Sources of Output Growth in Indian Agriculture during the Post-Reform Period *

K.R. Shanmugam
Professor
Madras School of Economics,
shanmugam@mse.ac.in

and

Vidhya Soundararajan
M.Sc. 2 year Student
Madras School of Economics,
vidhyas@mse.ac.in

* This paper was presented at the 44th Indian Econometric Society Conference at Hyderabad in January 2008.

WORKING PAPER 26/2008

February 2008

Price: Rs. 35

MADRAS SCHOOL OF ECONOMICS
Gandhi Mandapam Road
Chennai 600 025
India

Phone: 2230 0304/ 2230 0307/2235 2157
Fax : 2235 4847 /2235 2155
Email : info@mse.ac.in
Website: www.mse.ac.in

Sources of Output Growth in Indian Agriculture during the Post-Reform Period

K.R. Shanmugam and Vidhya Soundararajan

Abstract

Economic growth has failed to be sufficiently inclusive, particularly after the mid-nineties. Although agriculture is still a single major sector providing livelihood to more than 60 percent of the population, it has lost its growth momentum and the share has been declining continuously for a variety of reasons like low income due to inadequate output growth, low productivity, lack of credit at reasonable rates, natural calamities and unavailability of proper extension services.

Realizing the importance of this sector and its current crisis, the Eleventh Plan aims to reverse this trend. Output growth could be possible by increasing input growth, technical progress and improvement in technical efficiency. In order to identify the source of the problem, this paper attempts to decompose the agricultural output growth obtained in 15 major states for the period 1994-95 to 2003-04 into the above three components using the random coefficients frontier production function model. Results of the study indicate that the efficiency has declined over time for all the states and the average technical efficiency is only 72 percent. This means that there is a potential to increase the existing output by 28 percent without increasing inputs. We found that in most of the states, growth was only due to higher inputs. Investment in extension services along with sustained investment in agricultural research and development, and infrastructure is the need of the hour. West Bengal is the most efficient state in applying labor and fertilizer inputs and also has a very high over all efficiency. This can be linked to the successful land reform policies of the state.

Acknowledgement

The authors are grateful to Dr. K.P. Kalirajan, Foundation for Advanced Studies in International Development, Tokyo for his valuable comments on the earlier draft of this paper.

1. Introduction

Changes in the agricultural sector have strong repercussions in the Indian economy, through the channels of poverty, food insecurity, inflation and many more. The crucial role played by the agricultural sector has been identified as central to inclusive growth and its recent economic slow down warrants a special attention for its revival. Although it provides employment to more than 60 per cent people, it contributes only about 20 per cent of Gross Domestic Product (GDP). The output growth of agricultural sector would definitely reduce poverty to a greater extent than growth in any other sector by providing employment, by stabilizing prices, by providing food security and by a multitude of other spill-over effects.

International comparisons reveal that agricultural productivity in India is very low. Production levels of India's many cash crops and food grains have top ranks in the world level, but their yield figures are below world average. For instance, although India ranks second in producing Rice and Paddy (next to China), its productivity is only half of that of China[1].This poor performance of agricultural sector can be partly attributed to the declining share of agricultural and allied activities in the plan outlays allocated by the Planning Commission of India. Increased

[1] India's yield of Rice and Paddy - 3152.08 kg/ha; China's yield of Rice and Paddy – 6250.83 kg/ha. It is very interesting to note that at the dawn of planning in 1952, Indian per capita income measured in PPP dollars in 1952 was about 54 per cent higher than China's. But now China is clearly ahead of India in agriculture**.** The Chinese planning was organized sequentially with sustained agriculture followed by industrial expansion. But the Indian planning left agriculture forlorn expect when there was a crisis. India is paying a price now for this limitation in its planning. The importance of agricultural sector and inclusive growth has been in light from the first five year plan and has been cited in every plan then upon. However, our planning and policies have so far been inadequate to ensure inclusive growth.

plan outlay can boost performance through increased availability of inputs and better technology. The decline in the share of agriculture started from the sixth plan where the share fell from 12.3 percent in the fifth plan to 5.8 percent in the sixth plan (Planning Commission, India 2002). But in the current scenario, increasing inputs is not a feasible way of increasing output because water and land inputs are scarce. Further, due to globalization, more and more land and labor inputs are allocated for non-agricultural purposes. One other alternative to increase output is technological advancement, but there has been no major technological breakthrough after the green revolution. The recent bio- technology revolution has not been very successful and has its own adverse effects due to high cost seeds and non-reusability of seeds.

