleration of growth. Have farmers grown their product efficiently with available technologies. We will examine how farm output, farm inputs, farm cost and input prices have responded to changes in prices of outputs, wages, factor prices, technical change, public investments, public infrastructure and local public expenditures.

The main objectives of this paper is to estimate the technical, economic and allocative efficiency of Indian agricultural farmers in both cross section and panel year of 1982, 1999 and 2007 using production and cost frontier model. We have estimated this for the crops level such as paddy, wheat, serials, pulses, oil seeds and other crops by appropriate season and for all across crops. We identify the factors affecting the production efficiencies. Here we try to identify the important factors such as household characteristics such as age and education level of the households, land characteristics such as land reforms, land size, land fragmentation and share of modern area to total village area, infrastructure variables such as distance to pucca road and wholesale market, proportion of irrigated area covered by canals, tanks and wells, the government agricultural prices to market prices, the government agriculture extension services, rainfalls, the governance variables such as participation of gram sabha meetings, agricultural expenditure by local government and women reservations. These factors may suggest identifying

the policy and investment priorities that will accelerate sustainable agricultural productivity and efficiencies.

This paper is organized in five sections. Section II describes NCAER ARIS/REDS the data base. Section III explains the methodology and section IV presents the empirical results. Section V concludes and provides implications for policy.

II. Data

We use the last three rounds (1982, 1999 and 2007)[1] of the NCAER ARIS and Rural Economic and Demographic (REDS) surveys that form a village and household data base providing consistent information on 242 villages spread across 16 states in India. The first round of the survey for which complete village and household information is available is the 1971 round of the Additional Rural Incomes Survey (ARIS), which includes 4527 households in 259 villages which was meant to be representative of the entire rural population of India residing in 17 major states. The original sampling frame was a stratified design that included the following:

(i) One district in each state that was part of the Intensive Agricultural District Programme (IADP), an extension and input provision programme placed in areas thought to have high potential for crop productivity growth.

(ii) One district from each state that was covered by the Intensive Agricultural Area Programme (IAAP).

(iii) A random sample of other districts. There are 100 districts represented in the 1971 ARIS.

In 1982, 250 of the original 259 villages were revisited (the state of Assam was excluded due to local political disturbances rendering survey activity impossible) and 4979 household surveyed, approximately two-thirds of which were the same as in 1971. In 1999, all of the 1971 villages were surveyed, but excluding the 8 sample villages from Jammu and Kashmir (again owing to problems of local insurgency). In this survey round, all of the surviving households in the 1982

[1] The data collection for the last round of the REDS survey started in 2006, which is why it is normally referred to as the 2006 round. However, for most states the household schedule that contains the agricultural data was collected in 2007, with the exception of Kerala, where it was collected in 2008.

survey were surveyed again, including in this round all split-off households residing in the same village, plus a small random sample of new households. Because of household division and the new sample design incorporating all village-resident male 1982 household surveyed household members, the number of households in the 1999 round increased to 7474. The current round of 2006 (agricultural seasons 2006-2009) has a sample size of 8659 households from 242 villages and it includes all of the households surveyed in 1999 and the split-off households residing within these villages. Each village has approximately 8 new randomly selected households. The panel date set encompassing 1999 and 2007 rounds of the survey includes 5885 households.

Each round of the survey has three components. A listing of the village households is first done and it broadly locates, identifies and collects information on household head, split offs, out migration etc. Households in the listing sheets of each successive round can be traced across rounds. The current round of the listing schedule, however is a census of these villages and has comprehensive information on Jatis, social networks, detailed incomes, occupation, participation in governance etc. The second component is the village (community questionnaire) that has detailed information on village characteristics, economy, prices and wages, employment, history of the village etc. A special feature of the 2007 data round is the addition of very detailed data on village governance, investment programs, and village finances. This information was canvassed from a range of sources from both within and outside of the village. The third component is the household questionnaire. In the current round, the listing and the village questionnaires were administered in 2006 while the household questionnaires were canvassed in over three agricultural years (most of the households surveyed in the agricultural year 2007-2008)

There have been two features of the current survey. First, the households were surveyed at the end of each cropping season. This is particularly relevant for cultivating households as the reporting of both inputs and outputs become more reflective of the season just passed. Second, the cost of cultivation is collected at the level of fragments rather than at the level of a crop. A fragment is a unit of cultivation. All outputs and inputs are collected at the level of fragments. The data have been collected at the level of fragments as they represent the unit of cultivation.
In all the tables reported below we use real prices, rather than nominal prices. We used the state level consumer price indices for rural agricultural labor. Since the survey was rolled out over more than two years, we matched the survey period in each state with the average of the respective months of the CPI for rural agricultural workers.

The data for the 1982, 1999 and 2007 rounds are summarized in table 1.1 and 1.2. We used the consumer price index to convert all values and prices in real term. We inflated 1982 values and deflated 2007 values using 1999 as a base period. In 1982 crop value per acre was about Rs.3700 which has increased more than double in 1999. However, it increased by 22% in 2007 which can be attributed to the high base effect of 1999. The data shows that the agricultural production has increased over the periods. The proportion of irrigated land has increased by 17 percentages from 1982 to 1999 but by only 8 percentages increased from 1999 to 2007. Further, the value of seed per acre has increased sharply from 1982 to 1999. The increase was almost 5 times. Even from 1999 to 2007 the rise was about 40 percent, though relatively small but still significant. Value of fertilizer and manure per acre while jumped from Rs. 385 to Rs. 942 from 1982 to 1999, it has since fallen to Rs. 713 in 2007. This perhaps reflects less demand for fertilizers and manures. Similar trend is seen in terms of proportion of manure to total value of fertilizer. This in 1982 was only 6 percentages and increased to 25 in 1999 and then decreasing to 16 percent in 2007. Value of pesticides per acre has increased from Rs. 36 in 1982 to 152 in 1999 and increased modestly in 2007 to Rs. 185. Labor cost in 1982 was at a low of Rs. 381 which has climbed to Rs. 1941 in 1999 and steadily moved towards 2225 in 2007. Hired labor per acre was Rs. 363 in 1982 which rose to Rs. 480 in 1999 and again declining to Rs. 322. Hired labor ratio to total labor was about 0.58 in 1999 but it has been declining from 1999 to 2007. Fixed cost per acre was only Rs. 1100 in 1982 and Rs. 15000 in 1999. It has increased to Rs. 43000 in 2007 reflecting the increased fixed cost component in farming. This seems that Indian agriculture is shifting to machinery though Indian agriculture is more labor intensive. Value of bullock cost has risen to Rs. 277 from a mere Rs. 27 in 1982. This suggests that still some farmers are using the traditional method of cultivation. This presumes that most of poor farmers are adopting the traditional methods.

Total cost has been rising but at a slower rate. In 1982 it was Rs. 3173 while in 1999 it rose to Rs. 3501 and in 2007 it rose only by 2 percent. Prices of seeds have increased by about 33 percent from 1999 to 2007. Total cost per acre has been steadily declining from 1982 to 2007, reflecting efficiency in production. Prices of fertilizers have fallen from Rs. 8.6 in 1999 to Rs. 6.7 in 2007. Both rental values of mechanical equipments' as well as for irrigation equipments have risen by about 160 percent from 1999 to 2007. The proportion of famers having expenses on irrigation has increases somewhat, as has the average expenditure on irrigation. The rising

machine hire cost is most likely the consequence of the continued shift from using draft animals and labor to hiring tractors and other machines. Wages have been raising steady from just Rs. 17 in 1982 to Rs. 25 in 1999 and to Rs. 35 in 2007. Share of family cost has fallen from 10% to 3% from 1999 to 2007.

Average age of household head has remain stable for all the periods while mean year of education has risen from a low of 2.2 in 1982 to 4.74 in 2007. Land holding in acres shows that it has declined over three periods; first it is falling from 6.39 to 5.61 and then falling to 4.47 in 2007. This is due to more splits in the rural households. Numbers of household and village shocks have raised over the periods, while gram sabha meeting held have increased to 1.62 in 2007.

Land registration has taken place 83 percent in the REDS villages. Mean distance to wholesale market rose by about 27 percent. Proportion of government canals irrigated has increased in 1999 to 68 percent and in 2007 they rose to 69 percent. The proportion of other stream water has increased 12 percent in 1982 to 32 percent in 1999 and it again decline by 1 percent in 2007. Proportions of tanks irrigated were 23 percent in 1982 and it increased to 44 percent in 1999 and rose marginally to 48 percent. It is interesting see that the proportions of wells irrigated area have increased sharply. This trend shows that in 1982 it was 19 percent then it increased 44 percent in 1999 which is more than double and it has increased 64 percent in 2007. Proportions of high yielding varieties (HYV) area have increased to 71 percent. This data shows that the irrigated area from different sources and high yielding verities (HYV) area has increased over the periods which is very good sign for Indian agriculture. Proportion of agriculture expenditure has stagnated in 2007 when compared to 1999 while it rose sharply to 5 percent in 1999 when compared to 1982. In 1999 women reservation was at 25 percent which rose to 29 percent in 2006.

III. Methodology

The measurement of economic efficiency has been closely associated with frontier functions. There are huge literature on these concepts namely Farrell (1957), Michael J. Farrell, greatly

influenced by Koopmans (1951)'s formal definition and Debreu (1951)'s measure of technical efficiency introduced a method to decompose the overall efficiency of a production unit into its technical and allocative components. Farrell proposed that the efficiency of a firm consisted of three components: technical, allocative and economic efficiencies. Technical efficiency is defined as the ability to produce a given level of output with a minimum quantity inputs under certain technology. Allocative efficiency refers to the ability to choose optimum input levels for given factor prices. Economic or total efficiency is the product of technical and allocative efficiencies. An economically efficient input-output combination would be on both the frontier function and the expansion path. Early studies focused primarily on technical efficiency using a deterministic production function with parameters computed using mathematical programming techniques. However, with inadequate characteristics of the assumed error term, this approach has an inherent limitation on the statistical inference on the parameters and resulting efficiency. Aigner (1992) and Meeusan, and Van den Broeck (1997) independently developed the stochastic frontier production function to overcome this deficiency.

The stochastic frontier production function for the panel data for estimating farm level technical efficiency is specified as:

$$Y_{it} = f(X_{it};\beta) + \varepsilon_{it} \quad \text{i=1,2,…n and t=1,2,..T} \qquad (1)$$

Where i is the nth observations and t id Tth time periods. Y_{it} is output, X_{it} denotes the actual input vector, β is vector of production function and ε is the error term that is composed of two elements, that is

$$\varepsilon = V_{it} - U_{it} \qquad (2)$$

Where V_{it} is the symmetric disturbances assumed to be identically, independently and normally distributed as N $(0,\sigma_{vt}^2)$ given the stochastic structure of the frontier. The second component U_{it} is a one sided error term that is independent of V_{it} and is normally distributed as $(0,\sigma_{ut}^2)$, allowing the actual production to short fall below the frontier but without attributing all short falls in output from the frontier as inefficiency.

The firm-specific technical efficiency is defined in terms of observed output (Y_{it}) to the corresponding frontier output ($\overset{*}{Y}_{it}$) using the available technology derived which is defined as follows:

$$TE_{it} = \frac{Y_{it}}{\overset{*}{Y}_{it}} = \frac{E(Y_{it} \mid u_{it}, X_{it})}{E(Y_{it} \mid u_{it} = 0, X_{it})} = E[\exp(-U_{it}) / \varepsilon_{it}] \quad (3)$$

TE takes values within the interval (0,1), where 1 indicates a fully efficient firm.

The stochastic frontier cost functions model for estimating firm level overall economic efficiency is specified as:

$$C_{it} = g(Y_{it}; P_{it}, \alpha) + \varepsilon_{it} \quad \text{i=1,2,…n and t=1,2,..T} \qquad (4)$$

Where C_{it} represents total production cost, Y_{it} represents output produced, P_{it} represent cost of input, α, represents the parameters of the cost function and the error term composed of two elements, that is:

$$\varepsilon = V_{it} + U_{it}$$

Here V_{it} and U_{it} are as defined earlier. However because inefficiencies are assumed to always increase costs, error components have positive signs.

