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Liberalised Era and Technical Efficiency in Agriculture: Variations in Gujarat and West Bengal

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I

INTRODUCTION

Technological innovation, exploitation of chosen technology as well as removing non-price and institutional constraints are essential for agricultural growth. Technology did play a crucial role in alleviating India's poverty in the 1970s; since then its contribution to agricultural growth has been rather dismal. This can be supported by the fact that India's average growth rate at 2.3 per cent per annum of the agricultural gross domestic product (GDP) in two decades of the green revolution (1968-88) compares modestly with trend rate of growth for green revolution crops (rice and wheat) in most other Asian countries over that period (Ahluwalia, 1991). There also exists a wide gap in India's performance between achievement in output and productivity. India compares poorly in terms of yield per hectare and yield gaps exist between technologically progressive and backward regions (Kalirajan and Shand, 1997).

In the liberalisation phase, terms of trade for agriculture have become favourable due to exchange rate devaluation and reduced protection to industry and services. However, the favourable internal terms of trade and freeing trade in agriculture would provide only feeble inducement for agricultural progress (Kashyap and Mathur, 1999). Growth in technical change or total factor productivity in agriculture is a necessary and sufficient condition for its development, as it prevents agriculture from falling into the trap of diminishing returns and leads to increasing production at reduced costs. It is therefore important to study what determines technical change in agriculture, as it would aid informed decision making in identifying policy priorities. The earlier studies (Rosegrant and Evenson, 1995; Kumar and Rosegrant, 1994) have shown that technical change in agriculture is influenced by non-price factors such as investments in research, extension, education and rural infrastructure.

The present paper seeks to ascertain the efficiency parameter in agricultural growth in Gujarat and West Bengal- two diverse agricultural scenarios. Whether reforms process has aided technical efficiency in agriculture has been assessed. Following the introduction, Section II highlights the variations in agricultural growth in Gujarat and West Bengal. Section III discusses the nature of technical change and measurement issues. The methodology used and model adopted to calculate technical

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efficiency are highlighted. Section IV discusses results of the frontier production function. The last section gives the concluding remarks.

II

AGRICULTURAL GROWTH TRENDS IN GUJARAT AND WEST BENGAL

Gujarat is a water scarce state and 27 per cent of its area is drought prone. The average annual rainfall varies from 573 mm to 1100 mm. The problem of water availability is manifested in irrigation development, with only 31.5 per cent of the state's cultivated area being irrigated. Of this nearly 82.3 per cent is from groundwater sources. Non-food crops dominate in Gujarat. Dryland cultivation of cash crops, notably groundnut in Saurashtra, seed spices, castor in North Gujarat and cotton cultivation is the mainstay of agriculture. Commercial orientation of agriculture is manifested in greater interface with markets for purchase of inputs and output disposal. Gujarat is predominantly a non-food crop based economy with preponderance of groundnut, cotton, tobacco. An examination of the cropping pattern (crop area share to gross cropped area) and changes between TE 1983 to TE 2005 show that there had been a decline in the share of cereals and foodgrains, giving way to non-foodgrain crops such as oilseeds, spices, horticultural crops or the non-traditional non-foodgrain crops. In the recent decades, commercial orientation is more associated with oilseeds, sugarcane, spices, potato, horticulture crops, etc. Cotton share declined up to 1993. However, with the onset of reforms and introduction of high-yielding BT cotton, the acreage picked up and is ranked now the most important cash crop after groundnut. More importantly the percentage of area under food grains in Gujarat has recently gone up, increasing from 38.2 lakh ha in TE 2005 to 42.17 lakh ha in TE 2009.

The agriculture scenario of Gujarat marked by absolute water scarcity presents a sharp contrast to water abundant West Bengal, not only in terms of the resource base (fertile alluvial soil and overlying a prolific river aquifer system) and cropping pattern, but also the production and agrarian systems. West Bengal receives average annual rainfall between 1430 mm to 2662 mm. Of the 43 per cent of irrigated sown area, 59 per cent is through underground development. Rice is the main food crop. The medium and large landholding farmers (4 ha and above) constitute more than 20 per cent of the cultivators in Gujarat. In contrast this figure is only around 2 per cent in West Bengal.

Growth rate of agricultural production for West Bengal in 1981-82 to 1990-91 was 6.4 per cent per annum (Table 1). This growth was striking in comparison to the past, as agricultural output growth for the period 1965 to 1980 was 2.7 per cent (Boyce, 1987). In the 1980s, crop production reportedly grew by over 5 per cent. Growth rate in the period 1992-93 to 2002-03 declined from 5.6 per cent to 2.3 per cent. Since the early 1990s, there was a downfall in agricultural production that became increasingly large in 2000. Growth rate of yield declined from around 5 per cent to 2 per cent.

TABLE 1. CHANGES IN OUTPUT, AREA AND YIELD IN WEST BENGAL, 1965 TO 2003

Period (1)	Production (2)	Area (3)	Productivity (4)
1965-1980*	2.74 (0.33)	0.84	1.32
1981/82-1990/91†	6.40 (0.9)	1.20 (0.2)	5.20 (0.8)
1992/93- 2002/03$	2.33 (0.4)	0.29 (0.3)	1.98 (0.3)

Sources: * Boyce (1987). Based on exponential functional form.
†Saha and Swaminathan (1994). (The estimates are exponential growth rates, based on index number series on aggregate agricultural production).
$ Bhattacharyya and Bhattacharyya (2007). (Simple exponential growth rates of foodgrains production).
Note: Standard errors are shown in parentheses.

