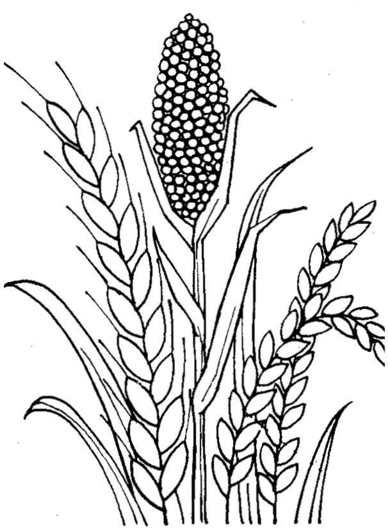
Vol XLII
No. 1

JANUARY-
MARCH
1987

ISSN 0019-5014

INDIAN JOURNAL OF AGRICULTURAL ECONOMICS



INDIAN SOCIETY OF
AGRICULTURAL ECONOMICS,
BOMBAY

Ind. Jn. of Agri. Econ.
Vol. 42, No. 1, Jan.-Mar. 1986.

RESEARCH NOTES

GROWTH OF INDIAN AGRICULTURE: A REAPPRAISAL

The questions as to how Indian agriculture has been doing over time and how different regions have responded to the changing economic conditions of the country in the last few decades, have been the centre of the debate among various economists. Different scholars, by analysing the same set of data, have obtained different trend rates of growth of agricultural production depending on the goodness of fit of different mathematical curves such as linear, exponential and occasionally Gompertz.[1] But the crux of the problem is that two different fitted curves could be more or less the same from the view-point of goodness of fit while implying completely different nature of the trend rate of growth. We, however, intend to examine the growth rate controversy in a somewhat different manner which can be explained as follows.

We felt the need to introduce the Logistic curve, $\frac{1}{y} = a + bc^t$ (where y is the estimated value of the dependent variable), to check whether the trend growth rates as obtained from the Gompertz fit remained largely valid even after the introduction of Logistic curve. The Logistic resembles the Gompertz and in that sense these two are competing curves. Moreover, in so far as the goodness of fit is concerned, we have introduced a measure known as 'C' test,[2] which can be defined as $C = \frac{P - Q}{n - 1}$, where P is the number of pairs of adjacent residuals of same sign and Q is the number of pairs of adjacent residuals of opposite sign. Obviously $P + Q = n-1$ and this C is an indicator of first order auto-correlation coefficient of the residuals. This coefficient, C, helps us to identify the best fitted curve where the different fitted trend curves give more or less the same D value.[3] Thus, out of two alternative forms of curves with more or less the *same* D value, one must choose that form which bears the lower value of C, indicating thereby the little fluctuations in the observed pattern of the variable to be explained. We may now turn to the results of our analysis.

1. Mention may be made of the works done by Mitra (1968), Minhas and Srinivasan (1968) Rudra (1970, 1982), Dey (1975), Vaidyanathan and Srinivasan (1977), Srinivasan (1979), Dandekar (1980), Chaudhuri (1981), Ray (1983) and Sau (1983).

2. In an ideal good fit, it is expected that the observed points should lie on both sides of the fitted curve evenly. In the extreme case we are likely to get fluctuations around the trend curve in every period and Q in that case equals (n—1) where P is zero. In such a case $C = -1$. On the other extreme a high value of C implies a high value of P relative to Q and little fluctuations around the trend curve. Therefore, $-1 \leq \beta \leq 1$. See for details, Bhattacharya and Maitra (1970).