The firm specific economic efficiency (EE) is defined as the ratio of minimum observed total production cost (C*) to actual total production cost C which is defined as follows:

$$EE_{it} = \frac{C_{it}}{\overset{*}{C}_{it}} = \frac{E(C_{it} \mid u_{it}, Y_{it}, P_{it})}{E(C_{it} \mid u_{it} = 0, Y_{it}, P_{it})} = E[\exp(-U_{it}) / \varepsilon_{it}] \qquad (5)$$

Here EE takes values between 0 and 1.

Hence a measure of firm specific allocation efficiency (AE) is thus obtained from technical and economic efficiencies estimated as:

$$AE = EE/TE \qquad (6)$$

This means that $0 \leq AE \leq 1$

The Cobb-Douglas production and cost function are employed to model production technology in this study. Here, we have used STATA.11 for the analysis. It is noted that this computer program estimates the cost efficiency (CE), which is computed originally as the inverse of the equation 5. Hence, firm-level economic efficiency (EE) was obtained using the relationship:

EE=1/Cost efficiency (CE) (7)

This is the inverse of CE.

Determinants of technical efficiency and allocative efficiency

The literature suggests that two important methods of analyzing the sources of technical efficiency based on stochastic production functions. The first approach is the two-stage estimation procedure in which first the stochastic production function is estimated, from which efficiency scores are derived, then in the second stage the derived efficiency scores are regressed on explanatory variables using ordinary least square methods or tobit regression. This approach has been criticized on grounds that the household's knowledge of its level of technical inefficiency affects its input choices. Therefore inefficiency may be dependent of the explanatory variables. The second approach estimates the one stage simultaneous estimation approach as in Battese and Coelli (1995), in which the inefficiency effects are expressed as an explicit function of a vector of household-specific variables. The technical inefficiency effects are defined as

$$U_{it} = Z_{it}\delta \quad (8)$$

Where z is a vector of observable explanatory variables and δ is a vector of unknown parameters. Thus, the parameters of the frontier production function are simultaneously estimated with those of an inefficiency model, in which the technical inefficiency effects are specified as a function of other variables. The one stage simultaneous approach is also implemented in Stata-11 and in addition to the basic parameters the program also provides coefficients for the technical inefficiency model. In the Stata-11, we would not able to estimate the cost function and cost inefficiency simultaneously. This is the limitation of the Stata-11 to estimate the inefficiency from the cost function. That's why we first estimated the allocative efficiency from the cost function and then in the second stage we estimated the determinants of

the allocative efficiency. Several factors including socio-economic and demographic factors, plot-level characteristics, shocks variables, village characteristics and governance factors are likely to affect the efficiency of the farmers.

IV. Results

Production function

We estimated Cobb Douglas production function for entire sample households and panel households in table 2.1, 3.1, 4.1, 5.1 and 6.1. We estimate these for each crop such as paddy, wheat, cereals, pulses, oil seeds and other crops by appropriate season as well as for household level. The results have shown that there is an inverse relationship between cropped area and output. The proportion of irrigated area have positively related with crop output. This attributes that to higher yields on larger irrigated cropped area of the households. All the inputs except bullocks used in the production led to increase the output of each crops. The seed input is important factor in a production process and it increases the output. The fertilizers compare to manures have more significant contributor to output. The uses of pesticide increase the production of the output. The results show that the hired labor is the important factor in a production. The coefficients of the hired labor are a larger compared to other inputs. The family labor has less productive than the hired labor though both have positive impact on production. The fixed cost such as value of mechanical assets, non-mechanical assets and other assets have increased 1 to 2 percent of the output. Nonetheless, the output elasticities at the means show positive response of output to changes in inputs and with all having positive values. Overall the results have shown that the coefficients of the labor inputs are larger than other inputs and here we conclude that mostly Indian agriculture depend upon the labor supply. The agricultural production increases in north and west compared to the south and east.

Technical Efficiency Analysis

The results show that the technical efficiency of paddy is 72 percent, wheat is 71.4 percent and the technical efficiency of cereals, pulses, oil seeds and other crops varies from 60 to 66 percent for whole sample households in 2007. The average technical efficiency at the household level is 77 percent. The technical efficiency of paddy and wheat is 76.9 percent and 73.5 percent

respectively in 1999. The technical efficiency of the households across all the crops is 78.4 percent. These results suggest that the technical efficiency is falling compared to 1999. These trends are same for cereals, pulses, oil seeds and other crops. The technical efficiency of entire sample households in 1982 shows lower than the 1999 and 2007. This seems that the technical efficiency has increased in 1999 and 2007 compared to 1982. The technical efficiency of panel 1999-2007 households for paddy and wheat is 75.5 percent and 77.2 percent and the technical efficiency of panel 1982-1999-2007 households for paddy and wheat is 73.5 percent and 74.7 percent respectively. This results show that on an average the panel households are more technical efficient than whole sample households and the technical efficiency has been increased over time for panel households.

Cost function

We estimated the cost function for 1999 and 2007 in table 7.1, 8.1 and 9.1. Here it is worthwhile that the production units should maintain the level of input utilization at this stage as this will ensure maximum output from a given level of input ceteris paribus. The result reveals that the factor prices (agricultural wage rate, price of seeds, price of fertilizer, rental rate of irrigation and rental rate of hired machinery) are positively related with the cost of production. Here we can say that as the factor prices increased, total production cost increased ceteris paribus. The coefficient of quantity of output per acre is positive and significant and it leads to increase the cost of production. The coefficient of wage is a larger than other input prices. It seems that the agriculture wage rate is increasing over time. We already found that the labor supply is the main contributor to the production. These results suggest that the labor cost increases more the cost of production and these lead to increase of the price of production.

Economic and Allocative Efficiency Analysis

Economic efficiency takes on to increase output without using more conventional inputs. The use of existing technologies is more cost-effective than applying new technologies if farmers cultivate their products with the existing technology inefficiently (Belbase and Grabowski, 1985; Shapiro, 1977). Allocative efficiency tries to capture farmer's ability to apply the inputs in optimal proportions with respective prices (Farrell 1957; Coelli et al. 2005). The economic efficiency analysis has shown that there was presence of cost inefficiency effects in the

production. The predicted economic efficiencies estimated as inverse of cost of efficiencies. We estimated allocative efficiency dividing the economic efficiency by technical efficiency. The results show that the economic and allocative efficiencies of paddy farmers are more than the wheat farmers in both the particular years 1999 and 2007. The panel households in 1999-2007 have almost equal economic and allocative efficiencies for paddy and wheat farmers. The economic efficiency of pulse farmers is 67.3 per cent and allocative efficiency is 96.6 percent in the panel year which are higher than entire sample households. The economic efficiency at the household level is 16.8 percent and allocative efficiency is 21.9 percent in 2007 and the economic and allocative efficiency is 18.2 percent and 23.3 percent in 1999 respectively. The results suggest that on an average the households are inefficient to use factor inputs with respective prices across all the crops. The panel 1999-2007 households are more economic and technical efficient than the entire sample households. The results clearly show that mostly the panel households are agricultural households they have better ability to achieve the maximum output with given and obtainable technology and also they use the inputs optimally.

Factors affecting technical efficiency and allocative efficiency

The results of determinants of technical efficiency are presented in the second stage of the production function estimations. Here we estimated the technical inefficiency and its determinants simultaneously using production frontier model in table 2.2, 3.2, 4.2, 5.2 and 6.2. The results of factors affecting to allocative efficiency are given in the second stage of the cost function. In table 7.2, 8.2 and 9.2, we estimated the allocative efficiency using cost function and then run a regression of determinants on allocative efficiency.

The household characteristic of the agricultural household is one of the important factors affecting the technical and allocative efficiency. The results show that the aged head of household is more efficient and produce the output efficiently. This ensures that aged households have more experience and using their past learning in the production process to produce more output with given level of inputs efficiently. They are both technical and allocative efficient. The average education of household is negative and significant with technical inefficiency in most of the regressions and it is a necessarily element of technically efficient increases for farmers. We

find that overall education does not have any significant impact on allocative efficiency. Only in 1999, education has positive impact on allocative efficiency for wheat farmers.

The larger farmers are more technical efficient. Also the larger proportion of fragmentation of a household increased the technical efficiency. This result is significant and consistent in all panel years. Farm size has negative impact in 2006, positive impact in 1999 and negative impact in both panel years on allocative efficiency. This reveals that large farmers are producing more output and they are inefficient to use the input optimally. The results have shown that if the proportion of high yielding verities area of a village increases then it tends to increase the technical efficiency of farmers in that village and this does not increase the allocative efficiency of the farmers. The estimation of land reforms with technical efficiency shows mixed results. This shows that paddy, cereals and pulse farmers are inefficient and they are technically efficient at the aggregate crop level. In general, these results suggest that the land reforms on registration take place for each household and this is a important factors to estimate technical efficient model at the aggregate level and not at crop level. The land registration increases the allocative efficiency of farmers. These results reveal that the reforms on land registration make the farmer independent and secure and it enhances to produce the output efficiently. It also suggests that the policy on land registration can be targeted to all the farmers.

The coefficient of proportion of family supervision to total labor cost is positively significant for wheat and pulse farmers in 2007, negatively significant for paddy and wheat farmers in 1999 and positively significant for pulse farmers in the panel households. This is negative and significant at the aggregate level in both cross sections and panel years. This ensures that the family supervision is technically inefficient at the crop level and technical efficient at the aggregate household level. Also the family supervision ensures the positive impact on allocative efficiency. Overall the family supervisions have greater role on production process.

The village and household shocks have mixed impact on technical efficiency. These show that village shocks adversely affect the technical efficiency for the panel households. Both the shocks variables reduce the allocative efficiency. Overall shocks have negative impact on farm production and these results suggest that the government should take preventive measures for farmers to overcome during distress events. The results also show that if the paddy farmers sell their output to government then their technical and allocative efficiency increase. This is

insignificant for other crop farmers. This result suggests that paddy farmers are getting better prices from government.

We find that the distance to pucca road, wholesale market and town from villages influences the production. This seems location matters. The results show that overall from all the regression models both technical and allocative efficiency have declined if household situated in remote area. The agriculture extension workers activities (AES) such as demonstration, film, exhibition and lecture about the agriculture production have significantly increased the farm efficiencies. This reveals the local government should undertake more AES activities in villages related to agriculture.

The most important factor on production is the different irrigation sources. We have taken the proportion of area irrigated by government canal, tanks, tank waters and open well water. We find that all the sources have made significant contribution to agricultural production and the technical and allocative efficiency have increased. The irrigation sources by tank and well have more influence the efficiencies than the government canal and the irrigated by tank waters show as most important factor in production to increase efficiencies of the farmers. We also find that more rainfall declined both the technical and allocative efficiencies.

The expenditure on agricultural programs by government shows mixed results in technical efficiency regression model. The paddy farmers are more benefited and their technical efficiency has increased in 2007. Similarly the pulses farmers have benefitted in 1999. Surprisingly the technical efficiency has increased in 1982 if government spent more in agricultural programs. The government agricultural expenditure increased the allocative efficiency and it is very strong results in the entire regression model. These results reveal that the government should increase the agricultural expenditure to push up the farmers to increase their efficiencies. The results from panel households of gram sabha meeting held related to agriculture by panchayat have influenced the technical efficiency and, the allocative efficiency has increased at the household level. This results hint that the participants in gram sabha meetings are distorted to discuss about agricultural issues. We find that the women headed panchayats are doing better and the technical efficiency of these villages has increased over the periods and, the allocative efficiency has increased for wheat and oil seed farmers in 1999. Overall we find that women headed villages are more technical efficient than allocative efficiency.

V. Conclusion

This paper attempted to examine the technical, economic and allocative efficiency and identify their determinants. The results have found that an increased cropped area has decreased the output. The proportion of irrigated area increases the crop output. All the inputs except bullocks used in the production have positively related to the production. The results have shown that the coefficients of the labor inputs are larger than other inputs and this reveals that mostly Indian agriculture are labor intensive. The result reveals that the factor input prices (agricultural wage rate, price of seeds, price of fertilizer, rental rate of irrigation and rental rate of hired machinery) have increased the cost of production. The coefficient of quantity of output per acre is positively and significantly related to the cost of production. The coefficient of wage is a larger than other input prices. These results reveal that the labor cost increases more the cost of production.