In the light of above facts, the immediate solution to increase agricultural production can come from an increase in production efficiency. Hence, it is essential to assess how the existing resources are being used and what possibilities exist for improving efficiency of agricultural production in India, given the resource constraints. Efficiency can be measured in terms of Allocative and Technical Efficiency. In this paper, we focus on the latter and employ the frontier production function technique to measure the extent of Technical Efficiency (TE)[2] of raising agricultural outputs in India using State level panel data for the period, 1994-95 to 2003-04. When the production is not on the frontier, there is a potential to increase

[2] Technical efficiency of a farm can be defined as the ability and willingness of the farm to obtain the maximum possible output with a specified endowment of inputs (represented by a frontier production function), given the technology and environmental conditions surrounding the farm.

output without increasing the inputs. The output growth can be due to either one or the combination of input growth, change in technology and change in TE. We also attempt to decompose output growth into the above three components for 3 sub-periods viz., 1994-95 to 1996-97, 1997-98 to 1999-00, and 2000-01 to 2003-04.

The rest of the paper proceeds as follows. Section 2 explains the methodology employed in this study to estimate state specific TE and to decompose the total output growth. Data, modeling strategy and variables are discussed in Section 3. Section 4 provides the empirical results, and Section 5 summarizes the findings and discusses the policy implications.

2. The Methodology

In this study, we employ the varying or random coefficients stochastic frontier production function methodology to measure Technical Efficiency (TE) of raising agricultural outputs in 15 major States of India. The frontier production function can be defined as the relation that gives the maximum possible or potential output that a decision making unit-DMU (such as firm/farm or region) can produce with a given level of inputs and technology. The actual production of the i^{th} DMU in period t (Q_{it}) can be written as:

$$Q_{it} \leq f(x_{it}; \beta) \quad ; \qquad i = 1,2,\ldots,n \text{ and } t = 1,2,\ldots\ldots,T \tag{1}$$

where x_{it} is a vector of inputs and β is a vector of parameters that describe the transformation process; f (.) is the frontier production function, or potential output of the DMU. If the operation of the DMU is inefficient (efficient) the actual output produced by it is less than (equal to) its potential output. Therefore, we can define the TE of the DMU as the ratio of its actual output to the output that could potentially be produced if all existing inputs/technologies are used in the best possible fashion.

The first empirical study to measure technical efficiency was carried out by Farrell (1957) for a cross-section of firms by using a deterministic/non-parametric frontier approach. Aigner *et al.,* (1977) and Meeusen and Broeck(1977) independently developed a stochastic frontier approach in which the error term was modeled as a composite variable, consisting of a random noise component and a one-sided residual component (which follows a half normal distribution). This approach has been extended in many ways, both in terms of the specification of the error term (through the use of truncated normal, exponential and gamma distributions), as well as in the consideration of panel data. Broadly, the panel data methodologies are grouped as time invariant and time varying TE models. A number of comprehensive literature reviews on these methodologies are available in Bauer (1990), Greene (1993), and Kalirajan and Shand (1994).[3]

The literature suggests that a farm obtains its full TE by following the "best practice" techniques, given technology. Stated differently, the method of application of inputs determines the TE regardless of level of inputs (i.e., scale of operation). This implies that different methods of

[3] All these extensions require the functional form of the frontier and distribution of the one-sided residual term to be specified. This can result in errors of mis-specification if the above specifications are incorrect.

applying various inputs will influence the outputs differently. In that case, the slope coefficient will vary from farm to farm and the constant slope approach is not consistent with the theoretical definition of TE. Therefore, a varying parameters model is appropriate.

Following Kalirajan and Bhide (2004), the general formulation of the Cobb-Douglas Stochastic Coefficients Frontier production function for panel data is written as:

$$\text{Ln } Q_{it} = \beta_{oit} + \sum_j \beta_{ijt} X_{ijt} + \varepsilon_{it} \qquad (1)$$

$$i = 1, 2, \ldots\ldots n$$
$$t = 1, 2, \ldots\ldots T$$

where, X_{jit} is the j^{th} input used by i^{th} DMU in t^{th} period and ε_{it} is the usual random error term; β_{oit} is the intercept term for i^{th} DMU in period t and β_{jit} is the actual response of the output to method of application of j^{th} input by i^{th} DMU in period t.

