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GROWTH AND INSTABILITY IN THE PRODUCTION OF MAIN CEREAL CROP OF WEST BENGAL AND PUNJAB-HARYANA, 1950-51 TO 1984-85 - A NOTE

The objective of this paper is to explore certain hypotheses regarding growth pattern and instability at the district level in the production of rice in West Bengal and of wheat in Punjab-Haryana during the post-Independence period, 1950-51 to 1984-85.[1] More specifically, we take a close look at the contrasts between the behaviour patterns of the production of rice in West Bengal and of wheat in Punjab-Haryana over the pre- and post-green revolution periods.

Data

Data on production of total rice (*i.e.*, *aman* plus *aus* plus *boro*), by district for the period 1950-51 to 1984-85, have been collected from the Socio-Economic Evaluation Branch, Department of Food and Agriculture, Government of West Bengal. Fourteen districts of the State have been considered, Darjeeling is left out. These are: 24-Parganas, Nadia, Murshidabad, Burdwan, Birbhum, Bankura, Midnapur, Hooghly, Howrah, Jalpaiguri, Malda, West Dinajpur, Cooch Behar and Purulia.

Data on production of wheat for the same period have been compiled from Area and Production of Principal Crops in India, a publication of the Ministry of Agriculture, Government of India. In order to work with a common set of districts of Punjab and Haryana, we have in a number of cases clubbed two or three contiguous districts together to get a region for which the series of production of wheat may be built for the entire period of 1950-51 to 1984-85. Thus we have for the study of behaviour of production of wheat, the following districts/regions for Punjab-Haryana:

(Hisar + Gurgaon + Mahendragarh), Rohtak, (Sangrur + Karnal),
(Ambala + Hoshiarpur), Ludhiana, (Bhatinda + Ferozepur),
Kapurthala, Patiala, Jullundar, Amritsar and Gurdaspur.

Methodology

Since the primary aim of this paper is to study the growth pattern and instability in the production of the main cereal crop during the post-green revolution period as compared with the experience of the pre-green revolution period, the entire period has been divided into two sub-periods: (*i*) 1950-51 to 1966-67 and (*ii*) 1967-68 to 1984-85, for each district of West Bengal and Punjab-Haryana.

For each sub-period the usual linear fit has been tried on annual data, total rice for the districts of West Bengal and wheat for the districts/regions of Punjab-Haryana.

The regression coefficient, which gives the absolute change per unit of time, for each district and for each sub-period, has been expressed as a percentage of the respective harmonic mean to get the average linear growth rate of the respective crops of the district for the period.[2]

In order to identify the fluctuation around the trend, we have sorted out (*i*) observed values which are higher (*i.e.*, having positive deviations) than the corresponding trend values, and similarly, (*ii*) observed values which are lower (*i.e.*, having negative deviations) than the corresponding trend values. A trend line through each of these pairs of sets of observed values, higher or lower than the corresponding trend values, is fitted. Thus for each original trend line, we have a similar pair of trend lines on both sides of the trend line - one through

the observed values higher than their respective trend values (hereafter termed as 'positive' trend line), and the other through the observed values lower than their respective trend values (hereafter termed as 'negative' trend line).

For each of the trend lines, all usual tests of significance and goodness of fit have been administered.[3]

An F-test has been administered to test the hypothesis that 'positive' and 'negative' trend lines are parallel, using the static:

$$F = \frac{(R_{yy}^{**} - R_{yy})/(\upsilon^{**} - \upsilon)}{R_{yy}/\upsilon}$$

where R_{yy}^{**} = residual sum of squares due to linear fit on observed values,

R_{yy} = residual sum of squares from 'positive' deviation trend line plus residual sum of squares from 'negative' deviation trend line,

υ^{**} = n - k - 1, υ = n - 2 k, where n = number of observations

and k = number of parameters estimated.

If $F > F_{k-1, n-2k}^{(\alpha)}$,

then the hypothesis is rejected at the level of significance α.

We have obtained the value of 't' at the point of intersection of 'positive' and 'negative' deviation trend lines:

$$Y(+) = a'' + b'' t \qquad (1)$$
$$Y(-) = a' + b' t \qquad (2)$$

At the point of intersection:

It $t > 0$, then (1) and (2) converge in the positive quadrant.

If $t < 0$, then (1) and (2) diverge in the positive quadrant.