These results find that on an average the panel households are more technical efficient than whole sample households and the technical efficiency has been increased over time for panel households. They are also more economic and allocative efficient. The results clearly suggest that mostly the panel households are agricultural households they have better ability to achieve the maximum output with given and obtainable technology and also they use the inputs optimally.

We found that aged households have more experienced and using their past knowledge in the production process to produce more output using optimal inputs efficiently. Education is a necessarily element of technically efficient increases for farmers. The larger farmers are doing significantly better off. The land reform on registration takes place at household level and this is an important factor to estimate technical efficient model at the aggregate level. The land registration has positively leaded to increase the allocative efficiency. The village and household level shocks decline the allocative efficiency. The remoteness of villages from town and wholesale market declines the technical and allocative efficiency. The tank irrigation is an important factor to increase the efficiencies of the agricultural farmers. The number of activities

by agricultural extension services led to have better off the technical and allocative efficient of farmers. The more rainfall seems to afford the worse off to the farmer's productivity. The local expenditure on agricultural programs increases the efficiency of the farmers. The results find that the gram sabha meeting does not help to agricultural farmers. The women reserved panchayats have positive impact on technical efficiency and negative impact on allocative efficiency.

References

Aigner, D.J, C.A.K Lovell and P. Schmidt (1992). Formulation and Estimation of stochastic frontier production models. Journal of Econometrics, 6:21-32.

Battese, G.E. and Coelli, T. (1995) A Model of Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data, Empirical Economics, 20, 325-332.

Belbase,K. and Grabowski, R. (1985). Technical efficiency in Nepalese agriculture. The Journal of Developing Areas, Vol.19, No. 4, 515-525.

Debreu, G. (1951). The Coefficient of Resource Utilization. Econometrica. 19(3): 273-292.

Coelli,T.D.S.R. and George E.B. (2005). An introduction to efficiency and productivity analysis, Springer Science, New York.

Farrell, M.J. (1957). The Measurement of Productive Efficiency. Journal of the Royal Statistical Society (A, general). 120: 253–281.

Binswangerh-Mkhize, Hans P. and Alwin d'Souza, 2012, Structural Transformation of the Indian Economy and of its Agriculture: 1961-2010, in Binswanger-Mkhize, Hans P., Kirit Parikh, and Natasha Mukherjee, eds, The Long Term Future of Indian Agriculture and Rural Poverty Reduction, Washington DC, Centennial Group, Washington DC, forthcoming

Koopmans, T.C. (1951). An analysis of Production as Efficient Combination of Activities. In Activity Analysis of Production and Allocation, Koopmans, T.C., eds, Cowles Commission for Research in Economics, Monograph no. 13. New York.

Meeusen, W. and J. van den Broeck.(1997). Efficiency Estimation from Cobb-Douglas Production Functions with Composed Error. International Economic Review. Vol. 18. 435-444.

Shapiro, K.H. (1977), Sources of technical efficiency: the roles of modernization and information, Economic Development and Cultural Change, Vol.25, No 2-3, 293-310.

Table 1.1: Descriptive statistics

Variables	2006		1999		1982	
Output and inputs	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Crop value per acre	9587.01	25806.29	7893.93	12864.32	3698.12	3908.68
Cropped area	2.62	3.52	2.83	3.50	3.70	4.31
Proportion of irritated land	0.67	0.44	0.62	0.43	0.53	0.44
Value of seed per acre	605.03	1731.99	433.68	1114.12	86.84	260.17
Value of fertilizer and manure per acre	713.52	1406.95	942.17	2022.78	384.99	1412.99
Prop. Of manure to total value of fertilizer manure	0.16	0.31	0.25	0.29	0.06	0.20
Value of pesticides per acre	185.13	514.39	151.02	384.74	35.70	242.56
Value of total labor cost per acre	2225.76	8991.06	1054.37	1941.63	381.54	2492.52
Hired labor per acre	322.05	1545.46	173.21	480.95	363.33	2484.63
Hired labor ratio	0.16	0.20	0.18	0.22	0.58	0.48
Value of fixed cost per acre	42927.09	224858.40	15092.35	78068.68	1096.98	2823.74
Value of bullock cost per acre	277.14	1319.48	61.73	187.92	26.94	150.21
Total cost	3563.32	8609.95	3501.55	7876.37	3173.17	6973.09
Price of seeds	34.82	116.85	23.74	26.76		
Total cost per acre	821.81	8700.07	914.27	4221.27	979.24	3022.00
Price of fertilizer	6.71	25.52	8.67	31.67		
Price of pesticides	95.11	169.42				
Rental Value of Mechanical equipments	307.77	431.42	118.60	216.00		
Rental value of irrigation equipments	77.26	147.12	30.17	87.44		
Wage	34.55	10.78	24.72	11.72	17.05	7.33
Proportion of fragmented area	0.68	0.35				
Share of family cost (Supervision lab)	0.03	0.09	0.10	0.19		
Share of government sale	0.03	0.17				
Observations: 2006-12171; 1999-10793; 1982-5675						

Table 1.2: Descriptive statistics

Variables	2006		1999		1982	
Household characteristics						
	Mean	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
HH head age	51.62	12.99	50.18	15.12	51.06	13.71
Mean education of the HH	4.74	2.96	3.93	2.35	2.20	1.64
Variance education of the HH	14.08	12.30	7.62	8.84	8.77	10.60
Land	4.47	6.41	5.61	8.35	6.39	3.82
No. of household shocks	0.21	0.47	0.12	0.35		
no. of village shocks	0.45	0.72	0.23	0.58		
Gram sabha meeting held	1.62	4.54	1.21	3.05		
Dummy land registration	0.83	0.38				
Observations: 2006-4881, 1999-4496, 1982-3144						
Village characteristics						
No. of times AES activities	17.57	25.07	12.20	20.31	4.99	9.71
Distance to public extension worker	12.29	8.84				
Distance to private extension worker	2.89	26.68				
Proportion of government canals irrigated	0.371	0.256	0.684	0.300	0.693	0.300
Proportion of areas of stream water irrigated	0.115	0.189	0.321	0.295	0.306	0.277
Proportion of tanks irrigated	0.228	0.214	0.437	0.347	0.468	0.374
Proportion of wells irrigated	0.191	0.193	0.444	0.329	0.643	1.375
Prop. Of HYV area	0.71	0.28	0.62	0.31		
Proportion of agriculture expenditure	0.04	0.11	0.05	0.11	0.02	0.07
Women reservation	0.29	0.46	0.25	0.44		
Observations: 238						

Table 2.1: Production function (2006)

VARIABLES	Paddy	Wheat	Cereals	Pulses	Oil seeds	Other crops	HH level
	Ln(Value of crop per acre)						
Ln(Cropped area)	-0.0433***	-0.0646***	-0.0279	-0.0670***	-0.0323	-0.158***	-0.034***
	(0.0129)	(0.0154)	(0.0183)	(0.0250)	(0.0260)	(0.0213)	(0.00897)
Proportion of irrigated area	0.0949***	0.0106	0.128***	-0.0594	0.0400	-0.132**	0.128***
	(0.0260)	(0.0307)	(0.0326)	(0.0484)	(0.0539)	(0.0588)	(0.0197)
Ln(Value of seeds per acre)	-0.00194	0.00566*	0.0452***	0.00861	0.00264	0.00140	0.008***
	(0.00218)	(0.00309)	(0.00615)	(0.00567)	(0.00502)	(0.00261)	(0.00280)
Ln(Value of fertilizer and manure per acre)	0.0260***	0.00275	0.0170***	0.0110***	0.023***	0.0129***	0.028***
	(0.00466)	(0.00323)	(0.00254)	(0.00223)	(0.00312)	(0.00311)	(0.00318)
Prop. Of manure to total value of fertilizer and manure	-0.176***	0.0126	-0.114***	-0.0653	-0.0970	0.0854	-0.153***
	(0.0425)	(0.0471)	(0.0377)	(0.0565)	(0.0599)	(0.0680)	(0.0301)
Ln(Value of pesticides per acre)	0.0124***	0.0090***	0.00513***	0.0126***	-0.00317	0.0284***	0.010***
	(0.00129)	(0.000897)	(0.00152)	(0.00216)	(0.00214)	(0.00189)	(0.0009)
Ln(Value of total labor cost per acre)	0.140***	0.0844***	0.197***	0.0888***	0.149***	0.0883***	0.105***
	(0.0144)	(0.0139)	(0.0169)	(0.0202)	(0.0252)	(0.0184)	(0.00940)
Prop. Of hired labor	0.293***	0.192***	-0.0119	0.157	0.205**	0.414***	0.222***
	(0.0514)	(0.0486)	(0.0749)	(0.106)	(0.101)	(0.0807)	(0.0413)
Ln(Value of fixed cost per acre)	0.0146***	0.0199***	0.0116***	0.00862**	0.012***	0.0175***	0.015***
	(0.00206)	(0.00346)	(0.00362)	(0.00394)	(0.00445)	(0.00569)	(0.00175)
Ln(Value of bullock cost per acre)	-0.00249**	-0.0074***	-0.00741***	0.00155	0.00292	-0.00385*	8.59e-06
	(0.000996)	(0.00119)	(0.00165)	(0.00208)	(0.00226)	(0.00216)	(0.0008)
East[2]	-0.326***	0.0311	-0.0742	-0.169*	-0.218*	-0.573***	-0.409***
	(0.0359)	(0.0509)	(0.0980)	(0.0909)	(0.116)	(0.0919)	(0.0273)
South	-0.488***	-0.767***	0.0796	-0.102	-0.169**	0.00265	-0.490***
	(0.0414)	(0.0872)	(0.0541)	(0.0761)	(0.0819)	(0.0795)	(0.0314)
West	-0.112***	-0.0122	0.225***	0.290***	-0.00962	0.0717	-0.248***
	(0.0401)	(0.0329)	(0.0391)	(0.0723)	(0.0638)	(0.0665)	(0.0261)
Semi-Arid temperate[3]	-0.0222	-0.122***	-0.155***	0.329***	-0.00175	-0.684***	-0.203***
	(0.0358)	(0.0467)	(0.0561)	(0.0984)	(0.0803)	(0.0696)	(0.0285)
Semi-Arid tropic	0.0462*	-0.160***	0.0191	0.115	0.0521	-0.325***	0.108***
	(0.0243)	(0.0480)	(0.0441)	(0.0809)	(0.0696)	(0.0691)	(0.0200)
Arid	-0.129**	-0.0808	-0.270***	-0.551***	-0.151	-0.682***	-0.344***
	(0.0609)	(0.0597)	(0.0663)	(0.107)	(0.0937)	(0.0849)	(0.0361)
Constant	7.921***	8.713***	6.780***	7.840***	8.162***	9.295***	8.206***
	(0.109)	(0.112)	(0.130)	(0.168)	(0.195)	(0.160)	(0.0824)
Observations	2,615	2,184	2,205	1,280	1,010	2,344	4,868
Technical efficiency	0.720	0.714	0.658	0.622	0.598	0.631	0.768

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

[2] North is the base
[3] Humid is the base

2.2: Determinants of technical inefficiency (2006)