Each unit's actual coefficient vector β_{jit} at a particular time is allowed to vary from the mean response coefficient vector $\overline{\beta_j}$ by some v_{jit}. That is, $\beta_{jit} = \overline{\beta_j} + v_{jit}$ where, v_{jit} is a random disturbances.

Further we assume the following:

1. $E(\beta_{jit}) = \overline{\beta_j}$; $V(\beta_{jit}) = \sigma^2_j > 0$; $Cov(\beta_{jit}\ \beta_{jkt}) = 0$ for $i \ddagger k$ (this implies that β_{jit} are i.i.d. with fixed mean);
2. $E(v_{jit}) = 0$; $E(v_l v_m') = \alpha_k$ for l=m (l and m are cross sectional units) and $E(v_l v_m') = 0$ otherwise.

With these assumptions, the equation (2) can be written as:

$$\ln Q_{it} = \sum \overline{\beta_j} \ln X_{jit} + \sum v_{jit} \ln X_{jit} + \varepsilon_{it} \qquad (2)$$

This is a linear model with mean response coefficients, but has heteroscedastic disturbances. Therefore, the OLS estimation of (2) will yield unbiased but inefficient estimates of $\overline{\beta_j}$. However using the iterative procedure suggested in Swamy (1971), one can obtain the feasible GLS estimates of $\overline{\beta_j}$ and using the procedure suggested in Griffiths (1972), one can estimate the individual response coefficients.

The assumptions underlying the model (2) are:

1. TE is achieved by adopting the best practice techniques, which involve the efficient use of inputs. TE stems from two sources: (i) Efficient use of each input that contributes individually to TE and can be measured by the magnitude of varying slope coefficients; and (ii) Any other sample unit specific intrinsic characteristics that are not directly included may produce a combined contributions over and above the individual contribution. This lump sum contribution can be achieved by the varying intercept.
2. The highest magnitude of each of the estimates (i.e., $\hat{\beta}_{jt}^* = Max(\hat{\beta}_{jit})$ from the production coefficients of the potential frontier production function.[4]

[4] In special cases of the production process in which constant returns to scale are imposed on the individual response coefficients, β_{ijt}, the estimation of $\hat{\beta}_{jt}^*$'s would be complicated and intractable. Even when the condition of constant returns to scale is imposed on the mean response coefficients, $\overline{\beta_j}$'s, the possibility that $\sum \hat{\beta}_j^* > 1$ cannot be ruled out. In either case, the problem that remains is that the best practice production outcome might not be feasible if all production processes had to have constant returns to scale by some strict technical rule.

Using the frontier coefficients $\hat{\beta}^*$'s, one can compute the potential output of each DMU in period t as:

$$\ln Q_{it}^* = \sum \hat{\beta}_{jt}^* \ln X_{jit} \qquad (3)$$

Then the TE of the i^{th} DMU in the t^{th} period can be calculated as:

$$(TE)_{it} = \frac{Q_{it}}{\exp(\ln Q_{it}^*)} \qquad (4)$$

The input-specific efficiency of the i^{th} sample unit in the t^{th} period, which is given by the ratio between actual response and potential response coefficient, can be computed as:

$$\pi_{jit} = (\hat{\beta}_{jit} / \hat{\beta}_j^*) x100 \qquad (5)$$

where, $\hat{\beta}_{jit}$ is the actual response coefficient of the j^{th} input of the i^{th} DMU in the t^{th} period and $\hat{\beta}_{jt}^*$ is the frontier coefficient of the j^{th} input in the t^{th} period.