3. With usual notations D is defined as

$$D = \frac{\Sigma (y_t - \hat{y}_t)^2}{\Sigma (y_t - \bar{y}_t)^2}$$

TABLE I. ESTIMATES OF TREND EQUATION FOR DIFFERENT CROP GROUPS, 1950-51 TO 1982-83

Dependent variable	Curve form	Estimates of trend equation for: Foodgrains: Estimated parameters a	b	c	Measure of goodness of fit D	C	Non-foodgrains: Estimated parameters a	b	c	Measure of goodness of fit D	C	All crops: Estimated parameters a	b	c	Measure of goodness of fit D	C
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Acreage	Semi-log	85·45	1·0070	—	0·1944	0·1250	79·95	1·0123	—	0·0417	0·5625	84·44	1·0081	—	0·1415	0·2500
	Straight line	85·32	0·6579	—	0·1772	0·2500	79·07	1·1763	—	0·0432	0·5625	84·18	0·7654	—	0·1209	0·0000
	Gompertz	106·84	0·7707	0·9325	0·1047	0·0000	100·30	0·6257	0·9333	0·0481	0·4375	110·68	0·7354	0·9394	0·0748	—0·1250
	Logistic	939·73	274·25	0·9249	0·1051	—0·1250	846·87	478·32	0·9246	0·0484	0·3750	910·39	317·82	0·9305	0·0757	—0·1875
Production	Semi-log	60·45	1·0258	—	0·0914	0·0000	61·55	1·0261	—	0·0417	0·0000	60·91	1·0259	—	0·0643	0·1250
	Straight line	55·16	2·4219	—	0·1005	0·1250	56·30	2·4792	—	0·0432	0·1250	55·59	2·4354	—	0·0714	0·1250
	Gompertz	3·17	20·1288	1·0073	0·0991	—0·1250	599·81	0·1026	0·9862	0·0481	0·3125	6·92 $\times 10^{-26}$	9·00 $\times 10^{26}$	1·0004	0·0647	0·0000
	Logistic	—500·00	2680·96	0·9832	0·0971	0·0000	393·22	1235·73	0·9595	0·0484	0·3125	—6·92	1598·15	0·9755	0.0698	—0·3750
Yield	Semi-log	74·35	1·0256	—	0·1438	0·0000	83·08	1·0109	—	0·1562	—0·1250	76·24	1·0149	—	0·1418	—0·0625
	Straight line	71·95	1·5351	—	0·1586	—0·0625	81·67	1·1122	—	0·1716	0·1250	73 76	1·4980	—	0·1618	0·0000
	Gompertz	61·09	1·2942	1·0336	0·1405	—0·2500	76·84	1·1344	1·4019	0·1245	0·0625	65·38	1·2414	1·0363	0·1177	—0·1875
	Logistic	1823·51	556·43	1·0199	0·1406	—0·2500	1364·41	215·51	1·0297	0·1227	—0·1875	1702·75	467·67	1·0216	0·1146	—0·1875

GROWTH OF AGRICULTURE, 1950-51 TO 1982-83

We have taken up for analysis three groups of crops, *viz.*, foodgrains, non-foodgrains and all crops as a whole. For each group we have considered all-India Index Numbers of three time variables—the acreage under that crop, the production and the yield rates and have fitted four different curves to the data on each variable over the period 1950-51 to 1982-83. The four curves fitted are (*i*) semi-logarithmic, (*ii*) straight line, (*iii*) Gompertz, and (*iv*) Logistic. These results are presented in Table I.

We observe from Table I that according to both the criteria of lowest D value and the lowest C value in the case of either acreage or the yield rate of three groups of crops, both Gompertz and Logistic curves give the best fits. However, in the case of production, semi-logarithmic curve yields the lowest D value for any of the three groups of crops. But even in these cases D values from the Gompertz fit seems to be reasonably close to those values of the exponential fit and there is no reason to accept semi-logarithmic fit as against the Gompertz fit. Rather if we go by the C value criterion, except in the case of non-foodgrains production, Gompertz fit always seems to be better than the semi-logarithmic fit.

Thus, we may now conclude that in so far as the goodness of fit is concerned, Gompertz curve provides the best fit for most of the variables considered here and for most of the crops so far under study. It may be noted in this context that the variation of growth rate measured from the fitted Logistic curve is almost the same as the variation of growth rate in the corresponding Gompertz curve and their growth implications do not differ much over time.

The implied trend rate of growth of each variable from the Gompertz is shown in Table II. Note that in each case the rate of growth is positive.