VARIABLES	Paddy	Wheat	Cereals	Pulses	Oils seeds	Other crops	HH level
HH head age	0.213	-0.0132	-0.782***	-0.850	-0.140	-0.895***	-0.0947
	(0.179)	(0.140)	(0.273)	(0.611)	(0.143)	(0.227)	(0.388)
Mean education of the HH	-0.0414	0.00907	-0.0366*	0.00300	0.0181	-0.0535**	0.000494
	(0.0254)	(0.0192)	(0.0221)	(0.0448)	(0.0167)	(0.0250)	(0.0219)
Variance education of the HH	0.298**	-0.115	-0.142	0.136	-0.0669	0.110	0.0261
	(0.124)	(0.0758)	(0.121)	(0.246)	(0.0680)	(0.0939)	(0.113)
Farm size (in acres)	-0.130***	-0.0501**	-0.0154	-0.329**	-0.099***	-0.174***	-0.0273
	(0.0383)	(0.0242)	(0.0437)	(0.159)	(0.0378)	(0.0567)	(0.0300)
Area of individual frag./total area of frag.	-2.267***	-0.804***	-0.370	-0.880	-0.999***	-1.259***	-10.20***
	(0.335)	(0.267)	(0.386)	(0.681)	(0.187)	(0.280)	(2.707)
Family supervision/labor cost	-0.462	4.940***	-0.130	85.15***	0.594	-1.071	-6.503**
	(1.905)	(1.636)	(1.435)	(23.85)	(0.703)	(1.324)	(2.599)
No. of HH shocks	-0.0417**	0.0124	-0.127***	-0.0277	-0.00488	0.0149	-0.0159
	(0.0188)	(0.0158)	(0.0378)	(0.0458)	(0.0137)	(0.0158)	(0.0215)
No. of village shocks	0.0174	0.00713	0.00848	-0.00717	0.0190**	-0.00860	0.0129
	(0.0111)	(0.00941)	(0.0152)	(0.0298)	(0.00840)	(0.0102)	(0.0131)
Dummy for land registration	1.348**	-0.171	1.461***	5.906**	0.121	2.956***	-0.571*
	(0.559)	(0.374)	(0.521)	(2.650)	(0.271)	(0.932)	(0.345)
Share of sale to govt. to total	-1.309*	-2.053	-119.0	5.720	0.598	-14.37	-244.1
	(0.734)	(1.401)	(8,459)	(719.9)	(0.525)	(66.16)	(12,634)
Distance to Pucca road	0.0396***	0.091***	0.051***	6.187***	0.0132	0.0205	0.234***
	(0.0135)	(0.0171)	(0.0192)	(1.735)	(0.00944)	(0.0125)	(0.0370)
Distance to wholesale Market	0.131***	0.0931**	0.435**	-0.973	0.00943	0.0735	0.0702
	(0.0354)	(0.0368)	(0.209)	(0.645)	(0.0586)	(0.0694)	(0.0457)
Distance to public worker related to AES	-0.150***	-0.126***	0.586**	-0.389**	0.188***	0.256**	-0.0900
	(0.0389)	(0.0418)	(0.234)	(0.170)	(0.0689)	(0.130)	(0.0563)
Distance to private worker related to AES	0.0650**	0.00395	-0.0866**	-0.150	-0.0340	-0.0706**	-0.567***
	(0.0258)	(0.0297)	(0.0395)	(0.235)	(0.0210)	(0.0327)	(0.170)
No. of times AES activities	-0.00816	-0.073***	-0.106***	-2.571***	-0.029***	0.0478***	-0.118***
	(0.0150)	(0.0144)	(0.0247)	(0.745)	(0.0101)	(0.0133)	(0.0197)
Proportion of gvt. canal irrigated	-0.412**	-0.555	-16.15***	35.06***	0.396*	-0.927**	-16.00***
	(0.204)	(0.570)	(4.816)	(10.26)	(0.240)	(0.376)	(4.847)
Proportion of tank irrigated	-20.50***	-12.01***	2.642***	-24.61***	0.0112	-1.799	0.747
	(7.099)	(4.151)	(0.901)	(8.440)	(0.437)	(1.444)	(0.987)
Proportion of well irrigated	5.390***	-1.282**	1.248	20.73**	-0.301	-0.489	0.432
	(1.855)	(0.606)	(0.983)	(8.511)	(0.284)	(0.556)	(0.854)
Prop. HYV area	-1.658***	-0.450	-0.742	-21.97***	-1.324***	0.327	0.00319
	(0.434)	(0.295)	(0.479)	(7.234)	(0.277)	(0.369)	(0.446)
Mean rainfall in Kharip	0.00274	-	0.069***	-3.596***	-0.0176	-0.0688***	-0.00300
	(0.0132)		(0.0231)	(1.079)	(0.0119)	(0.0152)	(0.0200)
Mean rainfall in Rabi	-	-7.00e-05	0.059***	0.619***	0.0243**	0.00686	0.0130
		(0.0104)	(0.0182)	(0.201)	(0.00964)	(0.0108)	(0.0152)
Proportion of agricultural expenditure	-24.40*	2.642***	10.17***	118.5***	0.733	-5.636**	4.253***
	(13.08)	(0.948)	(2.252)	(34.05)	(1.442)	(2.483)	(1.569)
No. GS meeting held	0.0576***	-0.0185	0.0472**	-0.0282	-0.039***	0.0146	-0.0274
	(0.0152)	(0.0153)	(0.0200)	(0.0684)	(0.0115)	(0.0134)	(0.0195)
Women reservation	-1.879***	-1.099***	-2.378***	-11.57***	-0.845***	-0.460**	-2.904***
	(0.408)	(0.353)	(0.412)	(3.871)	(0.177)	(0.204)	(0.660)
Observations	2615	2184	2205	1280	1010	2344	4848

Table 3.1: Production function (1999)

VARIABLES	Paddy	Wheat	Cereals	Pulses	Oil seeds	Other crops	HH level
	Ln(Value of crop per acre)						
Ln(Cropped area)	-0.00219	-0.0289**	-0.197***	-0.134***	-0.103***	0.00685	-0.065***
	(0.0133)	(0.0143)	(0.0214)	(0.0280)	(0.0260)	(0.0244)	(0.00802)
Proportion of irrigated area	0.132***	0.226***	0.160***	0.103**	0.124***	0.242***	0.186***
	(0.0234)	(0.0285)	(0.0350)	(0.0518)	(0.0403)	(0.0455)	(0.0166)
Ln(Value of seeds per acre)	0.192***	0.328***	0.144***	0.293***	0.217***	0.0942***	0.290***
	(0.0141)	(0.0187)	(0.0147)	(0.0217)	(0.0162)	(0.00856)	(0.00799)
Ln(Value of fertilizer and manure per acre)	0.0154***	0.012***	0.0181***	0.0076***	0.015***	0.0262***	0.0206***
	(0.00435)	(0.00482)	(0.00363)	(0.00242)	(0.00334)	(0.00397)	(0.00339)
Prop. Of manure to total value of fertilizer and manure	-0.0509	-0.239***	-0.0638	-0.180***	-0.0114	-0.222***	-0.0469
	(0.0442)	(0.0563)	(0.0450)	(0.0494)	(0.0539)	(0.0648)	(0.0316)
Ln(Value of pesticides per acre)	0.00755***	0.003***	-0.00120	0.00530**	0.007***	0.0071***	0.009***
	(0.00105)	(0.00107)	(0.00155)	(0.00215)	(0.00167)	(0.00193)	(0.00078)
Ln(Value of total labor cost per acre)	0.0649***	0.058***	-0.0253	0.0597**	0.0481**	0.228***	0.0686***
	(0.0119)	(0.0123)	(0.0184)	(0.0242)	(0.0204)	(0.0227)	(0.00869)
Prop. Of hired labor	0.262***	0.240***	0.269***	0.0506	0.000404	0.379***	0.290***
	(0.0422)	(0.0542)	(0.0709)	(0.0875)	(0.0747)	(0.0823)	(0.0335)
Ln(Value of fixed cost per acre)	0.00353	0.015***	0.0358***	0.00626	0.018***	-0.00992*	0.0054***
	(0.00237)	(0.00395)	(0.00584)	(0.00636)	(0.00580)	(0.00586)	(0.00209)
Ln(Value of bullock cost per acre)	0.000102	-0.005***	0.00438***	-0.0079***	0.000907	0.00476**	0.000803
	(0.000990)	(0.00159)	(0.00157)	(0.00304)	(0.00172)	(0.00213)	(0.00075)
East[4]	-0.621***	-0.655***	-0.737***	-0.993***	-1.007***	-0.737***	-0.551***
	(0.0488)	(0.0360)	(0.0630)	(0.0686)	(0.0720)	(0.0693)	(0.0265)
South	-0.270***	-0.485***	-0.373***	-0.390***	-0.277***	-0.343***	-0.341***
	(0.0514)	(0.126)	(0.0628)	(0.0760)	(0.0677)	(0.0650)	(0.0240)
West	-0.659***	-0.227***	-0.545***	-0.430***	-0.299***	-0.365***	-0.193***
	(0.0553)	(0.0281)	(0.0554)	(0.0740)	(0.0586)	(0.0624)	(0.0272)
Semi-Arid temperate[5]	-0.281***	-0.0720*	-0.457***	0.139**	-0.109	-0.460***	-0.256***
	(0.0430)	(0.0414)	(0.0603)	(0.0634)	(0.0710)	(0.0611)	(0.0246)
Semi-Arid tropic	0.0434**	0.142***	-0.0683	0.0981	-0.115**	-0.150***	-0.0309*
	(0.0218)	(0.0453)	(0.0497)	(0.0606)	(0.0491)	(0.0534)	(0.0176)
Arid	-0.0389	0.180***	-0.265***	-0.263**	-0.182**	-0.687***	-0.109***
	(0.0895)	(0.0561)	(0.0799)	(0.119)	(0.0720)	(0.0778)	(0.0346)
Constant	7.595***	6.334***	8.066***	6.897***	7.718***	7.992***	6.878***
	(0.112)	(0.129)	(0.153)	(0.189)	(0.159)	(0.178)	(0.0747)
Observations	2,480	1,884	1,874	1,092	1,085	1,789	4,397
Technical efficiency	0.769	0.735	0.667	0.705	0.687	0.611	0.784

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

[4] North is the base
[5] Humid is the base

3.2: Determinants of technical inefficiency (1999)

VARIABLES	Paddy	Wheat	Cereals	Pulses	Oils seeds	Other crops	HH level
HH head age	-0.701***	-2.646***	-0.877***	-0.812**	-0.596**	-0.325***	-2.193***
	(0.149)	(0.454)	(0.251)	(0.413)	(0.248)	(0.116)	(0.432)
Mean education of the HH	0.0461	1.894***	0.0179	0.113	0.00483	0.0656	0.0747
	(0.0754)	(0.480)	(0.0630)	(0.206)	(0.129)	(0.0443)	(0.0872)
Variance education of the HH	-0.203**	-0.299**	0.105	-0.0838	-0.0586	-0.0975*	0.0490
	(0.0991)	(0.152)	(0.0985)	(0.158)	(0.135)	(0.0535)	(0.139)
Farm size (in acres)	0.590***	0.911***	0.0382	0.00373	0.120	0.0645	0.274*
	(0.146)	(0.210)	(0.0845)	(0.0834)	(0.143)	(0.0507)	(0.146)
Family supervision/labor cost	-1.637**	-2.608**	-0.772	-0.255	-1.014	-0.270	-1.260
	(0.753)	(1.119)	(0.555)	(0.671)	(0.943)	(0.325)	(1.241)
No. of HH shocks	0.00792	0.183***	-0.0720*	-0.0331	-0.0800*	0.0190	0.0211
	(0.0259)	(0.0427)	(0.0367)	(0.0694)	(0.0437)	(0.0150)	(0.0366)
No. of village shocks	0.0136	0.085***	0.0434**	-0.0788	-0.00388	-0.0183	0.0363
	(0.0209)	(0.0301)	(0.0205)	(0.0521)	(0.0244)	(0.0122)	(0.0265)
Distance to Pucca road	-0.00580	0.183***	-0.0170	0.0657**	0.0235	-0.0174**	0.337***
	(0.0165)	(0.0441)	(0.0149)	(0.0283)	(0.0213)	(0.00804)	(0.0773)
Distance to wholesale Market	-0.118***	0.233***	0.0890	0.137	0.0107	0.00347	-0.0188
	(0.0220)	(0.0764)	(0.0612)	(0.0843)	(0.0395)	(0.0111)	(0.0263)
No. of times AES activities	-0.101***	0.0268	0.00804	-0.0324	-0.0240	-0.0151**	-0.252***
	(0.0174)	(0.0273)	(0.0127)	(0.0261)	(0.0172)	(0.00675)	(0.0538)
Proportion of gvt. canal irrigated	-0.500	0.917	-0.685*	-0.0373	-1.393*	0.856***	-11.82***
	(0.320)	(0.653)	(0.415)	(0.461)	(0.766)	(0.234)	(2.994)
Proportion of tank irrigated	-8.854***	10.44***	-10.22**	5.797***	-36.40*	0.169	-978.7
	(3.245)	(2.506)	(4.380)	(1.753)	(19.75)	(0.592)	(3,399)
Proportion of well irrigated	1.700***	-8.251***	-16.34***	-12.60**	0.158	0.381	-13.46***
	(0.400)	(2.916)	(3.863)	(5.753)	(0.868)	(0.269)	(3.357)
Prop. HYV area	-2.908***	3.539***	1.588***	-0.935	1.401***	-0.219	0.278
	(0.511)	(0.905)	(0.452)	(0.626)	(0.464)	(0.219)	(0.928)
Mean rainfall in Kharip	-0.0295*	-	0.0362	0.365**	0.0577	0.0464	0.496
	(0.0173)		(0.0339)	(0.159)	(0.0377)	(0.0296)	(0.316)
Mean rainfall in Rabi	-	1.087***	0.0426	-0.348**	-0.0755**	-0.0613**	-0.369***
		(0.306)	(0.0309)	(0.170)	(0.0360)	(0.0282)	(0.0780)
Proportion of agricultural expenditure	3.037**	1.583	-3.688	-6.993	-29.99***	1.024	16.53***
	(1.238)	(2.090)	(2.821)	(5.266)	(9.894)	(0.630)	(3.462)
No. GS meeting held	0.0275	-0.0342	-0.0551*	0.0857*	0.0101	-0.0290**	-0.0142
	(0.0208)	(0.0381)	(0.0284)	(0.0473)	(0.0294)	(0.0128)	(0.0328)
Women reservation	0.921***	1.059**	-0.513	-0.254	-0.127	-0.385***	-0.222
	(0.287)	(0.457)	(0.331)	(0.419)	(0.343)	(0.147)	(0.569)
Observations	2,480	1,884	1,874	1,092	1,085	1,789	4,397