Agricultural growth in Gujarat faces a fluctuating trend (Dholakia, 2005). The phase coinciding with green revolution (1971-73 to 1981-83), was characterised by faster agricultural output growth, accelerating to 3.6 per cent on account of technological developments in agriculture (Table 2). Growth of agricultural output between 1981-83 to 1991-93 marked a turnaround reflected in the deceleration of output growth to -2.12 per cent from 3.6 per cent recorded in the previous phase. Output growth continued to decline during post-liberalisation phase, although the rate decelerated to -0.37 per cent. The 1970s decade was a sort of watershed as far as output from agriculture is concerned and output declined continuously thereafter.

TABLE 2. CHANGES IN AGGREGATE OUTPUT AND LAND PRODUCTIVITY, GUJARAT, 1963 TO 2003

	Per cent Annual Compound Growth Rate				
	1963-73	1973-83	1983-93	1993-2003	1963-2003
(1)	(2)	(3)	(4)	(5)	(6)
Value of output (1990-93 prices)	3.19	3.64	-2.12	-0.37	0.81
Land productivity (Rs. per ha)	1.49	3.67	-0.51	0.14	1.19

Source: Mehta (2006).

Table 3 shows the growth rates of major crops for the two states. For West Bengal it points to an impressive growth trajectory in the 1980s and a slowdown in period of market reforms. In the 1980s for most of the crops, the component of productivity growth contributed largely to output growth, higher than the contribution of area. There was a decline in instability in the level of rice output, particularly in the case of *aman* (*kharif*) crop. Oilseeds and potato output also grew at impressive rates. The exception was wheat, whose production stagnated and yields recorded a decline. Agricultural resurgence in West Bengal in the 1980s was due to improvement in the farming practices and use of high-yielding varieties on a larger scale than before. From the beginning of the 1990s a trend break in agricultural development was witnessed. Production of all the major crops registered a significant decline indicating that the adverse effects of market reforms have been felt strongly by the peasantry here.

TABLE 3. LINEAR GROWTH RATES OF AREA, PRODUCTION AND YIELD OF MAJOR CROPS IN GUJARAT AND WEST BENGAL

	1980/81 to 1990/91						1990/91 to 2004/05					
	Production		Area		Yield		Production		Area		Yield	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
West Bengal												
Rice (Total)	3.96**	(0.79)	1.21	(0.70)	2.81	(0.75)	2.88	(0.22)	0.1	(0.03)	2.14	(0.87)
Aman	2.24	(0.57)	0.19	(0.16)	2.05	(0.53)	1.82	(0.50)	-0.5	(0.29)	2.3	(0.75)
Aus	5.48*	(0.59)	0.85	(0.06)	4.64*	(0.93)	-2.9	(0.17)	-3.9**	(0.95)	1.01	(0.03)
Boro	7.30*	(0.73)	8.09*	(0.95)	0.19	(0.00)	3.93**	(0.73)	3.71**	(0.80)	0.22	(0.06)
Wheat	0.83	(0.03)	0.29	(0.00)	0.69	(0.03)	3.95**	(0.77)	3.57**	(0.88)	0.45	(0.11)
Pulses	-2.09	(0.38)	-5.84*	(0.92)	2.98**	(0.68)	0.22	(0.00)	-20.4*	(0.14)	1.36	(0.38)
Potato	7.79*	(0.93)	5.50*	(0.90)	2.91**	(0.94)	2.15	(0.01)	3.34**	(0.79)	0.39	(0.05)
Rape,Mustard	11.5*	(0.94)	9.04*	(0.95)	3.97**	(0.95)	1.73	(0.19)	1.24	(0.21)	0.43	(0.04)
Jute	0.36	(0.00)	-3.87**	(0.40)	4.02**	(0.92)	3.33	(0.77)	1.67	(0.49)	1.70	(0.85)

	1980/81 to 1990/91						1990/91 to 2005/06					
	Production		Area		Yield		Production		Area		Yield	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Gujarat												
Bajra	-0.54	(0.00)	-0.60	(0.08)	-0.08	(0.00)	-0.01	.	-2.96	(0.82)	2.97**	(0.33)
Jowar	-7.52**	(0.58)	-4.77*	(0.31)	-2.94**	(0.03)	-5.71*	(0.49)	-11.29*	(0.95)	6.36*	(0.79)
Wheat	-3.0	(0.11)	-2.0	(0.08)	-1.30	(0.12)	2.10	(0.10)	0.80	(0.03)	1.10	(1.27)
Pulses	-1.03	(0.01)	0.59	(0.04)	-1.97	(0.07)	-1.34	(0.06)	-1.97	(0.63)	0.64	(0.02)
Groundnut	-2.48	(0.03)	-2.35	(0.38)	-0.37	(0.00)	6.35*	(0.23)	0.17	(0.03)	6.00*	(0.22)
Cotton	-2.78	(0.09)	-4.24**	(0.57)	1.17	(0.02)	7.57*	(0.40)	3.56**	(0.89)	3.85**	(0.20)
Spices	2.30	(0.03)	0.17	(0.00)	1.59	(0.03)	2.27	(0.10)	2.65	(0.27)	-1.18	(0.04)
Potato	2.94	(0.17)	5.86*	(0.93)	-2.80	(0.17)	6.63*	(0.81)	5.83*	(0.89)	0.64	(0.12)

Source: Area, Production, and Yield from Crop and Season Reports, Government of Gujarat.