Decomposition of Total Output Growth

Following Kalirajan and Shand (1997), Figure 1 illustrates the decomposition of total output growth into input growth, technical advancement and technical efficiency improvement. F_1 and F_2 are the frontier production functions in period 1 and 2 respectively. q_l^* and q_2^* are technically efficient levels of production and q_1 and q_2 are actual output levels in the respective periods. Technical inefficiency (TI) in any given period is indicated by the output gap (the difference between actual and frontier output levels). Suppose there is technological advancement (TA) in period 2, the frontier function will shift to F_2 at the end of period 2 and if the Decision making unit (DMU) keeps up with the advancement, DMU's output will be q_1** from the given x_1 input. Therefore, technological advancement can be measured by the distance between the frontier F_1 and F_2 (i.e, q_1**- q_1* evaluated at x_1). Let Δq_x be the contribution of input growth to output growth, (between periods 1 and 2). Then, the total output growth, G (= q_2 - q_1), can be decomposed into three components: input growth, technological progress and technical efficiency change.

In Figure 1, the decomposition of output growth, G can be shown as follows:

$$G = q_2 - q_1 = A + B + C = (q_1^* - q_1) + (q_1^{**} - q_1^*) + (q_2 - q_1^{**})$$
$$= (q_1^* - q_1) + (q_1^{**} - q_1^*) + (q_2^* - q_1^{**}) - (q_2^* - q_2)$$
$$= [(q_1^* - q_1) - (q_2^* - q_2)] + (q_1^{**} - q_1^*) + (q_2^* - q_1^{**})$$
$$= [TI_1 - TI_2] + TC + \Delta q_x \qquad (6)$$

= Technical efficiency change + Technology change + Input growth

Total Factor Productivity (TFP) growth can be defined as the output growth not explained by input growth. From equation (6), the TPF growth consists of two components: Technical efficiency change and technological advancement (i.e., TFP growth=TI_1 - TI_2 + TC). Kalirajan and Bhide (2004) also point out that this decomposition of TFP into these components helps us to distinguish technical changes from technology adoption. High rate of technological progress can exist with low rate of change in technical efficiency, a case in which there is poor technology adoption and diffusion. High growth in technical efficiency can also coexist with low technological advancement.

3. Data, Model and Estimation

Aggregate level data on agricultural output for 15 major States in India for the period 1994-95 to 2003-04 have been obtained from the Central Statistical Organization (CSO). Data on agricultural inputs have been obtained from Centre for Monitoring the Indian Economy (CMIE) and Census of India (1991, 2001). The final data set used in this study is a balanced panel of 150 observations.

The following Cobb-Douglas varying coefficients frontier production function has been employed in the empirical estimation:

$$\ln Q_{it} = \beta_{0it} + \beta_{1it} \ln L_{it} + \beta_{2it} \ln F_{it} + \beta_{3it} \ln E_{it} + \beta_{4it} \ln M_{it} + \beta_{5it} t + u_{it} \qquad (7)$$

where Q_{it} is the value of agricultural output in State i in period t in India (in 1993-94 prices);[5] L is the gross cropped area (in thousand hectare), F is the fertilizer (N+P+K) input use in agriculture (in thousand tonnes); E is the total labor force devoted to agriculture;[6] M is the number of tractors (a proxy for machinery) used in agricultural operation (measured in 125 equivalent domestic animal), and all the β_{jit}'s are input specific response coefficients for i^{th} DMU in t^{th} period. t is the trend variable.[7] As

[5] The output measure, value of agricultural output, represents the price-weighted sum of output for 35 crops, which account for over 97 percent of the total value of agricultural production in India.

[6] For labor, we used data from the Census of India, 1991 and 2001. First the state wise number of agricultural workers and cultivators (male and female) data for the years 1991 and 2001 were taken from Census of India 1991 and 2001. Using these data, the compound growth rates were computed for each variable. Using the compound growth rates, we projected the data for the years 1994-95 to 2003-04. Then the total work force in agriculture was computed by adding the number of agricultural workers and cultivators for the years 1991 and 2001 (while adding female were given 2/3 weight).

[7] We also tried to use the more flexible trans-log specification, but found that the Cobb-Douglas approach fits the data best.

illustrated above, we can calculate the overall and input specific technical efficiencies from the β's. Table 1 provides the means and standard deviations of the study variables used in the study.