Table 4.1: Production function (1982)

VARIABLES	Paddy	Wheat	Cereals	Pulses	HH level
	Ln(Value of crop per acre)				
Ln(Cropped area)	-0.136***	-0.219***	-0.292***	-0.191***	-0.196***
	(0.0141)	(0.0246)	(0.0364)	(0.0451)	(0.0125)
Proportion of irrigated area	0.0678*	0.0740	-0.133*	0.137*	0.207***
	(0.0361)	(0.0596)	(0.0757)	(0.0830)	(0.0292)
Ln(Value of seeds per acre)	0.00398	0.0312***	0.0481***	0.0599***	0.00535
	(0.00536)	(0.00853)	(0.0152)	(0.0156)	(0.00469)
Ln(Value of fertilizer and manure per acre)	0.0175***	0.0205***	0.0115***	0.0104***	0.0160***
	(0.00224)	(0.00277)	(0.00261)	(0.00384)	(0.00156)
Prop. Of manure to total value of fertilizer and manure	-0.0840	-0.191*	-0.185*	-0.316**	-0.0878*
	(0.0605)	(0.112)	(0.101)	(0.158)	(0.0465)
Ln(Value of pesticides per acre)	0.00981***	0.0103***	0.0187***	0.0123***	0.0127***
	(0.00142)	(0.00209)	(0.00311)	(0.00436)	(0.00123)
Ln(Value of total labor cost per acre)	0.102***	0.110***	0.128***	0.140***	0.164***
	(0.0113)	(0.0168)	(0.0195)	(0.0262)	(0.00892)
Prop. Of hired labor	-0.0305	-0.211***	0.126	0.195**	-0.120**
	(0.0747)	(0.0720)	(0.0800)	(0.0963)	(0.0516)
Ln(Value of fixed cost per acre)	0.00136	0.0254***	0.0135*	0.0133	0.0093***
	(0.00307)	(0.00623)	(0.00777)	(0.00937)	(0.00269)
Ln(Value of bullock cost per acre)	-0.00250	0.00201	0.000420	-0.00571	-0.006***
	(0.00154)	(0.00342)	(0.00387)	(0.00611)	(0.00143)
East[6]	0.159***	-0.216*	-0.325	-0.0888	0.0643
	(0.0510)	(0.124)	(0.432)	(0.151)	(0.0469)
South	0.0692	-0.390**	-0.102	-0.145	-0.0610*
	(0.0449)	(0.192)	(0.115)	(0.108)	(0.0367)
West	0.0966*	-0.210***	0.0590	0.210**	-0.0378
	(0.0560)	(0.0496)	(0.0757)	(0.0881)	(0.0339)
Semi-Arid temperate[7]	-0.0371	0.112*	0.184	0.187*	-0.0160
	(0.0488)	(0.0652)	(0.125)	(0.111)	(0.0392)
Semi-Arid tropic	-0.0526*	-0.143*	0.300**	0.110	-0.078***
	(0.0303)	(0.0740)	(0.130)	(0.0962)	(0.0285)
Arid	0.150	-0.0626	-0.250	-0.175	-0.160***
	(0.0925)	(0.0903)	(0.161)	(0.149)	(0.0475)
Constant	8.191***	8.115***	7.291***	7.017***	8.055***
	(0.103)	(0.140)	(0.190)	(0.256)	(0.0825)
Observations	1,453	946	685	608	2,508
Technical efficiency	0.664	0.670	0.576	0.510	0.668

[6] North is the base
[7] Humid is the base

4.2: Determinants of technical inefficiency (1982)

VARIABLES	Paddy	Wheat	Cereals	Pulses	HH level
HH head age	-0.240***	-0.276**	-0.216*	-0.242**	-0.197***
	(0.0381)	(0.139)	(0.112)	(0.117)	(0.0350)
Mean education of the HH	-0.0325	-0.0540**	0.107*	0.303*	-0.0127
	(0.0208)	(0.0265)	(0.0594)	(0.156)	(0.0149)
Farm size (in acres)	-0.0129	0.0878	0.362***	0.269**	-0.0583*
	(0.0307)	(0.122)	(0.135)	(0.119)	(0.0329)
Distance to wholesale Market	0.0147*	0.115***	-0.0152	0.0129	0.025***
	(0.00783)	(0.0315)	(0.0131)	(0.0132)	(0.00697)
No. of times AES activities	0.0161	0.106	-0.0523*	-0.0410*	-0.045***
	(0.0170)	(0.119)	(0.0297)	(0.0221)	(0.0123)
Proportion of gvt. canal irrigated	-0.0245***	0.055***	0.059***	0.00494	-0.00944*
	(0.00659)	(0.0133)	(0.0154)	(0.0105)	(0.00555)
Proportion of tank irrigated	-0.157*	0.155	-2.209*	0.253***	-0.0880**
	(0.0867)	(0.168)	(1.251)	(0.0886)	(0.0396)
Proportion of well irrigated	-1.641***	0.101	-1.175	-0.342	-1.810***
	(0.355)	(0.407)	(1.090)	(0.383)	(0.361)
Proportion of agricultural expenditure	-1.729***	-2.435***	-0.0154	-0.899*	-1.356***
	(0.359)	(0.719)	(0.386)	(0.508)	(0.257)
Women reservation	-1.294*	2.640**	-7.266**	-0.957	-2.756***
	(0.707)	(1.187)	(2.968)	(1.781)	(1.031)
Observations	1,453	946	685	608	2,508

Table 5.1: Production function (panel 1999-2006)

	Paddy	Wheat	Cereals	Pulses	Oil seeds	Other crops	HH level
VARIABLES	Ln(Value of crop per acre)						
Ln(Cropped area)	-0.120***	-0.0693***	-0.106***	-0.140***	-0.117***	-0.0876***	-0.090***
	(0.0102)	(0.0108)	(0.0147)	(0.0220)	(0.0224)	(0.0182)	(0.00646)
Proportion of irrigated area	0.0356	0.0263	0.087***	0.112**	0.0145	0.0615	0.119***
	(0.0232)	(0.0286)	(0.0318)	(0.0536)	(0.0502)	(0.0508)	(0.0159)
Ln(Value of seeds per acre)	0.00619***	0.00703**	0.0382**	0.0150***	0.00916*	-0.000447	0.0267***
	(0.00181)	(0.00275)	(0.00496)	(0.00448)	(0.00471)	(0.00243)	(0.00244)
Ln(Value of fertilizer and manure per acre)	0.0326***	0.0177***	0.0173**	0.00380*	0.021***	0.0136***	0.0358***
	(0.00432)	(0.00311)	(0.00218)	(0.00214)	(0.00273)	(0.00265)	(0.00233)
Prop. Of manure to total value of fertilizer and manure	0.00130	-0.0677	-0.110***	-0.104**	-0.103**	-0.152**	-0.179***
	(0.0343)	(0.0423)	(0.0354)	(0.0477)	(0.0504)	(0.0615)	(0.0236)
Ln(Value of pesticides per acre)	0.00403***	0.0028***	0.00210	0.0115***	0.007***	0.0210***	0.0104***
	(0.00102)	(0.000795)	(0.00129)	(0.00209)	(0.00184)	(0.00159)	(0.00065)
Ln(Value of total labor cost per acre)	0.0499***	0.0909***	0.106***	0.0860***	0.063***	0.0972***	0.0743***
	(0.0114)	(0.0115)	(0.0145)	(0.0195)	(0.0215)	(0.0168)	(0.00728)
Prop. Of hired labor	0.201***	0.119***	0.141**	0.00574	0.277***	0.407***	0.259***
	(0.0393)	(0.0380)	(0.0558)	(0.0835)	(0.0760)	(0.0688)	(0.0276)
Ln(Value of fixed cost per acre)	0.00606***	0.0135***	0.00538	0.0101**	0.0090**	-0.000414	0.007***
	(0.00174)	(0.00279)	(0.00340)	(0.00455)	(0.00376)	(0.00464)	(0.00137)
Ln(Value of bullock cost per acre)	0.00162**	-0.000855	-0.00112	0.0069***	0.00115	0.000333	0.0017***
	(0.000742)	(0.00105)	(0.00127)	(0.00210)	(0.00175)	(0.00177)	(0.00056)
East[8]	-0.0824	-0.141	-0.828	-0.235	-1.141*	0.124	-0.00328
	(0.199)	(0.127)	(0.957)	(0.687)	(0.612)	(0.851)	(0.181)
South	-0.332	-1.121***	-0.548	0.910	-0.414	1.981***	0.144
	(0.330)	(0.151)	(0.653)	(0.575)	(0.394)	(0.566)	(0.212)
West	0.120	0.0797	0.615	-0.718**	-0.215	2.841***	0.802***
	(0.343)	(0.110)	(0.725)	(0.359)	(0.418)	(0.610)	(0.233)
Semi-Arid temperate[9]	-0.222	0.297	-0.625	1.242*	0.910*	1.616**	0.193
	(0.179)	(0.197)	(0.574)	(0.663)	(0.544)	(0.810)	(0.161)
Semi-Arid tropic	0.0754	0.508***	-0.0578	-0.461	0.931**	0.501	0.262**
	(0.151)	(0.169)	(0.560)	(0.526)	(0.374)	(0.597)	(0.131)
Arid	-0.339	0.548***	-0.542	1.810***	0.524	-1.291**	-0.374**
	(0.292)	(0.203)	(0.460)	(0.696)	(0.467)	(0.572)	(0.162)
Constant	8.720***	7.926***	7.787***	7.349***	8.196***	7.657***	7.924***
	(0.185)	(0.203)	(0.528)	(0.632)	(0.502)	(0.793)	(0.161)
Observations	3,799	2,920	3,002	1,601	1,549	3,067	9,355
Technical efficiency	0.755	0.772	0.702	0.701	0.671	0.566	0.797

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

[8] North is the base
[9] Humid is the base

5.2: Determinants of technical inefficiency (panel 1999-2006)