Again, $|\tan(\theta^{+} - \theta^{-})| = \frac{b'' - b'}{1 + b'' \cdot b'}$ gives the rate per unit of time at which (1) and (2) converge/diverge.[4]

Growth Rates by District: Rice in West Bengal and Wheat in Punjab-Haryana

Tables I (A) and I (B) give the regression coefficients (of overall, 'positive' deviation and 'negative' deviation trend lines) for West Bengal and Punjab-Haryana, by district, for the two sub-periods respectively. Tables II (A) and II (B) give the average linear growth rates of rice output in West Bengal and wheat output in Punjab-Haryana, by district, for the two-sub-periods respectively.

From Table II (A) it is seen that during the period 1950-51 to 1966-67 the districts of West Bengal, in general, presented low rates of growth of rice production, except the three northern districts, West Dinajpur, Cooch Behar and Jalpaiguri, where the rates of growth of rice production during the period 1950-51 to 1966-67 were 6.5, 3.5 and 2.9 per cent per annum respectively. While Bankura and Howrah showed negative growth rates, in Purulia, Hooghly and 24-Parganas the rates of growth were low (all below 1 per cent per annum).

TABLE I(A). WEST BENGAL: REGRESSION COEFFICIENTS OF OVERALL, 'POSITIVE' DEVIATION AND NEGATIVE DEVIATION TREND LINES THROUGH RICE OUTPUT

District/ Region	1950-51 to 1966-67				1967-68 to 1984-85			
	b	b"	b′	F-test* (H_o:b"=b′)	b	b"	b′	F-test* (H_o:b"=b′)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
24-Parganas	5.52	-5.84	5.54	58.11	13.24	20.07	2.22	58.00
Nadia	2.63	1.21	2.68	58.76	9.09	10.52	6.32	62.72
Murshidabad	3.43	4.87	4.73	31.47	7.67	8.36	-1.27	52.23
Burdwan	8.93	7.50	11.35	20.60	16.31	22.18	3.24	77.92
Birbhum	4.07	2.65	5.69	14.00	3.92	5.20	-4.57	30.00
Bankura	-0.03	-1.37	-2.58	20.60	0.22	3.73	-7.71	73.68
Midnapur	4.00	3.37	2.36	22.67	9.24	18.29	-2.64	62.50
Hooghly	1.27	1.44	1.79	23.13	6.30	7.66	3.61	35.03
Howrah	-0.65	0.55	-1.29	19.50	2.82	2.14	1.72	32.77
Jalpaiguri	5.51	5.00	4.91	25.09	-0.81	-2.96	-1.99	35.65
Malda	1.49	1.36	1.68	30.32	7.50	7.88	6.83	67.79
West Dinajpur	17.24	20.07	17.56	27.15	3.27	1.11	4.19	41.49
Cooch Behar	5.64	6.26	5.23	26.67	1.36	0.32	0.57	35.73
Purulia[a]	0.92	4.15	2.67	24.15	0.08	3.19	-5.01	38.90
West Bengal	80.75	95.81	77.56	24.96	80.94	129.90	-4.12	75.25

a. First period: 1957-58 to 1966-67.
* All found significant at 1 per cent level.

TABLE I(B). PUNJAB-HARYANA: REGRESSION COEFFICIENTS OF OVERALL, 'POSITIVE' DEVIATION AND 'NEGATIVE' DEVIATION TREND LINES THROUGH WHEAT OUTPUT

District/ Region	1950-51 to 1966-67				1967-68 to 1984-85			
	b	b"	b′	F-test* (H_o:b"=b′)	b	b"	b′	F-test* (H_o:b"=b′)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(Hisar + Gurgaon + Mahendragarh)	15.06	14.45	14.74	31.08	62.40	72.87	29.21	33.25
Rohtak	9.17	9.52	8.69	31.47	17.42	21.80	10.56	27.85
(Sangrur + Karnal)	35.14	27.47	36.58	45.23	90.85	84.85	70.86	31.43
(Ambala + Hoshiarpur)	2.93	3.56	1.86	46.95	24.35	27.35	15.25	46.00
Ludhiana	15.59	17.09	10.28	36.88	21.92	19.96	24.54	44.87
(Bhatinda + Ferozepur)	28.93	31.55	29.15	32.48	170.80	123.83	56.02	58.02
Kapurthala[a]	6.08	6.60	5.77	18.93	12.51	11.55	11.63	86.02
Patiala[a]	7.14	-7.10	7.50	12.80	40.82	38.71	38.21	38.56
Jullundar	6.14	6.82	6.53	24.92	21.95	22.71	23.43	35.94
Amritsar	7.46	7.94	6.04	31.18	34.53	31.97	38.34	46.63
Gurdaspur	3.33	3.68	5.32	53.43	19.32	20.94	20.81	24.82
Districts combined	144.40	146.86	136.20	30.19	452.11	477.85	399.69	36.70

a. First period: 1957-58 to 1966-67.
* All found significant at 1 per cent level, except for Patiala for the first period, which is, however significant at 5 per cent level.