Notes: R Squared is shown in parentheses.

** and * significant at 10 and 5 per cent level, respectively.

Growth rate is computed from: In yt = a + bt, where y is the area, output or the yield, a is the constant term, t is time. The estimates of the co-efficient b are normalised by the mean value and multiplied by 100 to be taken as estimates of annual linear growth.

Deceleration of the agricultural growth in West Bengal after the mid-1990s has been commented upon by several researchers. The insights from literature (Ray and Ghosh, 2007; Bhattacharyya and Bhattacharyya, 2007; Bandopadhyaya, 2003; Banerjee *et al.,* 2002) strongly point that resource degradation faded the earlier glory of summer/*boro* cultivation. High agricultural growth in the 1980s was based on groundwater extraction. The belated green revolution was not sustainable and once the groundwater levels started to deplete it led to declining phase of agricultural growth. Withdrawal of fertiliser subsidy directly affected the production and yields of important crops. Liberalisation of food imports and crashing prices of agricultural commodities led to high cost of production of foodgrains. Absence of reasonable prices for products and mechanisms to distribute surplus foodgrains were further disincentives to produce.

The crop wise analysis depicted in Table 3 shows that in Gujarat, in the period under study and coinciding with the reforms phase, the area under wheat accelerated along with output. There was improvement in the yield levels for all major food crops, with accompanying commercialisation. The process of replacement of coarse cereals by oilseeds accelerated and oilseeds yield improved. Between 1990 and 2005 cotton area accelerated at statistically significant annual rate of 3.6 per cent. Most cultivators are switching over to Bt cotton. Thus during the reform period (upto the middle of the last decade, vis-à-vis the earlier decade), cotton output growth can be explained by area expansion and yield improvement in equal measure. For most other crops considerable headway was made on the yield front. The Northern and Middle Gujarat districts have an inherent advantage for production of potato and spices. These regions have taken advantage of liberalisation forces to expand area and output of these crops which are amenable to processing. Yield fluctuations experienced here are more in response to climatic anomalies. In general, crops with high proportion under assured irrigation show low and falling variability.

Improvements in crop yields in Gujarat in the second period of study are complemented by several Government initiatives. Noteworthy amongst them are improved quality of power supply to agriculture, completion of Sardar Sarovar project, promoting decentralised water-harvesting and check dams under Sardar Patel Participatory Irrigation Scheme, micro-irrigation systems through setting up Gujarat Green Revolution Company, and promoting watershed management (Gulati *et al.*, 2009; Shah *et al.,* 2009). Of the 1.8 million ha under the command area of Sardar Sarovar Project, the gravity flow of irrigation had reached 72,000 ha in 2008. However, it is noteworthy that over 215,000 ha are being irrigated by farmers lifting/siphoning water and transporting it by pipelines (Shah *et al.,* 2010). Thus while Narmada canals have not delivered water to fields in the entire command, the length of completed network has enabled farmers in many areas to tap water from the system. The gross irrigated area through this could be in the range of 2.4 -3.27 lakh ha (Kumar *et al.,* 2010). Since Narmada canal discharges water into several rivers of north and central Gujarat, Narmada water has been indirectly benefited by replenishing aquifers and rising water tables. Extension efforts are also being given a thrust to ensure direct communication of better farming practices, soil health and for improving input use efficiency.

III

TECHNICAL CHANGE IN AGRICULTURE

Technical change can be defined as growth in output associated with use of inputs and application of scientific knowledge. Inputs bringing in technological change in India, are fertilisers, improved seeds, tractors and other machinery, water lifting pumps, pesticides, improved cultural practices and improved quality of human labour (education and training). Use of inputs is highly complementary in nature and data on these is rare. Thus in practice technological change can be defined as "…growth in output that is not accounted for by the growth in all inputs. In other words, residual productivity growth is termed as technological change and is attributed to scientific knowledge, i.e., research and development (R & D). This is also known as total factor productivity (TFP) growth.…". This implies an upward/downward shift in production/cost function and hence it represents efficiency growth." (Desai and Namboodiri, 1997, p.A-165). The underlying premise behind efficiency estimation is that if farmers are inefficient users of the existing technology, their efforts to improve efficiency would be more cost effective than introducing new technologies as a means of increasing agricultural output (Evenson, 1994). From a policy perspective, it is useful to distinguish the increase in productivity due to technical progress and that resulting from improved efficiency in application of the already available technologies.