VARIABLES	Paddy	Wheat	Cereals	Pulses	Oils seeds	Other crops	HH level
HH head age	-0.201***	-0.702***	-0.327***	-0.192	-0.187	0.0946	-0.777***
	(0.0569)	(0.146)	(0.122)	(0.134)	(0.116)	(0.0645)	(0.159)
Mean education of the HH	0.000450	-0.0291	-0.0311**	-0.00255	0.0189	-0.0175	-0.0252
	(0.0108)	(0.0198)	(0.0140)	(0.0189)	(0.0158)	(0.0127)	(0.0172)
Variance education of the HH	-0.0405	0.124*	0.0916	-0.0712	0.0308	0.127***	-0.0660
	(0.0371)	(0.0738)	(0.0557)	(0.0713)	(0.0538)	(0.0401)	(0.0634)
Farm size (in acres)	-0.0368***	-0.0358**	0.0152	0.0158	-0.0710**	0.0189	-0.00523
	(0.0121)	(0.0169)	(0.0219)	(0.0267)	(0.0294)	(0.0160)	(0.0218)
Family supervision/labor cost	0.241	0.496	0.197	2.103***	0.383	-0.0667	-1.757***
	(0.391)	(0.824)	(0.544)	(0.548)	(0.510)	(0.514)	(0.679)
No. of HH shocks	-0.0151*	-0.00912	-0.048***	0.000396	0.00791	0.00109	0.00433
	(0.00841)	(0.0210)	(0.0146)	(0.0155)	(0.0134)	(0.00859)	(0.0211)
No. of village shocks	0.0131**	0.00463	0.0160*	0.0249**	0.031***	-0.0143**	-0.00651
	(0.00606)	(0.0101)	(0.00860)	(0.00997)	(0.00899)	(0.00575)	(0.0128)
Distance to Pucca road	0.0102*	0.122***	-0.00644	0.0160	-0.041***	0.00204	0.064***
	(0.00601)	(0.0216)	(0.00873)	(0.0114)	(0.0110)	(0.00605)	(0.0147)
Distance to wholesale Market	-0.0475***	-0.140***	-0.110***	0.0219	0.0930**	0.0646***	0.0220
	(0.00730)	(0.0163)	(0.0246)	(0.0231)	(0.0440)	(0.0193)	(0.0314)
No. of times AES activities	-0.0205***	-0.049***	-0.056***	-0.0275**	-0.0162*	-0.00806	-0.159***
	(0.00567)	(0.0114)	(0.0107)	(0.0114)	(0.00899)	(0.00587)	(0.0281)
Proportion of gvt. canal irrigated	-0.135*	-3.861	-1.760**	-0.851	-0.482	-0.303*	-2.550***
	(0.0787)	(2.454)	(0.848)	(0.568)	(0.327)	(0.164)	(0.852)
Proportion of tank irrigated	1.234***	7.611***	1.386***	1.704***	0.536*	-2.376**	-330.2**
	(0.275)	(1.504)	(0.456)	(0.440)	(0.325)	(1.163)	(166.5)
Proportion of well irrigated	-3.211***	-0.260	1.105***	-0.714	0.183	0.669**	2.275***
	(0.580)	(0.728)	(0.297)	(0.649)	(0.304)	(0.271)	(0.686)
Prop. HYV area	-0.505***	0.813**	-0.718**	-1.179***	-1.124***	-0.867***	-0.587
	(0.192)	(0.331)	(0.279)	(0.360)	(0.309)	(0.207)	(0.386)
Mean rainfall in Kharip	-0.0352***	-	0.042***	-0.037***	-0.0161	-0.0281***	-0.0173
	(0.00743)		(0.0153)	(0.0133)	(0.0135)	(0.0104)	(0.0302)
Mean rainfall in Rabi	-	0.00632	0.069***	0.0295**	0.0118	0.0109*	0.072***
		(0.0111)	(0.0116)	(0.0129)	(0.00880)	(0.00571)	(0.0195)
Proportion of agricultural expenditure	-1.958***	2.334*	-35.54**	0.802	1.706*	0.466	2.142*
	(0.746)	(1.391)	(17.31)	(1.630)	(0.936)	(0.320)	(1.260)
No. GS meeting held	0.0207***	-0.0213	0.042***	-0.0203	-0.0134	0.0207***	0.0523**
	(0.00707)	(0.0164)	(0.0111)	(0.0141)	(0.0111)	(0.00726)	(0.0215)
Women reservation	-0.459***	-0.429**	-0.597***	0.285	-0.395**	0.0493	-0.227
	(0.116)	(0.205)	(0.172)	(0.189)	(0.176)	(0.0971)	(0.174)
Observations	3,799	2,920	3,002	1,601	1,549	3,067	9,355

Table 6.1: Production function (panel 1982-1999-2006)

VARIABLES	Paddy	Wheat	Cereals	Pulses	HH level
	Ln(Value of crop per acre)				
Ln(Cropped area)	-0.0998***	-0.0993***	-0.130***	-0.0890***	-0.083***
	(0.00693)	(0.00884)	(0.0120)	(0.0169)	(0.00560)
Proportion of irrigated area	0.0577***	0.0584**	0.0453	0.0639	0.122***
	(0.0186)	(0.0238)	(0.0287)	(0.0440)	(0.0148)
Ln(Value of seeds per acre)	0.0109***	0.0243***	0.0555***	0.0388***	0.0334***
	(0.00180)	(0.00285)	(0.00496)	(0.00524)	(0.00212)
Ln(Value of fertilizer and manure per acre)	0.0165***	0.0228***	0.0192***	0.0154***	0.0230***
	(0.00175)	(0.00177)	(0.00151)	(0.00175)	(0.00117)
Prop. Of manure to total value of fertilizer and manure	-0.0230	-0.164***	-0.0852***	-0.111***	-0.129***
	(0.0283)	(0.0365)	(0.0299)	(0.0425)	(0.0210)
Ln(Value of pesticides per acre)	0.0111***	0.0046***	0.00539***	0.0105***	0.0122***
	(0.000735)	(0.000682)	(0.00108)	(0.00172)	(0.00057)
Ln(Value of total labor cost per acre)	0.0687***	0.0939***	0.103***	0.0896***	0.0988***
	(0.00685)	(0.00777)	(0.0102)	(0.0131)	(0.00517)
Prop. Of hired labor	-0.117***	-0.171***	0.0313	-0.286***	-0.098***
	(0.0206)	(0.0230)	(0.0331)	(0.0451)	(0.0170)
Ln(Value of fixed cost per acre)	0.00745***	0.0227***	0.0139***	0.0130***	0.0094***
	(0.00135)	(0.00240)	(0.00301)	(0.00368)	(0.00120)
Ln(Value of bullock cost per acre)	0.000572	-0.000734	-0.00519***	0.00140	0.000319
	(0.000614)	(0.000924)	(0.00108)	(0.00186)	(0.0005)
East[10]	-0.0291	1.594***	-0.224	-1.322**	-0.175
	(0.164)	(0.442)	(0.997)	(0.652)	(0.181)
South	-0.156	0.417*	0.493	0.274	-0.152
	(0.109)	(0.253)	(0.702)	(0.587)	(0.124)
West	0.129	-0.275***	0.580	1.533*	0.0983
	(0.402)	(0.0842)	(0.834)	(0.809)	(0.153)
Semi-Arid temperate[11]	-0.184	1.980***	0.132	0.156	-0.0908
	(0.155)	(0.517)	(0.888)	(0.650)	(0.170)
Semi-Arid tropic	0.0324	0.813*	-0.145	-0.900	-0.0637
	(0.131)	(0.459)	(0.648)	(0.578)	(0.144)
Arid	-0.312***	2.302***	-0.0897	-1.675***	-0.0434
	(0.116)	(0.516)	(0.620)	(0.574)	(0.116)
Constant	8.550***	6.066***	6.946***	8.167***	8.115***
	(0.153)	(0.519)	(0.845)	(0.629)	(0.166)
Observations	6,659	5,177	4,628	2,376	11,863
Technical efficiency	0.735	0.747	0.677	0.634	0.668

[10] North is the base
[11] Humid is the base

6.2: Determinants of technical inefficiency (panel 1982-1999-2006)

VARIABLES	Paddy	Wheat	Cereals	Pulses	HH level
HH head age	-0.432***	-1.43***	-0.273***	-0.277***	-0.526***
	(0.0238)	(0.193)	(0.0342)	(0.0515)	(0.0496)
Mean education of the HH	-0.0195***	-0.016***	0.00122	0.00142	-0.017***
	(0.00473)	(0.00629)	(0.00529)	(0.00852)	(0.00530)
Farm size (in acres)	-0.00470	-0.041***	0.0328	0.0346	0.00437
	(0.0103)	(0.0124)	(0.0211)	(0.0222)	(0.0125)
Distance to wholesale Market	0.0168***	0.067***	0.015***	0.039***	0.059***
	(0.00435)	(0.00710)	(0.00562)	(0.00901)	(0.00924)
No. of times AES activities	0.00265	0.583***	0.0344**	-0.0300*	-0.056***
	(0.0125)	(0.0689)	(0.0166)	(0.0171)	(0.0108)
Proportion of gvt. canal irrigated	-0.0254***	-0.023***	-0.0097**	-0.033***	-0.037***
	(0.00398)	(0.00567)	(0.00470)	(0.00742)	(0.00679)
Proportion of tank irrigated	-0.0792**	-0.116	-0.0275	0.145*	-0.0687**
	(0.0319)	(0.166)	(0.202)	(0.0848)	(0.0325)
Proportion of well irrigated	0.246*	1.433***	-0.154	0.216	-0.0877
	(0.143)	(0.263)	(0.251)	(0.301)	(0.189)
Proportion of agricultural expenditure	-0.274	-0.204	0.274*	0.768***	-0.136
	(0.200)	(0.237)	(0.157)	(0.287)	(0.193)
Women reservation	-2.082***	1.190***	-4.025**	-1.157	-1.840***
	(0.534)	(0.444)	(1.723)	(1.090)	(0.602)
Observations	6,659	5,177	4,628	2,376	11,863

Table 7.1: Cost function (2006)

Variables	Paddy	Wheat	Cereals	Pulses	Oils seeds	Other crops	HH level
Ln(Quantity of output per acre)	0.638***	0.474***	0.372***	0.250***	0.291***	0.275***	0.342***
	(0.0477)	(0.0318)	(0.0447)	(0.0409)	(0.0523)	(0.0270)	(0.0219)
Ln(price of seeds)	0.0205***	0.0137**	0.0855***	0.0237**	0.00333	0.0336***	0.0331***
	(0.00580)	(0.00555)	(0.0149)	(0.0114)	(0.0122)	(0.00592)	(0.00690)
Ln(price of fertilisers)	0.0217***	0.0312***	0.0280***	0.0264***	0.0645***	0.0276***	0.0343***
	(0.00794)	(0.00528)	(0.00478)	(0.00423)	(0.00700)	(0.00599)	(0.00418)
Ln(price of pesticides)	0.00969***	0.00581***	0.0111***	0.0151***	0.0158***	0.0300***	0.0063***
	(0.00299)	(0.00160)	(0.00330)	(0.00387)	(0.00470)	(0.00325)	(0.00187)
Ln(rental rate of machinery)	0.0220	-0.0109	0.00627	0.0362*	0.0316	0.0231	0.0215
	(0.0157)	(0.0123)	(0.0206)	(0.0215)	(0.0223)	(0.0235)	(0.0430)
Ln(rental rate of irrigation)	0.0115***	0.0104***	0.00683**	0.00787*	0.0123***	0.0102***	0.0089***
	(0.00259)	(0.00205)	(0.00296)	(0.00410)	(0.00463)	(0.00362)	(0.00185)
Ln(wage)	0.329**	0.462***	0.320	0.889***	0.0933	0.0429	0.292**
	(0.147)	(0.158)	(0.210)	(0.262)	(0.274)	(0.226)	(0.125)
East[12]	-0.0254	-0.0267	-0.192	-0.622***	-0.209	0.425*	-0.101
	(0.128)	(0.161)	(0.266)	(0.212)	(0.314)	(0.222)	(0.125)
South	0.0260	-0.823***	-0.476***	-0.928***	-0.213	-0.866***	-0.278**
	(0.126)	(0.297)	(0.176)	(0.205)	(0.212)	(0.184)	(0.137)
West	0.146	-0.317***	0.0621	-0.298*	-0.0340	0.119	0.0775
	(0.142)	(0.105)	(0.133)	(0.177)	(0.177)	(0.150)	(0.119)
Semi-Arid temperate[13]	-0.0351	0.239*	-0.235	0.0733	-0.0642	-0.0677	-0.0634
	(0.135)	(0.145)	(0.190)	(0.225)	(0.249)	(0.202)	(0.120)
Semi-Arid tropic	-0.267***	0.171	-0.0485	0.132	0.167	-0.376*	-0.0446
	(0.0892)	(0.152)	(0.171)	(0.186)	(0.221)	(0.192)	(0.0876)
Arid	0.0813	0.0218	-0.438*	-0.208	-0.294	-0.567**	-0.216
	(0.209)	(0.188)	(0.228)	(0.287)	(0.292)	(0.234)	(0.155)
Constant	0.355	0.409	1.779	-0.00564	2.526	2.722	1.154
	(0.579)	(9.795)	(1.146)	(28.94)	(20.43)	(42.08)	(28.40)
Observations	2615	2184	2205	1280	1010	2344	4848
Economic efficiency	0.658	0.556	0.569	0.543	0.583	0.535	0.168
Allocative efficiency	0.914	0.779	0.865	0.873	0.975	0.848	0.219