TABLE II(A). WEST BENGAL: AVERAGE LINEAR GROWTH RATE OF RICE PRODUCTION

(per cent per annum)

District	1950-51 to 1966-67	1967-68 to 1984-85
24-Parganas	0.957	1.735
Nadia	1.772	3.715
Murshidabad	1.284	2.138
Burdwan	1.541	1.992
Birbhum	1.021	0.790
Bankura	-0.008	0.048
Midnapur	0.478	0.868
Hooghly	0.608	1.733
Howrah	-0.783	2.504
Jalpaiguri	2.896	-0.316
Malda	1.043	3.229
West Dinajpur	6.453	0.762
Cooch Behar	3.517	0.531
Purulia	0.391[a]	0.031
West Bengal	1.804	1.287

a. 1957-58 to 1966-67.

TABLE II(B). PUNJAB-HARYANA: AVERAGE LINEAR GROWTH RATE OF WHEAT PRODUCTION

(per cent per annum)

District/Region	1950-51 to 1966-67	1967-68 to 1984-85
(Hisar + Gurgaon + Mahendragarh)	8.569	7.416
Rohtak	6.585	4.164
(Sangrur + Karnal)	14.147	5.191
(Ambala + Hoshiarpur)	1.613	4.468
Ludhiana	10.898	2.828
(Bhatinda + Ferozepur)	7.143	5.883
Kapurthala	11.537	7.083
Patiala	4.126	6.776
Jullundar	4.693	4.456
Amritsar	4.714	5.606
Gurdaspur	3.858	5.724
Districts combined	7.726	5.310

a. 1957-58 to 1966-67.

In the second sub-period, 1967-68 to 1984-85, the three northern districts of West Dinajpur, Cooch Behar and Jalpaiguri which surpassed the State's average growth rate in the first sub-period fell miserably below it - in Jalpaiguri it was negative, and was below 1 per cent per annum in West Dinajpur and Cooch Behar during the second sub-period. The growth rate fell in Purulia from 0.391 to 0.031 per cent per annum, and also in Birbhum from 1.021 to 0.79 per cent per annum during 1967-68 to 1984-85. Ins the second sub-period the growth rate of rice production increased appreciably in the districts of Nadia, Murshidabad, Malda, Howrah, Hooghly and 24-Parganas. It increased in Burdwan from 1.5 to

about 2 per cent per annum; in Midnapur, too, from 0.5 to 0.87 per cent per annum. In Bankura, in the second sub-period, the growth rate was positive but very low, only 0.05 per cent per annum during the period.

During the period 1950-51 to 1966-67, the districts in Punjab-Haryana recorded higher rates of growth of wheat production, far greater than the districts of West Bengal in the production of rice, the combined districts average for Punjab-Haryana being 7.7 per cent per annum in the production of wheat. While in (Ambala + Hoshiarpur) the rate of growth was very low and in Gurdaspur, Patiala, Jullundar, Amritsar, Rohtak and (Bhatinda + Ferozepur) it was below the overall average, the rates of growth of wheat production in (Sangrur + Karnal), Kapurthala, Ludhiana and (Hisar + Gurgaon + Mahendragarh) were magnificent. However, during the second sub-period, the districts could not maintain their rates achieved in the first. It fell in seven districts/regions, significantly in Ludhiana, (Sangrur + Karnal) and Kapurthala. The rate of growth of wheat production, on the other hand, increased appreciably in (Ambala + Hoshiarpur), Gurdaspur and Patiala.

Instability in Production: Pre- and Post-Green Revolution Periods

The F-test confirms that, for each sub-period in all the districts, 'positive' and 'negative' deviation trend lines, through the rice output in West Bengal and wheat output in Punjab-Haryana, are not parallel; all are found highly significant [Tables I (A) and I (B) for West Bengal and Punjab-Haryana respectively].

Tables III (A) and III (B) give, for West Bengal and Punjab-Haryana respectively, the value of 't' at the point of intersection of 'positive' and 'negative' trend lines for each district of West Bengal and Punjab-Haryana and for both the sub-periods. The convergence/divergence of respective outputs along the trend line has been identified, as has been noted earlier, by the sign of the corresponding 't' value. The positive value of 't' implies convergence, while the negative value indicates divergence of the pair of corresponding 'positive' and 'negative' trend lines.