TABLE II. TREND RESULTS FROM BEST FITTED GOMPERTZ CURVE

Variable/Group of crops	Foodgrains	Non-foodgrains	All crops
(1)	(2)	(3)	(4)
Acreage ..	b=0·77, c=0·93 *declining* rate of growth	b=0·63, c=0·93 *declining* rate of growth	b=0·77, c=0·94 *declining* rate of growth
Production ..	b=20·1, c=1·0073 *increasing* rate of growth	b=0·10, c=0·9860 *declining* rate of growth	b=9·0, c=1·0004 *increasing* rate of growth
Yield rate ..	b=1·29, c=1·0336 *increasing* rate of growth	b=1·13, c=1·04 *increasing* rate of growth	b=1·24, c=1·03 *increasing* rate of growth

Our observation suggests that a sharp increase in the growth of agricultural production had not been possible during the period 1950-51 to 1982-83 mainly because of the diminishing rate of growth of cropped area. Although the rate of growth of productivity of land in the agricultural sector is found to be rising, the rate of growth of agricultural output remained more or less constant in view of the fact that semi-logarithmic curve gave the best fit. Presumably this may be due to the fact that the rate of growth of cropped area has been declining over time.

GROWTH OF AGRICULTURE: BEFORE AND AFTER ADOPTION OF NEW TECHNOLOGY

Presented in Table III are the forms of the best fitted trend curves separately for the two periods, namely, the pre-green revolution period (1950-51 to 1964-65) and post-green revolution period (1965-66 onwards).

TABLE III. BEST FITTED TREND CURVES DURING PRE-GREEN REVOLUTION AND POST-GREEN REVOLUTION PERIODS

Variables	1950-51 to 1964-65			1965-66 to 1982-83		
	Food-grains	Non-food grains	All crops	Food-grains	Non-food grains	All crops
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Acreage	Gompertz (declining)	Straight line (declining)	Straight line (declining)	Straight line (declining)	Semi-log (constant)	Straight line (declining)
Production	(Straight line (declining)	Semi-log (constant)	Straight line (declining)	Straight line (declining)	Straight line (declining)	Straight line (declining)
Yield rate	Straight line (declining)	Semi-log (constant)	Straight line (declining)	Straight line (declining)	Semi-log (constant)	Semi-log (constant)

Table III shows that the trends in growth of acreage, output and yield for food crops during 1950-51 to 1964-65 are consistent with the retardation hypothesis. In the case of acreage under food crops the Gompertz with $b < 1$ and $c < 1$ provides the best fit whereas in the case of both production and yield rate of food crops the straight line provides the best fit. Similar observation can be drawn in the case of acreage, output and yield for all crops as a whole.

Growth trends of non-food crops, however, give somewhat different picture. In the case of either output or yield rate for non-food crops, semi-logarithmic curve gives the best fit, while for acreage, straight line gives the best fit. These indicate that the growth rates of output and yield for non-food crops remained constant whereas that of acreage declined during the pre-green revolution period.

Coming now to the post-green revolution period, we find from the same table that the same retardation hypothesis regarding the growth of agricultural output can be accepted unambiguously for the current decades also. As a matter of fact, in the green revolution period straight line provides the best fit for each of the three groups of crops. However, one interesting finding is that both acreage and production for each of the three groups of crops imply a diminishing rate of growth, while yield rate for each group remains more or less unchanged.

It is clear from the above discussion that one cannot discover any tendency of shifting of trend curves with the introduction of new technology in Indian agriculture. No break could be located in most of the cases and, therefore, smooth trends seem to fit the data of the entire period for most of the crops. Thus, the results of our trend analysis bear very close resemblance to the trend results analysed by Rudra (1982) up to the year 1976-77.

Although the growth of agriculture for some major groups of crops reveals a smooth trend so as to rule out any change in the production conditions, a crop specific analysis might have to give some what different picture. The following section attempts to examine this.

CROP SPECIFIC TREND RESULTS

Crop specific exercises enable us to verify some commonly prevailed popular ideas. Some of these are noted below.

(*a*) After the introduction of high-yielding variety (HYV) technology in the mid-sixties, the importance of cash crops had increased in the agricultural sector as a whole, while the relative importance of inferior cereals and pulses had declined.

(*b*) Acceleration in the yield rate was more pronounced in the case of *rabi* crops, particularly in the case of wheat, compared to that of the *kharif* crops.