4. Empirical Results

Table 2 provides the iterative GLS estimation results of the equation (7). While Column 1 of Table 2 shows the mean response coefficients of the model 1 that includes all input variables including tractor and trend variable, Column 2 shows the mean response parameters of all variables after dropping tractor variable (as it is not significant in model 1). As the tractor and trend variables are not statistically significant at 5 per cent, the model 3 in Column 3 drops these two variables. Columns 4 and 5 show the minimum and maximum values of the individual response coefficients of model 3.[8] The range of the coefficients clearly shows that the input-specific response coefficients did vary across States. All the three input variables (land, fertilizer and employees) positively and significantly influence agricultural output variable at the 5 per cent level.

Using the frontier (maximum response) coefficients for each sample year, the potential (frontier) outputs for each period t for the sample States are calculated. For the sample States, these frontier estimates show the maximum possible contribution of core inputs to output when the inputs are applied in accordance to the best practice techniques of the given technology. The overall TE and input specific efficiency of the i^{th} State in the t^{th} period are computed using equations (4) and (5).

[8] For the sake of brevity, we report only overall frontier coefficients for the study period. Year specific frontier coefficients are not shown here but available with authors on request.

Table 3 reports the State specific mean (overall) TE values during 1994-95 to 2003-04. The mean TE in the sample is roughly 72 per cent, which means that the sample states on an average could increase their agricultural output by 28 per cent without additional resources through proper use of existing input resources and technology. Put differently on an average approximately 28 per cent of the technical potentials of the Indian States was not realized in raising agriculture. The mean TE values vary widely among states. Orissa has the lowest mean TE (49.6 per cent) while Kerala has the highest (89.1 per cent).

The mean input specific efficiency values given in Table 3 show that West Bengal is the most efficient in applying labor and fertilizer inputs. West Bengal has gone through major land reforms. Despite the fact that the state ranks third from bottom in irrigated acreage, third most densely agricultural state with 77 percent of its land under agriculture, its yield is one among the top three states in the post reform period (Guruswamy, 2005). Our results also show that Assam is the most efficient in utilizing land and second most in employing labors. Kerala is the second most efficient in using land and fertilizer inputs. The results related to Assam and Kerala are more of a statistical phenomenon as these states have very low inputs and very low outputs. In this case, the potential output is low and very likely to be closer to the actual output and it seems like the efficiency is very high.

Table 4 shows the TE growth and input growth between 1994-95 and 1996-97 (immediate reform period), between 1997-98 and 1999-00 (East-Asian crisis period), and between 2000-01 and 2003-04 (matured reform period). The numbers given are in absolute terms. The TC contribution to output growth is not reported due to space constraints. If one analyses the percentage contribution of technical efficiency to growth over the three sub periods in each of the states, it can be seen that for almost all the states, the contribution decreases over time (Figure 2). This shows that even though there was very little growth, much of it occurred due to increased input growth. This is not a very good sign and it indicates that output growth could have in fact been higher if there was complete technical efficiency.

This indirectly highlights the deficiency in good policies in favor of raising the efficiency of agriculture in India in the post reform period. Liberalization and opening up of the Indian economy to the world necessitates improved productivity to compete in the world market. This should have brought in efficiency according to the micro-economic theory. But our results indicate that the Indian agriculture has been losing its competitiveness in the world market due to low technical efficiency.[9]

Low efficiency may be linked to the market failure in the agricultural sector. The most important cause of market failure in Indian agriculture is information asymmetry. Presence of technical inefficiency indicates lack of efficient resource utilization, lack of use of best practices and absence of technology diffusion. Given that there has been no major breakthrough in agricultural technology after the green revolution, it is understood that improving technical efficiency by adopting appropriate policies to provide extension services and other information dissemination tool is the need of the hour. We do not deny the importance of investment in R & D, but as we need to wait to realize the fruits of these investments, an immediate solution to the Indian agricultural crisis could be an improvement in technical efficiency.

[9] To quote an example, we can take the case of tea leaves, where India was doing very well in the world market before the economic reforms. But after India started liberalizing and after the formation of the WTO, many other countries started producing and exporting tea at lower cost. India started losing out in the price based competition in the world market due to the low efficiency in production coupled with excessive dependence with USSR in the pre-reform period. Efficiency as we can see had a multitude of spill over effects in the post reform period.