It is to be noted from Table III (A) that while in six districts - 24-Parganas, Nadia, Burdwan, Birbhum, Hooghly and Malda - the 'positive' and the 'negative' deviation trend lines had tendencies to converge, implying diminishing year-to-year fluctuations in production during the first sub-period, they had deviated from each other during the second sub-period in all these districts, indicating increasing year-to-year fluctuations in the post-green revolution period. The production of rice in Murshidabad, Midnapur, Howrah, Bankura and Purulia showed increasing fluctuations in both the sub-periods. However, in Jalpaiguri, West Dinajpur and Cooch Behar the 'positive' and 'negative' trend lines had the tendencies to converge during the second sub-period, though they were divergent during the first sub-period.

In the case of Punjab-Haryana, it is to be noted from Table III (B) that while in Ludhiana, Kapurthala, Jullundar and Amritsar the 'positive' deviation and the corresponding 'negative' deviation trend lines tended to diverge during the pre-green revolution period, they tended to converge in the post-green revolution period, indicating diminishing year-to-year fluctuations along the trend line in the production of wheat. On the other hand, (Hisar + Gurgaon + Mahendragarh), (Sangrur + Karnal), Patiala and Gurdaspur recorded increasing instability in the second sub-period in the production of wheat, although they had tendencies towards diminishing instability in production during the pre-green revolution period. (Ferozepur + Bhatinda), Rohtak, (Ambala + Hoshiarpur) had growing instability in the production of wheat in both the sub-periods.

TABLE III(A). WEST BENGAL: CONVERGENCE/DIVERGENCE OF 'POSITIVE' DEVIATION AND 'NEGATIVE' DEVIATION TREND LINES THROUGH RICE OUTPUT

District	1950-51 to 1966-67			1967-68 to 1984-85		
	$t=\frac{a''-a'}{b'-b''}$	Convergent(C)/ Divergent(D)	$\lvert\tan(\theta''-\theta')\rvert$	$t=\frac{(a''-a')}{(b'-b'')}$	Convergent(C)/ Divergent(D)	$\lvert\tan(\theta''-\theta')\rvert$
(1)	(2)	(3)	(4)	(5)	(6)	(7)
24-Parganas	27.56	C	0.36	-1.96	D	0.39
Nadia	50.63	C	0.35	-9.47	D	0.06
Murshidabad	-493.64	D	0.01	-3.15	D	1.001
Burdwan	36.16	C	0.04	0.53	D	0.26
Birbhum	28.04	C	0.19	-4.78	D	0.42
Bankura	-67.17	D	0.27	-4.39	D	0.41
Midnapur	-183.08	D	0.11	-2.89	D	0.44
Hooghly	188.03	C	0.10	-19.47	D	0.14
Howrah	-9.86	D	6.33	-91.19	D	0.09
Jalpaiguri	-241.56	D	0.004	84.65	C	0.14
Malda	164.41	C	0.10	-31.61	D	0.02
West Dinajpur	-10.73	D	0.01	42.37	C	0.55
Cooch Behar	-26.72	D	0.03	249.64	C	0.21
Purulia[a]	-52.49	D	0.12	-2.91	D	0.55
West Bengal	-34.39	D	0.002	0.31	D	0.25

a. First period: 1957-58 to 1966-67.

TABLE III(B). PUNJAB-HARYANA: CONVERGENCE/DIVERGENCE OF 'POSITIVE' DEVIATION AND 'NEGATIVE' DEVIATION TREND LINES THROUGH WHEAT OUTPUT

District	1950-51 to 1966-67			1967-68 to 1984-85		
	$t=\frac{a''-a'}{b'-b''}$	Convergent(C)/ Divergent(D)	$\lvert\tan(\theta''-\theta')\rvert$	$t=\frac{(a''-a')}{(b'-b'')}$	Convergent(C)/ Divergent(D)	$\lvert\tan(\theta''-\theta')\rvert$
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(Hisar + Gurgaon + Mahendragarh)	191.90	C	0.001	2.20	D	0.02
Rohtak	-10.28	D	0.01	-2.33	D	0.05
(Sangrur + Karnal)	21.68	C	0.01	-22.52	D	0.002
(Ambala + Hoshiarpur)	-13.96	D	0.22	0.42	D	0.03
Ludhiana	-2.48	D	0.04	31.97	C	0.01
(Bhatinda + Ferozepur)	-38.83	D	0.003	3.07	D	0.001
Kapurthala[a]	-22.43	D	0.02	570.75	C	0.001
Patiala[a]	9.18	C	0.28	-206.36	D	0.0003
Jullundar	-88.62	D	0.01	110.03	C	0.001
Amritsar	-17.47	D	0.04	30.59	C	0.01
Gurdaspur	37.09	C	0.08	-477.54	D	0.003
Districts combined	-23.28	D	0.001	-9.63	D	0.0004

a. First period: 1957-58 to 1966-67.