Farrell (1957) provides a distinction between technical and allocative efficiency (price efficiency) in production through the use of a "frontier" production function. Co-existence of a high rate of technological progress and low rate of change in technical efficiency (TE) may reflect failures in technological mastery. The production function is used to assess TE and defines maximum possible output of a firm for a combination of inputs and technology. Production frontier of i-th firm, producing single output with multiple inputs following the best practice techniques can be defined as:

$$Y_i = f(X_{i1}, X_{i2}, \ldots X_{im})/T$$

Where, T is given technology. If a firm is not producing its maximum possible output owing to non-price and socio-economic organisational factors, production function of this firm can be specified in modified neo-classical framework as:

$$Y_i = f(X_{i1}, X_{i2}, \ldots X_{im}) \exp(u_i)$$

Where, u represents the combined effects of non-price and organisational factors that pose constraints to the firm. Thus $\exp(u_i)$ reflects the firm's ability to produce at its present level or its technical efficiency. A measure of TE of the firm can be defined as:

$\exp(u_i) = Yi/Y^*i$ = actual output/maximum possible output

In this model the denominator is not observable. There are various techniques to measure the denominator and thereby explain $\exp(u_i)$. These include the stochastic production function based on composed error model of Aigner *et al.,* (1977), Meeusen and Van den Broeck (1977), Kalirajan *et al.,* (1996), Kalirajan and Shand (1997).[1] Owing to problems encountered in time series, district level data, we did not decompose the TFP growth into its components, but stopped at arriving at technical efficiency estimates for the pre- and post-liberalisation phases for districts of Gujarat and West Bengal through a deterministic frontier production function. While deterministic methods assume that all deviations from the frontier function result from technical inefficiency, stochastic methods attribute this to statistical noise also. Given that alternative empirical tools are available, choice as to the "best" method is unclear. However, it has been found that ordinal efficiency rankings obtained from different models appear to be similar suggesting that choice between deterministic and stochastic methods is somewhat arbitrary (Xu and Jeffrey, 1995).

In the Deterministic Frontier Production Function employed, maximum output is the production function underlying the best practice techniques utilised by the economic decision making units or firm-specific frontier production function (FPF). The FPF with one output and m-inputs and specifying a Cobb-Douglas functional form has been elaborated by Kalirajan and Shand (1999) as the following:

$Yi = A^* X_{i1}ß_1, X_{i2}ß_{2,..} X_{im}ß_m$ i=1,2,...n number of inputs

Taking logarithm on both sides and representing the value of logarithms in small case, we get,

$yi = \alpha + \sum ß_j\chi_{ij}$ $_{i=}$ 1,2,....n

Assuming FPF is given by $\sum ß_j\chi_{ij}$, it can be said that each unit's output is bounded by a deterministic quantity for each combination of inputs. It can be expressed as:

$yi \leq \alpha + \sum ß_j\chi_{ij.}$ The observed output of each economic unit can be written as:
$yi \leq \alpha + \sum ß_j\chi_{ij} + u_{i\,,}$

Where, u is the difference between the realised output and the maximum output estimated by fitting the function $\alpha + \sum ß_j\chi_{ij.}$ Production coefficients of the FPF represent the highest magnitude of each response coefficient. Technical efficiency will be non-negative (between zero and one) for firms not using the best practice techniques and the value of u will vary among the economic units depending on their technical efficiency. The estimation of technical efficiency can thus be specified as:

u = Frontier or maximum output - realised output and,
TE = $\exp(-u_i)*100$.

Total output in Gujarat was calculated for 22 major crops, including foodgrains, oilseeds, potato, sugarcane, cotton, tobacco, chillies and cumin which comprised 90 per cent of the gross cropped area (GCA) in 1983-84, 87.8 per cent in 1993-94 and 81.3 per cent in 2003-04. In West Bengal output is derived from rice, wheat, pulses, oilseeds, potato and jute that together comprised 91.7 per cent of the GCA in 1981, 88.7 per cent in 1993 and 82.06 per cent in 2004. Farm-harvest prices for the year 1979-81 (average of three years) have been used to arrive at the value of output. The deterministic frontier production function described above was used to identify the maximum possible output given inputs for the years 1981, 1991 and 2001 (three year averages were considered in the case of Gujarat). The inefficiency measure, as described earlier was computed for Gujarat and West Bengal districts. The first two time points signified the pre-liberalisation phase, while the last captured the situation after the onset of reforms.

IV

CHANGES IN TECHNICAL EFFICIENCY IN GUJARAT AND WEST BENGAL

(A) Gujarat

Table 4 shows changes in physical inputs per unit of land in the last four decades. Since 1963 there has been tremendous increase in the use of purchased inputs. Despite rising cost of cultivation, evidence points towards diffusion of available farm technologies. The relationship between use of modern inputs and magnitude of crop output was strong. Between early 1960s and 1980s, output nearly doubled and the effects of increased input use were evident through doubling of land productivity. Consequently growth of output between 1971-73 and 1981-83 accelerated at 3.6 per cent. Input use continued to increase during the next decade.

TABLE 4. INPUT USE PATTERN IN GUJARAT, 1963 TO 2003

Inputs (1)	1963 (2)	1983 (3)	1987/93 (4)	2003 (5)
Tractors (per 000 ha)	0.4	2.9	4.81	15.4
CV	77.3	65.2	62.2	40.3
Pump sets (per 000ha)	13.6	58.7	73.4	98.8
CV	76.6	79.1	73.4	59.2
Fertiliser consumption (kg/ha)	3.6	39.6	66.2	107.0
CV	89.3	65.8	61.1	57.0
Percentage of GCA irrigated	7.4	22.8	27.8	32.7
CV	63.7	53.8	53.0	52.9

Source: Adapted from Table 5, Mehta (2006).
Note: CV is Coefficient of Variation across districts.