Our crop specific trend results presented in Table IV indicate that there has neither been an increasing rate of growth nor any break in the trends of any of the variables for any of the crops under study for the entire period, 1950-51 to 1982-83.

TABLE IV. ESTIMATES OF BEST FITTED TREND EQUATION FOR DIFFERENT CROPS 1950-51 TO 1982-83

Variables	Estimated Parameters	Rice	Wheat	Bajra	Pulses	Potato	Sugarcane
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		(3)	(2)	(1)	(5)	(2)	(1)
	a	113·94	60·22	88·41	960·01	45·78	67·40
Acreage ..	b	0·6924	1·0280	0·2240	156·98	1·0404	1·8812
	c	0·9445	—	—	0·7245	—	—
		(1)	(2)	(3)	(1)	(2)	(1)
	a	57·70	31·91	109·59	96·13	34·94	47·49
Production ..	b	2·2252	1·0608	0·4112	0·0756	1·0597	2·2887
	c	—	—	0·8916	—	—	—
		(1)	(2)	(1)	(1)	(2)	(1)
	a	73·27	53·14	69·14	94·12	76·58	77·37
Yield	b	1·4270	1·0320	1·7771	0·0624	1·0148	1·0462
	c	—	—	—	—	—	—

Note:— Figures in brackets indicate the form of the best fitted trend curves against codes: (1) straight line, (2) semi-logarithmic, (3) Gompertz with $b < 1$ and $c < 1$, (4) Gompertz with $b > 1$ and $c > 1$ and (5) Logistic.

Analysis of data by dividing the whole period into two sub-periods give some interesting results. Following observations can be drawn on the basis of the results presented in Table V.

TABLE V. VARIATION OF GROWTH FROM BEST FITTED TREND CURVE FOR VARIOUS CROPS DURING PRE- AND POST-GREEN REVOLUTION PERIODS

Crops	Pre-green revolution period (1950-51 to 1964-65)			Post-green revolution period (1965-66 to 1982-83)		
	Acreage	Production	Yield	Acreage	Production	Yield
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Rice ..	1·42 (2)	4·87-2·90 (1)	2·62-1·92 (1)	0·68-0·61 (1)	3·25-2·09 (1)	1·94-1·99 (4)
Wheat ..	3·10-2·16 (1)	5·14-2·99 (1)	1·60 (2)	6·48-1·11 (3)	13·30-4·08 (1)	4·94-2·68 (1)
Jowar ..	0·92-0·82 (1)	2·99-2·11 (1)	1·87-1·48 (1)	—0·91 (2)	1·99 (2)	2·89 (2)
Bajra ..	4·17-0·01 (3)	2·96-2·09 (1)	0·48-4·27 (4)	—0·72 to —0·83 (1)	0·62-0·56 (1)	2·10-0·34 (3)
Pulses ..	2·16-1·66 (1)	11·32-0·01 (1)	—0·26 to —0·27 (1)	0·33-0·31 (1)	0·62-0·56 (1)	0·61-0·55 (1)
Potato ..	4·40 (2)	4·17 (2)	—0·19 to —0·20 (1)	3·73 (2)	6·80 (2)	3·02 (1)
Sugarcane	3·09 (2)	4·51 (2)	1·42 (2)	1·65 (2)	2·99 (2)	1·33-1·08 (2)
Kharif foodgrains	—	—	—	0·21-0·20 (1)	2·49-1·75 (1)	2·23-1·61 (1)
Rabi foodgrains	—	—	—	1·54-0·53 (3)	6·27-3·03 (1)	4·44-2·53 (1)

Note:—Figures in brackets indicate the form of best fitted trend curves as in the previous table.

(*a*) The rates of growth of acreage, output and yield rate of wheat in particular seem to have declined both in the pre- and post-green revolution periods. The rates, as such, however, seem to be higher in the latter period than the former.

(*b*) Average growth rates of acreage and production of some inferior food crops like jowar and bajra and that of pulses are much less in the post-green revolution period compared to the previous period.

(*c*) Some of the crops which are generally regarded as cash crops or commercial crops like potato, sugarcane, etc., seemed to have maintained a steady rate of growth during the two phases of agricultural development.