5. Conclusions

Our study finds that the mean TE in the post reform period is roughly 72 per cent, indicating a scope for raising outputs without additional resources through proper use of existing input resources and technology. Since technological progress and technical efficiency are the two key sources of agricultural growth and they declined in recent periods, more attention should be paid to promote them in order to sustain the growth. The accelerated introduction of better technologies and best techniques depends on sustained investment in agricultural R& D and infrastructure including agricultural credit. Instead of providing input subsidies, the Governments should spend more effectively on infrastructure (Kalirajan and Shand, 1997). It is also necessary to invest in information dissemination tools, because the major problem we have identified is that of technical inefficiency, the rectification of which can provide a new channel of agricultural growth for India.

References

Aigner, D.J., C.A.K. Lovell and P. Schmidt (1977), “Formulation and Estimation of Stochastic Frontier Production Function Models”, *Journal of Econometrics*, 6 (1), July, pp. 21-37.

Bauer, P. W. (1990), “Recent Developments in the Econometric Estimation of Frontier”, *Journal of Econometrics*, 46, pp. 39-56.

Farrell, M.J. (1957), “The Measurement of Productive Efficiency”, *Journal of Royal Statistical Society*, 120 (Part 3), pp. 253-81.

Government of India (GOI), Central Statistical Organization (CSO), Ministry of Statistics and Programme Implementation (website: http://mospi.nic.in).

Greene, W. H. (1993), “The Econometric Approach to Efficiency Analysis”, in H. O. Fried, C.A.K. Lovell and S. S. Schmidt (Eds.), *The Measurement of Productive Efficiency: Techniques and Applications*, Oxford University Press, London, pp.68-117.

Griffiths, W.E. (1972), “Estimation of actual response coefficients in the Hildreth-Houck random coefficient model”, *Journal of the American Statistical Association*, 67, 633-635.

Guruswamy, Mohan (2005), “Economic growth in West Bengal”, *The Hindu*, March 19, 2005.

Kalirajan, K.P. and R.T. Shand (1994), *Economics in Disequilibrium: An Approach from the Frontier*, Macmillan India Ltd., New Delhi.

Kalirajan, K.P. and R.T. Shand (1997), “Sources of Output Growth in Indian Agriculture”, *Indian Journal of Agricultural Economics*, 52, pp. 693-706.

Kalirajan, K.P. and S. Bhide (2004), “The Post-Reform Performance of the Manufacturing Sector in India, *Asian Economic Papers, Vol.3, No.2, pp.126-165.*

Meeusen, W. and J.V.D. Broeck (1977), “Efficiency Estimation from Cobb Douglas Production Function with Composed Error”, *International Economic Review, 18, pp.435-44.*

Planning Commission of India (2002), *Tenth Plan Document*, Vol.2, (http://planningcommission.nic.in/plans/planrel/fiveyr/10th/volume2/v2_ch5_1.pdf).

Swamy, P.A.V.B. (1971), “Statistical Inference in Random Coefficient Regression Models”, Berlin: Springer-Verlag.

Table 1: State-wise Mean for Input and Output Variables (1994-95 to 2003-04)