The changes in technical efficiency for Gujarat were ascertained for the pre- and post- liberalisation eras. FPF was estimated and the estimates of coefficients of the frontier function for TE 1983, 1993 and 2004 are given in Table 5A. These functions were used to measure the degree of efficiency in input use (Table 5B). In Gujarat besides land and labour inputs, pumpsets and fertiliser use have been significant. In the early 1980s, the response of output was much more elastic to the total area sown, labour use in agriculture and pump sets. This was true to a lesser degree for purchased inputs like fertilisers. The negative response to irrigation related variables perhaps captures a picture of varying agro-climate and irrigation patterns across regions. Irrigation access is associated with rising costs of cultivation. Unreliable volume and distribution of water (both rainfall and irrigation) are the major sources of uncertainty and variability in producers' income (World Bank, 2006). The problem of multi-collinearity (all the variables show correlations exceeding 0.60) exists and has resulted in no variable emerging as statistically significant.

TABLE 5A. DETERMINISTIC FRONTIER FUNCTIONS FOR TOTAL PRODUCTION, GUJARAT (TRIENNIUM ENDING 1980-83, 1990-93 AND 2001-04)

No. (1)	Variables (2)	1980-83 (n=19) (3)	1990-93 (n=19) (4)	2001-04 (n=19) (5)
1.	Constant	-0.693	-2.91	2.06
		(-0.13)	(-0.45)	(0.37)
2.	Land	0.564	0.578	0.649
	(GCA 00 ha)	(1.37)	(1.25)	(0.98)
3.	Labour	0.551	0.755**	0.221
	(Agri. workers Nos.)	(1.38)	(2.16)	(0.56)
4.	Tractors	-0.043	0.299	-0.257
	(Numbers)	(-0.12)	(1.02)	(-0.53)
5.	Pumpsets	0.422	0.351*	0.859
	(Numbers)	(1.06)	(1.53)	(1.37)
6.	Fertilisers	0.162	0.272	0.226
	(NPK tonnes)	(0.66)	(0.16)	(0.33)
7.	Net irrigated area	-0.079	-0.28	0.061
	(00 ha)	(-0.23)	(-0.68)	(0.12)
8.	Canal area	-0.057	-0.079	-0.009
	(00 ha)	(-0.90)	(-0.96)	(-0.19)
9.	Dug and tube wells	-0.193	-0.419*	-0.556
	(Numbers)	(-0.61)	(-1.60)	(-0.81)
10.	Adjusted R^2	0.88	0.91	0.78
11.	Mean square error $\sigma 2$	0.98	0.88	0.78

Notes: The numbers in parentheses are the t-ratios.
** and * represents significance at 0.05 and 0.10 level, respectively.

In the early 1990s, besides manual labour and land variables, output emerged to be highly elastic to use of tractors, pump sets and fertilisers. In early 2000s, output was responsive to use of diesel and electric pumpsets (0.86).

During the 1980s and 1990s, with increasing rural electrification, submersible electric pump sets became popular. Moreover with switching over to flat tariff electricity rates linked to horsepower of pumps, tubewell irrigation accelerated. Private tapping of Narmada water by installing pump sets for lifting water into fields through plastic pipes benefited a large section of farmers. Output is also highly responsive to cropped area (0.64). Acreage is being increasingly diverted to remunerative crops, such as substitution by Bt cotton, finer grains and oilseeds in place of coarse cereals, and also to condiments and spices, fruits and vegetables. Besides labour (whose elasticity has declined considerably), fertiliser use and irrigated area, no other factor emerged important for output.

The level of technical inefficiency (Table 5B) indicates that farmers are not having adequate technical knowledge. Dynamism generated by the green revolution up to 1980s waned in most districts. Mean technical efficiency was estimated to have declined from 67 per cent to 60 per cent and further to 55 per cent during the last two decades. If districts achieved TE of their most efficient counterpart, they could realise 45 per cent of incremental output in 2001-04. This magnitude has swelled from 33 per cent (in early 1980s) and 40 per cent in early 1990s.[2]

TABLE 5B. EFFICIENCY MEASURE FOR TOTAL PRODUCTION BY DISTRICTS, GUJARAT

(per cent)

	1980-83	1990-93	2001-04
(1)	(2)	(3)	(4)
North Gujarat Region			
Banaskantha	65.6	74.6	49.9
Sabarkantha	44.6	56.8	29.7
Mehsana	93.4	66.4	59.9
Middle Gujarat Region			
Ahmedabad	53.8	41.3	42.4
Gandhinagar	59.8	58.3	52.8
Baroda	50.5	41.6	35.6
Kheda	70.1	51.9	45.1
Panchmahals	57.1	56.6	38.5
South Gujarat Region			
Surat	100.0	100.0	100.0
Bharuch	52.4	59.1	68.7
Valsad	49.5	53.7	47.8
Dangs	74.4	61.1	52.1
Saurashtra Region			
Amreli	90.5	66.1	78.6
Bhavnagar	99.9	70.2	54.9
Jamnagar	67.7	57.4	74.0
Rajkot	52.4	49.7	47.0
Surendranagar	56.0	49.4	44.1
Junagadh	67.5	61.9	80.0
Kutch	66.2	67.7	38.9
Mean	66.9	60.2	54.7
Std Deviation	17.4	13.1	18.0
Coefficient of Variation	0.26	0.22	0.33

Source: Computed as cited in text.