(*d*) Classification of crops in terms of *kharif* and *rabi* seasons shows that the linear trend gives the best fit for output and yield of *kharif* crops as well as *rabi* crops for the post-green revolution period. Similar trend (either linear or Gompertz with $b < 1$ and $c < 1$) is obtained in the case of yield rate of these two types of crops for the same period. Comparable data are not available for the pre-green revolution period. Trend results for post-green revolution period, however, suggest that the effects of HYV technology on *rabi* crops are far from satisfactory.

All these evidences thus suggest that the commonly prevailed popular belief regarding the wheat revolution and that of the breakthroughs in *rabi* crops in the new technology period is far from correct. The much talked green revolution in agriculture might at best be a localised phenomenon and did bear very little impact on the economy as a whole.

In order to examine this proposition a little more, analysis of data by choosing at least two heartlands of green revolution and carrying out of similar exercises would be useful.

STATE SPECIFIC TREND RESULTS

Trend analysis on acreage and output of various crops for West Bengal and Punjab reveal some striking differences. The results obtained for these two States often do not conform with the all-India trends. A close look at the results presented in Table VI is necessary in this context.

TABLE VI. COMPARATIVE PICTURE OF CONSTANT AVERAGE ANNUAL GROWTH RATES OBTAINED FOR WEST BENGAL, PUNJAB AND ALL-INDIA

Item	Average growth rate (per cent)					
	West Bengal		Punjab		All-India	
	Pre-green revolution	Post-green revolution	Pre-green revolution	Post-green revolution	Pre-green revolution	Post-green revolution
(1)	(2)	(3)	(4)	(5)	(6)	(7)
I. Growth of acreage						
Rice ..	1·03	0·42	6·80	10·40	1·42	0·65
Wheat ..	1·10	3·38	2·60	3·30	2·66	3·23
All foodgrains	1·09	0·36	1·61	2·36	0·51*	0·47
II. Growth of production						
Rice ..	1·56	1·15	8·10	16·90	3·70	2·64
Wheat ..	—0·33	7·09	4·40	6·30	3·90	6·91
All foodgrains	1·12	0·98	3·22	5·94	2·54*	2·97

*Results obtained for the period 1956-57 to 1982-83.

A time-series analysis of acreage and output data of West Bengal for the years 1952-53 to 1981-82 reveals that except in the case of wheat, the effect of new technology for other crops is almost negligible. Smooth linear trends give the best fit in the production data of the State. In the case of wheat, a break in trend is located in both production and acreage data, around 1967-68. Average rates of growth of production and acreage before and after this break are presented in Table VI. The table shows a moderately high rate of growth of both acreage and output of wheat during the post-green revolution period. The rates of growth during the pre-green revolution period show a negative rate. This indicates that the new technology had a clear positive effect on the growth of output of wheat in West Bengal.

Coming to the data on Punjab, we observe that while the growth rates of production of rice and wheat increased at a decreasing rate (linear fit) during 1951-52 to 1967-68, the exponential curve seems to fit best with an average annual growth rate of 16.90 per cent in the case of rice and 6.30 per cent in the case of wheat during the period 1968-69 onwards. Thus, a sharp rise in the growth of rice production compared to the wheat producton is observed in Punjab during the post-green revolution period. Again among the *kharif* crops while the acreage under cultivation of rice had increased at a high rate, the acreage under bajra had declined at an average rate of 1.30 per cent per annum. The area under cultivation of pulses (which are mostly *rabi* crops) had also declined at an average annual rate of 4.29 per cent. This suggests that some sort of crop substitution might have taken place in Punjab in terms of shifting cereals from inferior to superior ones.

The results presented in Table VI also suggest that the sharp rise in the production levels of rice and wheat in Punjab was always associated with similar increase in the acreage under cultivation of the same crops in the same period. In West Bengal, on the other hand, the acreage under cultivation of various crops did not increase except in the case of wheat during the post-green revolution period. Thus, in spite of being a rice growing region, West Bengal can hardly be compared with Punjab in terms of the intensity of cropping and cropping pattern.

From the above observations it is clear that the data for the two regions of India give two distinct pictures of the growth of farm output. In the case of West Bengal, new agricultural technology has a positive impact on the growth of wheat output; in the case of Punjab, its effect is towards the growth of rice output. One thing that we may now conclude is that the effects of new technology on agricultural output of different varieties of crops vary from one region to another, and it will be misguiding to treat specific effects as if they are the same everywhere.