STATE	Gross Cropped Area (000' hectare)	Fertilizer (in 000' tonnes)	Labor (male equivalent in lakh)	Tractor (125 animal equivalent)	Output (Rs. in lakh)
Andhra Pradesh	12824.50	1864.40	180.24	7529084.89	1944985.20
	(656.88)	(190.46)	(5.02)	(2497602.17)	(218452.62)
Assam	3980.50	105.60	44.00	1009590.77	550549.90
	(61.18)	(55.57)	(1.45)	(136430.97)	(21160.20)
Bihar	10024.50	837.80	239.45	11097845.23	1573485.70
	(75.18)	(98.51)	(22.23)	(2566121.50)	(185393.93)
Gujarat	10737.50	887.00	89.61	27005546.50	1394821.70
	(531.63)	(114.20)	(8.08)	(6742262.93)	(279225.44)
Haryana	6135.60	863.50	34.61	33260718.38	1032601.10
	(153.93)	(107.20)	(5.09)	(7098568.89)	(63507.75)
Karnataka	11934.60	1073.30	108.92	11792756.15	1510357.30
	(330.36)	(188.39)	(5.26)	(2790004.67)	(207006.45)
Kerala	3001.80	194.90	22.63	871464.30	664035.40
	(45.13)	(15.08)	(2.04)	(185635.09)	(78948.23)
Madhya Pradesh	23985.30	1051.30	207.75	30257181.13	1801090.80
	(2600.94)	(155.08)	(18.94)	(7630863.78)	(203803.85)
Maharashtra	21948.60	1571.20	182.76	19339559.88	2222072.70
	(411.71)	(186.11)	(10.55)	(5258957.70)	(153389.59)
Orissa	8637.20	294.00	78.84	2853402.49	605750.30
	(640.88)	(46.08)	(4.54)	(457229.37)	(57582.79)
Punjab	7870.60	1354.90	33.10	52161368.13	1541041.50
	(154.16)	(99.61)	(1.14)	(4714611.58)	(102264.83)
Rajasthan	19866.70	705.90	121.52	39439656.75	1450793.90
	(2547.92)	(89.68)	(17.47)	(9754390.98)	(247722.77)
Tamil Nadu	6252.50	872.30	116.95	7929602.61	1323127.20
	(573.17)	(114.68)	(0.22)	(1145412.15)	(147882.58)
Uttar Pradesh	25961.10	3078.00	325.69	73498395.75	3726117.60
	(886.80)	(335.77)	(21.46)	(16098195.20)	(247439.18)
West Bengal	9292.90	1021.70	115.82	3824430.74	1882892.70
	(333.72)	(158.47)	(5.85)	(840647.66)	(176467.63)
Total Sample	12163.59	1051.72	126.79	21458040.24	1548248.20
	(7179.12)	(728.06)	(84.25)	(21403860.39)	(775851.98)

Source: Authors' calculation. Figures in parentheses are standard deviations.

Table 2: Mean Response Coefficients, and Range of Estimates of the Actual Response Coefficients

	Model 1	Model 2	Model 3		
Variables	Mean Response Coefficients		Mean Response Coefficients	Minimum Response Coefficients	Maximum Response Coefficients
	(1)	(2)	(3)	(4)	(5)
Intercept	9.521 (25.138)	9.542 (25.353)	9.578 (26.059)	9.266	9.946
Ln (Land)	0.210 (2.852)	0.140 (2.401)	0.128 (2.200)	0.116	0.140
Ln (Fertlizer)	0.408 (6.987)	0.422 (9.140)	0.411 (8.855)	0.405	0.415
Ln (Employees)	0.120 (2.359)	0.104 (2.925)	0.137 (3.885)	0.117	0.158
Ln (Tractors)	(0.042) (1.336)	-	-	-	-
Trend	0.013 (1.600)	0.001 (0.184)	-	-	-
Sample (N)			150		

Source: Authors' estimation. Figures in parentheses are absolute t values.

Table 3: State Specific Input Specific (Average) Efficiency Values and Overall Efficiency

States	Overall TE*		Land Efficiency		Fertilizer Efficiency		Labour Efficiency	
	(%)	Rank	(%)	Rank	(%)	Rank	(%)	Rank
Andhra Pradesh	62.8	14	89.54	14	97.50	14	82.94	14
Assam	88.5	2	94.35	1	98.25	4	90.40	2
Combined Bihar	70.1	7	91.08	7	97.83	7	85.64	7
Gujarat	68.6	9	90.65	10	97.74	10	84.96	9
Haryana	64.4	13	89.55	13	97.51	13	83.68	13
Karnataka	65.8	11	90.12	12	97.64	12	84.10	12
Kerala	89.1	1	94.34	2	98.40	2	89.78	4
Combined MP*	65.6	12	90.38	11	97.70	11	84.45	11
Maharashtra	71.3	6	91.48	6	97.90	6	86.31	6
Orissa	49.6	15	85.81	15	96.94	15	77.49	15
Punjab	77.9	5	92.40	5	98.11	5	87.33	5
Rajasthan	69.3	8	90.93	8	97.80	8	85.38	8
Tamil Nadu	68.2	10	90.66	9	97.74	9	84.89	10
Combined UP*	81.0	4	93.39	4	98.31	3	89.84	3
West Bengal	86.8	3	94.12	3	98.44	1	90.70	1
Average	**71.9**		**91.25**		**97.85**		**85.86**	

Source: Authors' calculation.

* MP - Madhya Pradesh, UP - Uttar Pradesh, and TE - Technical Efficiency.