By early part of 2000 decade, the gap between actual and frontier output due to technical inefficiency widened for nearly all Gujarat districts. Inter-district variability in technical efficiency improved by early 1990s (CV of 0.22). However, it has considerably worsened over the years (0.33) with the performance of districts of North and Middle Gujarat and a few in Saurashtra further languishing. Perhaps this reflects the failure of achieving technological mastery or lack of effective diffusion of best practices. The distance between frontier and actual output can be significantly bridged by improving the efficiency and without additional inputs. Towards this end, strengthening of agricultural extension services and dissemination of best practices for efficient and timely use of inputs including credit is desired. As of now agriculture in Gujarat is heading towards avoidable waste, with output growth overwhelmingly dependent on the use of purchased inputs.

While the results of our analysis indicate that the overall agricultural output in the early 2000s was not significantly related with irrigation development, recent studies show that from 2002 onwards, increase in irrigated cotton area had been steady and making a dent on production. "Any analysis of cotton yield increases at the state level in Gujarat has to note this increase. In addition, the watershed programmes of the government would also have contributed their share to yields in the rainfed cotton plots too" (Kuruganti, 2009).

(B) West Bengal

Output growth in West Bengal was not accompanied by accelerated growth in the use of inputs. Trend break in the state may not have been a simple case of higher input use or diffusion of green revolution (Sen and Sengupta, 1994). Growth of fertiliser use, percentage of high-yielding variety (HYV) area and irrigated area, unlike other eastern states, declined in West Bengal in the 1980s (see Table 6). Possibly the institutional factors or unmeasured technological shifters (Operation Barga, land redistribution and panchayat activity) played a major role in raising production and productivity in the post-panchayat years.

Changes in technical efficiency for West Bengal were ascertained for 1980-81, 1990-91 and 2000-01. FPF was estimated and the functions were used to measure the degree of efficiency. Since none of the response coefficients emerged statistically significant, estimates of coefficients for the pooled data set (taking the three points of time together) were ascertained by introducing intercept dummies (Table 7A). The dummies were not significant; apparently there was no structural shift in the behaviour of output across the three years even though the direction of change in the constant was as expected. We have thus not reported the equations for the three years separately. During the 1980s (up to 1990-91) there was an upward shift in the constant, though by 2000-01 it showed a downward slide as was expected.

TABLE 6. RATE OF GROWTH OF INPUTS IN WEST BENGAL

Input/Period	Annual Growth Rate		
	West Bengal	Bihar	Orissa
(1)	(2)	(3)	(4)
Fertiliser			
1971-81	12.3	7.9	4.1
1981-91	10.3	11.6	10.6
1992/93-2002/03	5.6	-	-
HYV area (per cent of total area)			
1971-81	7.0	6.9	14.3
1981-91	5.8	3.0	5.5
1992/93-2002/03	2.8	-	-
Irrigated area			
1971-81	3.6	2.9	4.6
1981-91	1.5	2.5	6.4
1995-96 to 2000-01	-0.3	-	-
Electricity use			
1971-81	12.2	21.2	26.4
1981-91	15.6	15.0	15.4
1992/93-2002/03	-	-	-
Cropping intensity			
1981-92	1.83		
1992/93-2002/03	1.3		

Sources: Adapted from Sen and Sengupta (1994) Table 4 and Bhattacharyya and Bhattacharyya (2007).

TABLE 7A. DETERMINISTIC FRONTIER FUNCTIONS FOR TOTAL PRODUCTION, WEST BENGAL POOLED DATA 1980-81, 1990-91 AND 2000-01 (N=45)

Sr. No.	Variable	Coefficient	t-value
(1)	(2)	(3)	(4)
1.	Constant (2000-01)	4.139**	2.43
	(1990-91)	4.147	
	(1980-81)	4.012	
2.	D1 (1980-81)	-0.127	-0.92
3.	D2 (1990-91)	0.005	0.06
4.	Land (GCA 00 ha)	0.245	1.31
5.	Labour (Agri. Workers Nos.)	0.423**	2.09
6.	Tractors (Numbers)	0.017	0.54
7.	Pumpsets (Numbers)	0.239**	4.02
8.	Fertilisers (NPK tonnes)	-0.057	-0.59
9.	Net irrigated area (00 ha)	0.129*	1.79
10.	Canal area (00 ha)	0.009*	1.64
11.	Tube wells (Numbers)	-0.012*	-1.43
12.	Adjusted R^2	0.95	
13.	Mean square error $\sigma 2$	0.76	

Note: ** and * represents significance at 0.05 and 0.10 level, respectively.

The results show elasticity of labour was highest (0.42) and statistically significant in explaining output growth, rice being a labour intensive crop. This is also supported by low elasticity of mechanisation/tractor variable across the districts. Pumpsets used for irrigation similarly show high elasticity (0.24). Coefficient for net irrigated area also shows the desired direction and is statistically significant. Intensive cultivation of land and access to private irrigation have been the drivers of agricultural growth in the state. For the latter, diesel and electric pumpsets would have played a critical role.

Tubewells and fertilisers show negative elasticity. The problem of multi-collinearity cannot be ruled out with other crucial variables. Our findings corroborate the results of earlier researchers, in that there are unmeasured technological shifters and not inputs alone which have been more important in West Bengal.