CONCLUDING REMARKS

Our analysis, based on fitting of four trend curves—linear, semi-logarithmic, Gompertz, and Logistic—and then judging the goodness of fit on the basis of D value and C value, yields some interesting results. First, the results of the fitted curves allow us reject the hypothesis that the rate of growth of agriculture for the country as a whole has increased over time. This has not been possible mainly because of the diminishing rate of growth of cropped area. Secondly, the growth of agriculture reveals a smooth trend so as to rule out any country-wide sharp changes in the growth of agricultural output due to the introduction of new agricultural technology. Thirdly, cropwise trend analysis suggests that except for some commercial crops like potato, sugarcane, the new technology in agriculture had no impact on inferior cereals and had little impact on superior food crops. Fourthly, the commonly prevailed popular belief that the green revolution had succeeded only in the case of *rabi* crops in general and wheat in particular is far from true. In the regions where new technology has disseminated, its effects are no less pronounced in the case of superior *kharif* cereals, *e.g.*, rice. Finally, some kind of regional disparities are observed in the growth of output of various crops in the so-called green revolution areas.

On the basis of the foregoing discussions, following conclusions emerge: Breakthroughs in production conditions through the evolution of HYV technology around 1965 have taken place in such a scattered and fragmentary way that they have little impact on the country as a whole. The new agricultural technology has not been in any case more effective for *rabi* crops in general, and for wheat in particular.

Manabendu Chattopadhyay and Gautam Bhattacharya*

REFERENCES

1. N. Bhattacharya and T. Maitra: An Analysis of Engel Curves Based on NSS Household Budget Data from 7th to 22nd Rounds, Technical Report No. Econ/9/70, Research and Trianing School, Indian Statistical Institute, Calcutta, 1970.

2. Maitreyi Chaudhuri, "Is the Rate of Growth of Indian Agriculture Diminishing ?", *Economic and Political Weekly*, Vol. XVI, No. 5, January 31, 1981.

3. V. M. Dandekar, "Introduction to Seminar on Data Base and Methodology for the Study of Growth Rates in Agriculture", *Indian Journal of Agricultural Economics*, Vol. XXXV, No. 2, April-June 1980.

4. Amal Krishna Dey, "Rates of Growth of Agriculture and Industry", *Economic and Political Weekly*, Vol. X, Nos. 25 and 26, June 21 and 28, 1975.

5. B. S. Minhas and T. N. Srinivasan, "Food Production Trends and Buffer Stock Policy", *Statesman*, November 14, 1968.

6. Ashok Mitra, "Bumper Harvest has created Some Dangerous Illusions", *Statesman*, October 14-15, 1968.

7. S. K. Ray, "An Empirical Investigation of the Nature and Causes for Growth and Instability of Indian Agriculture: 1950-80", *Indian Journal of Agricultural Economics*, Vol. XXXVIII, No. 4, October-December 1983.

8. Ashok Rudra, "The Rate of Growth of Indian Economy", in E. G. Robinson and M. Kidron (Eds.): Economic Development in South Asia, Kandy Conference Proceedings, The Macmillan, London, 1970.

9. Ashok Rudra: Indian Agricultural Economics: Myths and Realities, Allied Publishers Pvt. Ltd., Delhi 1982, Chapter 11.

10. Ranjit Sau, "Growth, Stagnation and Fluctuation in Indian Economy", *Economic and Political Weekly*, Vol. VIII, No. 7, February 12, 1983.

11. T. N. Srinivasan, "Trends in Agriculture in India, 1949-50—1977-78", *Economic and Politindl Weekly*, Vol. XIV, Nos. 30, 31 and 32, Special Number, August 1979.

12. A. Vaidyanathan, "Performance and Prospects of Crop Production in India", *Economic and Political Weekly*, Vol. XXII, Nos. 33 and 34, Special Number, August 1977.

---

* Indian Statistical Institute, Calcutta. The authors have greatly benefitted from discussions and comments from Dr. Dipankar Coondoo.