Table 4: Source of Agricultural Growth in Various States

States	1994-95 to 1996-97			1997-98 to 1999-00			2000-01 to 2003-04		
	TE Growth	Input Growth	Total growth	TE Growth	Input Growth	Total growth	TE Growth	Input Growth	Total growth
Andhra Pradesh	0.266	0.040	0.125	0.151	0.105	0.200	0.018	-0.074	0.000
Assam	-0.001	0.178	0.010	-0.190	0.188	-0.052	-0.088	0.124	0.086
Combined Bihar	0.124	0.088	0.031	0.116	0.044	0.104	-0.058	-0.063	-0.065
Gujarat	0.348	0.003	0.175	-0.217	-0.030	-0.300	0.426	0.147	0.627
Haryana	0.179	0.040	0.051	0.085	0.041	0.077	-0.037	0.072	0.086
Karnataka	0.230	0.010	0.062	0.205	0.066	0.217	-0.330	-0.160	-0.436
Kerala	0.227	-0.034	0.030	0.106	-0.023	0.036	-0.062	0.027	0.013
Combined MP	0.165	0.078	0.060	0.135	0.000	0.079	0.167	0.137	0.361
Maharashtra	0.381	-0.011	0.188	0.127	0.086	0.156	-0.048	-0.046	-0.037
Orissa	0.009	0.036	-0.129	-0.148	0.091	-0.109	0.099	0.032	0.183
Punjab	0.261	-0.024	0.067	0.100	0.048	0.099	-0.096	0.074	0.030
Rajasthan	0.261	0.076	0.158	-0.100	0.009	-0.146	0.255	0.105	0.416
Tamil Nadu	0.072	-0.054	-0.158	0.041	0.045	0.033	-0.205	-0.148	-0.299
Combined UP	0.214	0.077	0.104	0.129	0.017	0.088	-0.050	0.061	0.069
West Bengal	0.174	0.081	0.078	-0.067	0.105	-0.015	0.000	0.028	0.083

Source: Authors' calculation.

Figure 1: Decomposition of Total Factor Productivity Growth

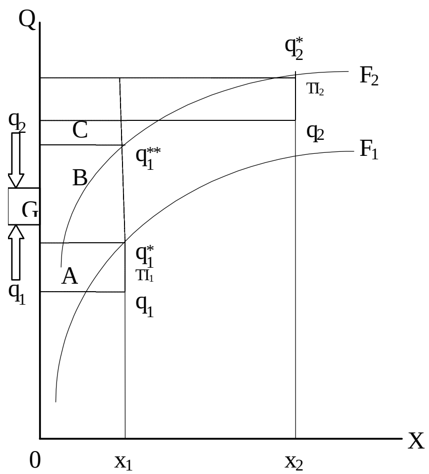
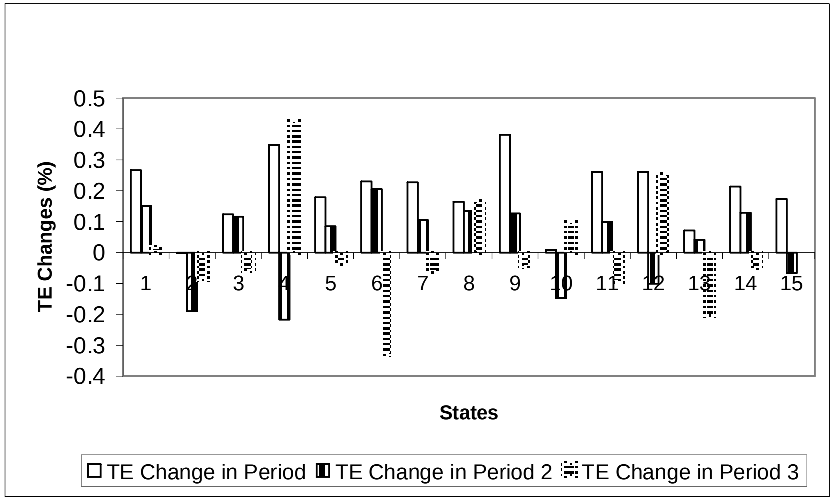


Figure 2: TE changes in Indian Agriculture (1994-95 to 2003-04)



Source: Authors' calculation.