The level of technical efficiency in West Bengal was of a higher order than Gujarat. Table 7B shows the changes in technical efficiency over three points of time. In the 1980s in rural West Bengal, there was development of minor irrigation structures, better water management and improvement in the farming practices that contributed positively to total factor productivity. High-yielding varieties seeds were used on a larger scale than ever before that spurred green revolution. However, given the changes in technology adoption and input usage, the technical efficiency parameter still had significant room for improvement. As in Gujarat, in West Bengal also the mean technical efficiency declined from 83 per cent to 79 per cent and to 78

TABLE 7B. EFFICIENCY MEASURE FOR TOTAL PRODUCTION BY DISTRICTS, WEST BENGAL

(per cent)

District (1)	1981 (2)	1991 (3)	2001 (4)
Barind Plains			
West Dinajpur	92.6	65.5	62.6
Malda	93.0	92.6	72.2
Alluvial Plains			
Burdwan	97.0	73.3	73.4
Nadia	82.3	82.0	86.2
Howrah	84.7	70.7	67.8
Hooghly	90.7	100.0	100.0
Midnapore	84.4	91.7	81.3
Murshidabad	68.3	69.2	72.9
Rarh and Eastern Plateau			
Birbhum	93.3	77.7	78.5
Bankura	100.0	82.2	85.5
Purulia	87.1	79.2	78.6
Coastal Region			
N and S 24 Parganas	87.8	62.6	63.2
Terai and Hills			
Jalpalguri	91.6	79.8	79.7
Cooch Behar	88.0	90.9	90.7
Darjeeling	84.1	74.4	73.8
Mean	88.34	79.47	77.75
Standard Deviation	7.45	10.75	10.15
Coefficient of Variation	0.08	0.14	0.13

Source: Computed as cited in text.

per cent by early 2000. It can be estimated from the mean and maximum levels of TE that if the districts achieved the TE of their most efficient counterpart, they could realise 22 per cent of the incremental output in 2001. This magnitude has swelled from 12 per cent in the early 1980s and 21 per cent in the early 1990s. No significant changes in technical efficiency were discernable between 1990-91 and 2000-01, though the decline from the level of early 1980s is quite noticeable.

In the early 1990s, technical inefficiency increased across the state (Table 7B). By early 2000s the difference between frontier and actual output due to technically inefficient input use widened for four districts and in the remaining districts the efficiency levels either stagnated or improved marginally. Inter-district variation in technical efficiency widened during the 1980s (from 0.08 to 0.14), and subsequently remained unchanged. The diffusion of technical information and best practices has been uniform across the state, even though there exist considerable room to increase agricultural output with the current input use and technological frontier. Extension activities and diffusion of information about the efficient ways of producing crops may increase output substantially without any augmentation of resources. As it is over-exploitation of ground water and increased chemical use in the state is threatening the sustainability of resources.

V

CONCLUDING REMARKS

The process globalisation and liberalised international trade is unlikely to shift production possibility frontier higher especially for a developing country that has a dominant agricultural sector. The insights from Gujarat and West Bengal are quite revealing in this respect. Technical change in agriculture has a far greater role so that "diminishing returns to scale" are averted. This requires both government and private expenditure on research and development and its transfer on a sustained basis. What is needed is ".... an integrated farming system approach, with land, labour, intermediate inputs with complementary capital augmenting. When total factor productivity growth under such a technical change increases, (rural) poverty ratio also declines." (Desai, 2002). Liberalisation process can help to accelerate agricultural production and facilitate exploitation of the full potential only if the supply side constraints with respect to the efficient use of technology are removed. For the country at large the post 1995 slackness in yield growth rates for practically all food crops has been largely due to technology fatigue. It is well known that freeing trade links the domestic commodity production to highly unstable global prices. Besides increased spending on infrastructure, agriculture would gain far more from non-price factor like technological innovation. It is imperative to step up investment on research and dissemination activities that stimulate adoption of efficient farming practices and avoidance of wasteful use of resources. The international competitiveness of agriculture would have to be ensured from technical change and identification of efficiency shifters. Gujarat agriculture has perhaps responded more favourably to market reforms than West Bengal. However, deceleration in the growth of foodgrain yields in West Bengal and increasing technical inefficiency across both the states calls for serious rethinking on the part of policy formulation and its implementation. Governments have to step up the focus on wider dissemination of scientific knowledge and ensuring its adoption to enhance the efficiency levels in agriculture.

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NOTES

1. In the stochastic production function model (y = f(xi, ß) e^{ϵ}), ϵ is a stochastic error term consisting of two independent elements (u + v). The symmetric component v accounts for random variation in output due to external and are independently and identically distributed. $U \leq 0$ reflects technical inefficiency relative to the stochastic frontier. We attempted a stochastic frontier production function for cross section data on output in West Bengal and Gujarat for pre- and post-liberalisation periods. However, the model specified did not show convergence and the results were not significantly different from ordinary least square model.

2. Technical efficiency of 100 per cent is a statistical phenomenon arising out of unrestricted nature of FPF. It indicates maximum residual (best practice) between the expected and actual output and is used for the calculation of frontier output.

REFERENCES

Ahluwalia, D. (1991), "Growth Performance in Indian Agriculture", *Journal of Indian School of Political Economy*, Vol.3, No.4.

Aigner, D.J., A.K. Lovell and P. Schmidt (1977), "Formulation and Estimation of Stochastic Frontier Production Function Models", *Journal of Econometrics*, Vol.6, No.1.

Bandopadhyaya, D. (2003), "Land Reforms and Agriculture: the West Bengal Experience", *Economic and Political Weekly,* Vol.38, No.9, March 1.

Banerjee, A., P. Bardhan, K. Basu, M.D. Chaudhuri, M. Ghatak, A.S. Guha, M. Majumdar, D. Mookherjee and D. Ray (2002), "Strategy for Economic Reform in West Bengal, *Economic and Political Weekly,* Vol.37, No.41, October 12.