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

[12] North is the base
[13] Humid is the base

Table 7.2: Determinants of Allocative efficiency (2006)

VARIABLES	Paddy	Wheat	Cereals	Pulses	Oils seeds	Other crops	HH level
HH head age	0.247***	0.280***	0.264***	0.263***	0.361***	0.129***	0.00281
	(0.0122)	(0.0131)	(0.0219)	(0.0207)	(0.0653)	(0.0151)	(0.00943)
Mean education of the HH	-0.000413	0.00106	-0.00322	0.000201	0.00681	-0.00243	-0.000354
	(0.00181)	(0.00195)	(0.00255)	(0.00319)	(0.00853)	(0.00262)	(0.0006)
Variance education of the HH	0.00925	0.0144*	0.0113	-0.0152	0.0102	0.0226**	0.00197
	(0.00729)	(0.00783)	(0.0114)	(0.0123)	(0.0360)	(0.00917)	(0.00287)
Farm size (in acres)	-0.0135***	-0.00573**	-0.0170***	-0.0184***	-0.044***	-0.0135***	-0.00149
	(0.00250)	(0.00270)	(0.00374)	(0.00454)	(0.0166)	(0.00330)	(0.00097)
Area of individual frag./total area of frag.	-0.316***	-0.0838***	-0.0805***	-0.114***	-0.387***	-0.217***	0.423***
	(0.0295)	(0.0252)	(0.0275)	(0.0296)	(0.0908)	(0.0224)	(0.0393)
Family supervision/labor cost	-0.00754	0.340***	0.472***	0.601***	0.269	0.187	0.377***
	(0.0769)	(0.127)	(0.108)	(0.112)	(0.377)	(0.121)	(0.0306)
No. of HH shocks	-0.005***	-0.00512***	-0.0157***	-0.00202	0.0110	-0.00965***	-0.0010**
	(0.001)	(0.00139)	(0.00165)	(0.00204)	(0.00705)	(0.00162)	(0.0004)
No. of village shocks	-0.000459	0.00143*	0.00294**	-0.00253*	0.00974**	-0.00352***	-0.001***
	(0.0009)	(0.000864)	(0.00124)	(0.00132)	(0.00449)	(0.00103)	(0.0003)
Dummy for land registration	0.115***	0.0191	0.214***	-0.0332	0.211	0.165***	0.00596
	(0.0206)	(0.0344)	(0.0311)	(0.0419)	(0.131)	(0.0348)	(0.00828)
Share of sale to govt. to total	0.0772**	-0.0581	0.132	-0.0757	0.223	-0.0957**	0.092***
	(0.0303)	(0.0543)	(0.150)	(0.157)	(0.251)	(0.0399)	(0.0149)
Distance to Pucca road	-0.000432	0.0126***	0.00547***	-0.0033***	0.0103**	-0.00691***	0.004***
	(0.000888)	(0.000970)	(0.00119)	(0.00128)	(0.00468)	(0.00114)	(0.0003)
Distance to wholesale Market	-0.0068***	0.0107***	-0.0337***	-0.0187***	-0.0257	0.0331***	-0.00137
	(0.00198)	(0.00360)	(0.00609)	(0.00539)	(0.0221)	(0.00522)	(0.00095)
Distance to public worker related to AES	0.00312	-0.0146***	0.0333***	0.0253***	0.0596**	-0.0247***	0.005***
	(0.00232)	(0.00368)	(0.00600)	(0.00348)	(0.0243)	(0.00712)	(0.00111)
Distance to private worker related to AES	-0.00454***	-0.00120	0.00156	-0.00218	-0.00161	-0.0110***	0.004***
	(0.00170)	(0.00180)	(0.00222)	(0.00262)	(0.00867)	(0.00188)	(0.0006)
No. of times AES activities	-0.00277***	-0.00214**	-0.00721***	0.000559	-0.013***	0.0114***	0.004***
	(0.000955)	(0.000944)	(0.00134)	(0.00147)	(0.00498)	(0.00110)	(0.0004)
Proportion of gvt. canal irrigated	-0.00510***	-0.0358*	0.230***	0.130***	0.178	-0.104***	-0.000358
	(0.000917)	(0.0205)	(0.0478)	(0.0257)	(0.119)	(0.0251)	(0.0005)
Proportion of tank irrigated	0.144***	0.0321	0.228***	0.105**	-0.462**	0.156**	-0.0258**
	(0.0372)	(0.126)	(0.0663)	(0.0492)	(0.190)	(0.0732)	(0.0126)
Proportion of well irrigated	-0.203***	0.0753	-0.0133	-0.122**	0.0506	0.0283	0.0232*
	(0.0600)	(0.0467)	(0.0427)	(0.0570)	(0.126)	(0.0541)	(0.0120)
Prop. HYV area	0.0202	-0.111***	-0.231***	-0.0795**	-0.297**	0.117***	-0.136***
	(0.0281)	(0.0272)	(0.0317)	(0.0366)	(0.126)	(0.0356)	(0.00971)
Mean rainfall in Kharip	-0.00253**	-	0.00377**	0.00298*	-0.0152**	-0.00890***	-0.006***
	(0.00112)		(0.00175)	(0.00179)	(0.00721)	(0.00152)	(0.0005)
Mean rainfall in Rabi	-	0.00826***	-0.00470***	-0.0037***	0.00956**	-0.00213**	0.003***
		(0.000931)	(0.00124)	(0.00140)	(0.00478)	(0.000919)	(0.0003)
Proportion of agricultural expenditure	0.0864	0.245***	0.146	1.381***	0.396	-0.166***	0.231***
	(0.0957)	(0.0765)	(0.0970)	(0.247)	(0.707)	(0.0533)	(0.0281)
No. GS meeting held	0.000116	0.00174	0.00328**	0.00370**	-0.0118**	-0.00119	0.002***
	(0.00102)	(0.00130)	(0.00146)	(0.00158)	(0.00523)	(0.00140)	(0.0004)
Women reservation	-0.0366**	-0.0283**	-0.108***	-0.0190	-0.123	0.00106	0.00324
	(0.0153)	(0.0140)	(0.0198)	(0.0241)	(0.0885)	(0.0164)	(0.00557)
Observations	2615	2184	2205	1280	1010	2344	4848

Table 8.1: Cost function (1999)

Variables	Paddy	Wheat	Cereals	Pulses	Oils seeds	Other crops	HH level
Ln(Quantity of output per acre)	0.485***	0.418***	0.326***	0.150***	0.412***	0.214***	0.234***
	(0.0414)	(0.0269)	(0.0428)	(0.0339)	(0.0543)	(0.0149)	(0.0132)
Ln(price of seeds)	0.0575*	0.0854***	0.0320	0.0170	0.0402	0.0302***	0.0755***
	(0.0330)	(0.0252)	(0.0321)	(0.0453)	(0.0359)	(0.0108)	(0.0155)
Ln(price of fertilisers)	0.0187**	0.0538***	0.0404***	0.0405***	0.0316***	0.0493***	0.0306***
	(0.00861)	(0.00710)	(0.00650)	(0.00386)	(0.00589)	(0.00745)	(0.00592)
Ln(rental rate of machinery)	0.00918***	0.0105***	0.0148***	0.0224***	0.0089***	0.0087***	0.0083***
	(0.00195)	(0.00185)	(0.00272)	(0.00359)	(0.00262)	(0.00259)	(0.00150)
Ln(rental rate of irrigation)	0.00659***	0.0117***	0.0205***	0.0286***	0.0102***	0.0123***	0.0105***
	(0.00206)	(0.00176)	(0.00390)	(0.00614)	(0.00348)	(0.00316)	(0.00164)
Ln(wage)	0.136	-0.00396	-0.112	-0.292*	0.197	-0.0208	0.127
	(0.0938)	(0.104)	(0.127)	(0.155)	(0.130)	(0.142)	(0.0916)
East[14]	-0.482***	-0.453***	-0.207	-0.144	-0.202	-0.496**	-0.595***
	(0.171)	(0.107)	(0.211)	(0.147)	(0.198)	(0.233)	(0.131)
South	0.0376	-0.0756	0.421**	-0.141	0.0739	-0.285	-0.206*
	(0.179)	(0.296)	(0.195)	(0.175)	(0.185)	(0.208)	(0.124)
West	0.149	-0.276***	0.322**	-0.113	0.196	-0.513***	-0.0861
	(0.207)	(0.0946)	(0.159)	(0.155)	(0.161)	(0.197)	(0.135)
Semi-Arid temperate[15]	-0.205	0.00658	-0.587***	-0.347**	-0.661***	-0.931***	-0.429***
	(0.169)	(0.118)	(0.185)	(0.153)	(0.171)	(0.209)	(0.124)
Semi-Arid tropic	-0.0541	0.185	-0.207	-0.0739	-0.126	0.00396	-0.165*
	(0.0862)	(0.123)	(0.163)	(0.133)	(0.134)	(0.139)	(0.0867)
Arid	-0.499*	-0.267*	-0.0815	0.0910	-0.537***	-0.553**	-0.756***
	(0.280)	(0.158)	(0.243)	(0.257)	(0.197)	(0.242)	(0.166)
Constant	2.143***	2.186	3.431***	6.011***	2.185	3.406	3.077
	(0.808)	(53.11)	(0.904)	(2.316)	(9.535)	(127.8)	(3.780)
Observations	2,480	1,884	1,874	1,092	1,085	1,789	4,397
Economic efficiency	0.617	0.519	0.565	0.615	0.654	0.492	0.182
Allocative efficiency	0.802	0.706	0.846	0.872	0.952	0.806	0.233

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

[14] North is the base
[15] Humid is the base

Table 8.2: Determinants of Allocative efficiency (1999)