Bhattacharyya, M. and S. Bhattacharyya (2007), "Agrarian Impasse in West Bengal in the Liberalisation Era", *Economic and Political Weekly*, Vol.42, No.52, December 29.

Boyce, James (1987), *Agrarian Impasse in Bengal: Constraints to Technological Change*, Oxford University Press, Oxford.

Desai, Bhupat (2002), "Terms of Trade, Trade and Technical Change: Strategies for Agricultural Growth", *Economic and Political Weekly*, Vol.37, No.8, February 23, p.803.

Desai, Bhupat and N.V Namboodiri (1997), "Determinants of Total Factor Productivity in Indian Agriculture", *Economic and Political Weekly*, Vol.32, No.52, December 27.

Dholakia, R.H. (2005), "Macro Economic Framework for Development of Gujarat", paper presented at National Seminar on Gujarat 2010, Ahmedabad, School of Planning, February 1-2.

Evenson, R.E. (1994), *Analyzing the Transfer of Agricultural Technology,* CAB International Wallingford, Oxon, United Kingdom.

Farrell, M. (1957), "The Measurement of Productivity Efficiency", *Journal of the Royal Statistical Society,* Series A General, Vol.120, No.3, pp.253-282.

Gulati, A., T. Shah and G. Shreedhar (2009), *Agriculture Performance in Gujarat since 2000- Can it Be Divadandi for Other States?*, International Water Management Institute and International Food Policy Research Institute (mimeo).

Kalirajan, K.P. and R.T. Shand (1999), "Frontier Production Functions and Technical Efficiency Measures", *Journal of Economic Surveys*, Vol.13, No.2.

Kalirajan, K.P. and R.T. Shand (1997), "Sources of Output Growth in Indian Agriculture", *Indian Journal of Agricultural Economics*, Vol.52, No.4, October-December.

Kalirajan, K.P., M.B. Obwona and S. Zhou (1996), "A Decomposition of Total Factor Productivity Growth: The Case of Chinese Agriculture Growth Before and After Reforms", *American Journal of Agricultural Economics*, Vol.78, No.2.

Kashyap, S.P. and Niti Mathur (1999), "Ongoing Changes in Policy Environment and Farm Sector in India: Role of Agro-Climatic Regional Planning Approach", *Economic and Political Weekly*, Vol.34, No.26, June 26.

Kumar, Dinesh M., A. Narayanamoorthy, O.P. Singh, M.V.K. Sivamohan, M. Sharma and N. Bassi (2010), *Gujarat's Agricultural Growth Story-Exploding Some Myths*, Occasional Paper No. 2-0410, Institute for Research Analysis and Policy, Hyderabad.

Kumar, P. and M.W. Rosegrant (1994), "Productivity and Sources of Growth for Rice in India", *Economic and Political Weekly*, Vol.29, No.53, December 31.

Kuruganti, K (2009), "Bt Cotton and the Myth of Enhanced Yields", *Economic and Political Weekly*, Vol.44, No.22, May 30, p.31.

Meeusen, W., and van den Broeck (1977), "Efficiency Estimation from Cobb-Douglas Production Function with Composed Error", *International Economic Review*, Vol.18.

Mehta, Niti (2006), "Performance of Agriculture in Gujarat: Some Recent Evidence", Paper presented at the National Seminar on Agricultural Growth in the Post Reform Period: Regional Perspectives" , 27-29 March 2006, Organised by Giri Institute of Development Studies, Lucknow.

Ray, S. and D. Ghosh (2007), "Modern Agriculture and the Ecologically Handicapped - Fading Glory of Boro Paddy Cultivation in West Bengal", *Economic and Political Weekly*, Vol.42, No.26, June 30.

Rosegrant, M.W. and R.E. Evenson (1995), *Total Factor Productivity and Sources of Long Term Growth in Indian Agriculture*, EPTD Discussion Paper No. 7, International Food Policy Research Institute, Washington, D.C., U.S.A.

Saha, A. and M. Swaminathan (1994), "Agricultural Growth in West Bengal in the 1980s: A Disaggregation by Districts and Crops", *Economic and Political Weekly*, Vol.19, No.13, April.

Sen, Abhijit and R. Sengupta (1994), "The Recent Growth in Agricultural Output in Eastern India, with Special Reference to the Case of West Bengal" (mimeo.).

Shah, Tushaar, S. Krishnan, P. Hemant, S. Verma, A. Chandra and C. Sudhir (2010), *A Case for Pipelining Water Distribution in the Narmada Irrigation System in Gujarat*, Working Paper 141, International Water Management Institute, Colombo, Sri Lanka.

Shah, Tushaar, A. Gulati, P. Hemant, G. Shreedhar and R.C. Jain (2009), "Secret of Gujarat's Agrarian Miracle after 2000", *Economic and Political Weekly,* Vol.44, No.52, December 26.

World Bank (2006), "Gujarat- Agriculture Sector Growth", *Discussion Paper*, South Asia Sustainable Development Unit, Washington, D.C., U.S.A., p.57.

Xu, Xiaosung and S.R. Jeffrey (1995), *Efficiency and Technical Progress in Traditional and Modern Agriculture: Evidence from Rice Production in China*, Staff Paper 95-02, Department of Rural Economy, University of Alberta, Canada.