VARIABLES	Paddy	Wheat	Cereals	Pulses	Oils seeds	Other crops	HH level
HH head age	0.183***	0.160***	0.128***	0.137***	0.197***	0.157***	0.0405***
	(0.00579)	(0.00841)	(0.0148)	(0.0154)	(0.0176)	(0.0204)	(0.00295)
Mean education of the HH	-0.00198	0.00624**	-0.00430	-0.00989	-0.00545	-0.00525	0.000540
	(0.00269)	(0.00317)	(0.00566)	(0.00634)	(0.00905)	(0.00847)	(0.00152)
Variance education of the HH	-0.000255	-0.00846	-0.00557	0.00399	0.00380	-0.0147	-0.00682***
	(0.00420)	(0.00542)	(0.00807)	(0.00755)	(0.0104)	(0.0129)	(0.00227)
Farm size (in acres)	0.00161	0.00632***	-0.00354	0.00335	0.000481	0.0198***	0.00117
	(0.00144)	(0.00182)	(0.00469)	(0.00304)	(0.00636)	(0.00667)	(0.000861)
Family supervision/labor cost	-0.169***	-0.153***	-0.125**	-0.0165	-0.135**	-0.318***	-0.153***
	(0.0243)	(0.0297)	(0.0518)	(0.0325)	(0.0605)	(0.0771)	(0.0137)
No. of HH shocks	-9.68e-05	-0.00367**	-0.009***	-0.00313	-0.006***	-0.0107***	-0.00129**
	(0.00109)	(0.00173)	(0.00213)	(0.00263)	(0.00230)	(0.00338)	(0.000569)
No. of village shocks	-0.00231***	-0.00337***	0.00170	-0.009***	-0.00104	0.000338	-0.00210***
	(0.000858)	(0.00129)	(0.00182)	(0.00171)	(0.00206)	(0.00267)	(0.000466)
Distance to Pucca road	-0.00351***	0.00810***	-0.006***	-0.003***	0.009***	-0.00367**	0.00179***
	(0.000579)	(0.000775)	(0.00115)	(0.00106)	(0.00150)	(0.00181)	(0.000312)
Distance to wholesale Market	-0.00193***	-0.000837	0.006***	0.005***	-0.005**	0.0118***	-0.000547
	(0.000662)	(0.00117)	(0.00198)	(0.00133)	(0.00239)	(0.00256)	(0.000392)
No. of times AES activities	-0.00576***	-0.00124*	-0.007***	0.004***	-0.005***	-0.00380**	-0.00122***
	(0.000510)	(0.000647)	(0.00103)	(0.0009)	(0.00125)	(0.00157)	(0.000269)
Proportion of gvt. canal irrigated	-0.0596***	-0.0322*	0.098***	-0.051***	0.122***	0.184***	-0.0111*
	(0.00905)	(0.0189)	(0.0365)	(0.0159)	(0.0445)	(0.0511)	(0.00577)
Proportion of tank irrigated	-0.124***	0.148	-0.229***	0.101	-0.426***	0.315**	0.0469**
	(0.0319)	(0.137)	(0.0857)	(0.0766)	(0.0793)	(0.133)	(0.0182)
Proportion of well irrigated	0.0663***	0.0807*	-0.329***	0.0290	0.102*	-0.125**	-0.00437
	(0.0244)	(0.0449)	(0.0595)	(0.0528)	(0.0540)	(0.0597)	(0.0128)
Prop. HYV area	0.0415**	0.0728***	0.170***	0.096***	0.0733*	-0.0346	0.0370***
	(0.0176)	(0.0213)	(0.0350)	(0.0278)	(0.0426)	(0.0512)	(0.00923)
Mean rainfall in Kharip	-0.00604***	-	0.005***	0.027***	-0.0051**	0.000734	-0.000112
	(0.00107)		(0.00196)	(0.00446)	(0.00232)	(0.00694)	(0.000698)
Mean rainfall in Rabi	-	-0.00116	0.009***	-0.022***	0.006***	-0.0200***	0.00127**
		(0.00103)	(0.00180)	(0.00473)	(0.00204)	(0.00676)	(0.000583)
Proportion of agricultural expenditure	0.248***	0.146	0.0159	-0.449***	-0.397***	-0.0552	0.216***
	(0.0418)	(0.0927)	(0.168)	(0.0945)	(0.129)	(0.164)	(0.0252)
No. GS meeting held	-0.00231***	-0.00255	-0.006***	0.00260	-0.015***	-0.0130***	-0.00228***
	(0.000794)	(0.00155)	(0.00168)	(0.00189)	(0.00180)	(0.00251)	(0.000421)
Women reservation	-0.0181	0.0270**	-0.0356*	-0.0229	0.116***	-0.101***	-0.0114*
	(0.0115)	(0.0134)	(0.0215)	(0.0184)	(0.0287)	(0.0322)	(0.00583)
Observations	2,480	1,884	1,874	1,092	1,085	1,789	4,397

Table 9.1: Cost function (panel 1999-2006)

Variables	Paddy	Wheat	Cereals	Pulses	Oils seeds	Other crops	HH level
Ln(Quantity of output per acre)	0.581***	0.426***	0.443***	0.216***	0.365***	0.214***	0.295***
	(0.0293)	(0.0205)	(0.0300)	(0.0318)	(0.0369)	(0.0139)	(0.0112)
Ln(price of seeds)	0.0252***	0.0237***	0.0822***	0.0298***	0.00585	0.0449***	0.0544***
	(0.00573)	(0.00583)	(0.0132)	(0.0113)	(0.0106)	(0.00485)	(0.00630)
Ln(price of fertilisers)	0.0262***	0.0484***	0.0398***	0.0351***	0.0555***	0.0460***	0.0438***
	(0.00550)	(0.00433)	(0.00368)	(0.00285)	(0.00431)	(0.00457)	(0.00331)
Ln(rental rate of machinery)	0.00778***	0.00692***	0.0144***	0.0163***	0.0110***	0.00352	0.00594***
	(0.00174)	(0.00171)	(0.00237)	(0.00310)	(0.00270)	(0.00272)	(0.00135)
Ln(rental rate of irrigation)	0.00849***	0.0108***	0.0154***	0.0136***	0.0163***	0.0164***	0.0118***
	(0.00157)	(0.00131)	(0.00234)	(0.00330)	(0.00266)	(0.00237)	(0.00119)
Ln(wage)	0.116**	0.333***	0.266***	0.206**	0.266***	-0.198**	0.230***
	(0.0466)	(0.0442)	(0.0700)	(0.101)	(0.0822)	(0.0817)	(0.0362)
East[16]	-0.197**	-0.258**	-0.163	-0.384**	-0.178	-0.129	-0.322***
	(0.0991)	(0.114)	(0.217)	(0.158)	(0.207)	(0.192)	(0.0942)
South	0.171*	-0.646***	-0.109	-0.464***	0.0125	-0.276**	-0.0191
	(0.0930)	(0.212)	(0.134)	(0.134)	(0.134)	(0.137)	(0.0804)
West	0.246**	-0.237***	0.155	-0.0642	0.0960	-0.0887	0.0865
	(0.109)	(0.0715)	(0.101)	(0.114)	(0.111)	(0.123)	(0.0722)
Semi-Arid temperate[17]	-0.0466	0.119	-0.483***	-0.326**	-0.408**	-0.637***	-0.265***
	(0.102)	(0.103)	(0.145)	(0.150)	(0.162)	(0.161)	(0.0877)
Semi-Arid tropic	-0.207***	0.0735	-0.143	-0.0678	-0.0125	-0.421***	-0.185***
	(0.0656)	(0.103)	(0.127)	(0.123)	(0.135)	(0.129)	(0.0648)
Arid	-0.0187	-0.165	-0.452**	-0.150	-0.515***	-0.809***	-0.455***
	(0.161)	(0.136)	(0.180)	(0.200)	(0.188)	(0.194)	(0.118)
Constant	1.400	1.562	1.508	3.232	2.716**	4.654	2.809**
	(1.072)	(18.47)	(1.240)	(8.985)	(1.187)	(31.44)	(1.332)
Observations	3,799	2,920	3,002	1,601	1,549	3,067	9,355
Economic efficiency	0.633	0.630	0.596	0.673	0.556	0.509	0.316
Allocative efficiency	0.839	0.817	0.849	0.960	0.829	0.899	0.396

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

[16] North is the base
[17] Humid is the base

Table 9.2: Determinants of Allocative efficiency (panel 1999-2006)

VARIABLES	Paddy	Wheat	Cereals	Pulses	Oils seeds	Other crops	HH level
HH head age	0.184***	0.221***	0.171***	0.250***	0.314***	0.258***	0.114***
	(0.00618)	(0.00580)	(0.0133)	(0.0140)	(0.0366)	(0.0294)	(0.00238)
Mean education of the HH	-0.000580	-0.00197	-0.00154	0.00195	0.00178	-0.00497	-0.00190***
	(0.00137)	(0.00124)	(0.00182)	(0.00267)	(0.00610)	(0.00632)	(0.000556)
Variance education of the HH	0.00659	0.0147***	0.0135**	-0.0163*	0.0234	0.0519***	0.00262
	(0.00453)	(0.00427)	(0.00664)	(0.00906)	(0.0206)	(0.0187)	(0.00168)
Farm size (in acres)	-0.00572***	-0.00183	-0.00702***	-0.0124***	-0.0149	0.00260	-0.00157***
	(0.00162)	(0.00129)	(0.00272)	(0.00339)	(0.0111)	(0.00662)	(0.000604)
Family supervision/labor cost	-0.125***	-0.0650	0.0647	0.446***	0.0764	0.0128	-0.0944***
	(0.0454)	(0.0473)	(0.0626)	(0.0688)	(0.200)	(0.227)	(0.0122)
No. of HH shocks	-0.00279***	-0.00267***	-0.0129***	-0.00176	-0.00227	-0.0128***	-0.00256***
	(0.000916)	(0.000935)	(0.00128)	(0.00176)	(0.00495)	(0.00420)	(0.000400)
No. of village shocks	-0.00115	0.000261	0.00205**	-0.00183*	0.00787**	-0.00945***	-0.00085***
	(0.000717)	(0.000586)	(0.000955)	(0.00108)	(0.00348)	(0.00269)	(0.000308)
Distance to Pucca road	-0.00239***	0.00629***	-0.00123	-0.000792	0.000128	-0.00441*	0.00367***
	(0.000569)	(0.000546)	(0.000785)	(0.000954)	(0.00276)	(0.00232)	(0.000210)
Distance to wholesale Market	-0.00113	-0.00452***	-0.00371*	0.00690***	0.000690	0.0165***	1.42e-05
	(0.000832)	(0.00110)	(0.00221)	(0.00226)	(0.00569)	(0.00542)	(0.000329)
No. of times AES activities	-0.00291***	-0.000635	-0.00673***	0.00149	-0.00320	-9.95e-05	0.000598***
	(0.000578)	(0.000495)	(0.000808)	(0.000984)	(0.00260)	(0.00223)	(0.000203)
Proportion of gvt. canal irrigated	-0.00371***	-0.0503***	0.147***	-0.00125	0.0297	0.0108	0.000624
	(0.000763)	(0.0120)	(0.0307)	(0.0171)	(0.0782)	(0.0563)	(0.000448)
Proportion of tank irrigated	0.0636***	0.266***	0.195***	0.130***	-0.364***	0.111	0.0664***
	(0.0235)	(0.0733)	(0.0445)	(0.0390)	(0.105)	(0.158)	(0.00970)
Proportion of well irrigated	-0.0850***	0.112***	0.0592**	0.0162	0.114	0.0845	0.00751
	(0.0292)	(0.0267)	(0.0288)	(0.0437)	(0.0802)	(0.0936)	(0.00840)
Prop. HYV area	0.0547***	0.0204	-0.0808***	-0.115***	-0.189**	-0.169**	-0.0492***
	(0.0180)	(0.0153)	(0.0225)	(0.0265)	(0.0795)	(0.0748)	(0.00621)
Mean rainfall in Kharip	-0.00677***	-	0.00278***	0.00122	0.00163	-0.0147***	-0.00336***
	(0.000832)		(0.00108)	(0.00128)	(0.00413)	(0.00393)	(0.000333)
Mean rainfall in Rabi	-	0.00295***	0.000413	-0.00256***	0.00291	-0.00401*	0.000854***
		(0.000473)	(0.000763)	(0.000983)	(0.00258)	(0.00212)	(0.000208)
Proportion of agricultural expenditure	0.218***	0.249***	-0.138*	-0.130	-0.0401	-0.297**	0.239***
	(0.0529)	(0.0478)	(0.0715)	(0.123)	(0.283)	(0.126)	(0.0180)
No. GS meeting held	-0.00102	0.00135	0.00239**	0.00213	-0.00770**	0.00148	0.00153***
	(0.000803)	(0.000890)	(0.00115)	(0.00133)	(0.00389)	(0.00351)	(0.000356)
Women reservation	-0.0178*	0.00882	-0.0354**	-0.0347*	-0.0282	0.0843**	0.00387
	(0.0107)	(0.00841)	(0.0138)	(0.0177)	(0.0537)	(0.0370)	(0.00390)
Observations	3,799	2,920	3,002	1,601	1,549	3,067	9,355