Growth and Instability: Post-Green Revolution Period

From Tables II (A) and III (A), it is seen that the increase in growth rate in the districts of West Bengal is generally associated with instability in the production of rice. As many as nine out of 14 districts - 24-Parganas, Nadia, Murshidabad, Burdwan, Bankura, Midnapur, Hooghly, Howrah and Malda - had registered during the second sub-period higher rate of growth of production over the first sub-period along with growing instability in the production of rice. On the contrary, the three northern districts, Jalpaiguri, West Dinajpur and Cooch Behar, which showed poor performance in production during the second sub-period, had diminishing instability in the production of rice. There was growing instability in production along with a fall in the rate of growth of rice production in the districts of Birbhum and Purulia.

In Punjab-Haryana, too, most of the districts/regions showed instability in production of wheat during the second sub-period, whether or not there had been increase in the rate of growth of production in these districts during the post-green revolution period compared to the first sub-period. In Ludhiana, Kapurthala and Jullundar, however, there had been a fall in the rate of growth of wheat production along with diminishing instability (*i.e.*, convergence of the 'positive' and 'negative' trend lines) in production during the second sub-period. Amritsar is the only district where there had been an increase in the rate of growth of production and tendency towards convergence of the 'positive' deviation and 'negative' deviation trend lines during the post-green revolution period.

Nature of Instability/Stability in Rice Production in West Bengal and Wheat Production in Pubjab-Haryana: Pre- and Post-Green Revolution Periods

As has been noted earlier, the value of $|\tan(\theta^+ - \theta^-)| = \frac{b^+ - b'}{1 + b^+ \cdot b'}$ will be treated as the index of convergence/divergence of the 'positive' deviation and 'negative' deviatien trend lines. Columns 4 and 7 in Table III (A) give the value of $|\tan(\theta^+ - \theta^-)|$ for the districts of West Bengal for the periods of 1950-51 to 1966-67 and 1967-68 to 1984-85 respectively. Similarly, the same columns in Table III (B) present the indices for the districts/regions of Punjab-Haryana for the two periods respectively.

Apart from the three northern districts, Jalpaiguri, West Dinajpur and Cooch Behar, which showed diminishing instability in the production of rice during the second sub-period, in all the remaining eleven districts of West Bengal the 'positive' and 'negative' deviation trend lines deviated from each other during the post-green revolution period. Of these eleven districts, as many as six districts, 24-Parganas, Nadia, Burdwan, Birbhum, Hooghly and Malda, had converging trends in production of rice during the pre-green revolution period. The remaining five districts had diverging trends in both the periods and, except in Howrah, the index of divergence had increased during the post-green revolution period in the districts of Murshidabad, Midnapur, Bankura and Purulia in the production of rice. It is to be further noted from col. (8) in Table I (A) that b', the regression coefficient of the 'negative' deviation trend line, is negative for the period 1967-68 to 1984-85 in six districts - Murshidabad, Birbhum, Midnapur, Bankura, Purulia and Jalpaiguri. Thus in West Bengal as a whole, fluctuations during the post-green revolution period in the production of rice had significantly increased compared to the pre-green revolution period.

In Punjab-Haryana the behaviour of the trend lines is altogether different. In the districts of Ludhiana, Kapurthala, Jullundar and Amritsar the 'positive' deviation and 'negative' deviation trend lines had tendencies to converge during the post-green revolution period, indicating diminishing fluctuations in the production of wheat. In the districts/regions of (Ambala + Hoshiarpur) and (Bhatinda + Ferozepur) the rate of divergence had decreased during the second sub-period compared to the first, the value of $|\tan(\theta^{+} - \theta^{-})|$ fell from 0.22 to 0.03 and from 0.003 to 0.001 respectively. Although the rate of divergence had increased in Rohtak, and the districts/regions of (Hisar + Gurgaon + Mahendragarh), (Sangrur + Karnal) and Patiala had diverging 'positive' deviation and 'negative' deviation trend lines in the second sub-period only, the overall Punjab-Haryana (combined districts) presented diminishing instability in the production of wheat during the post-green revolution period. The rate of divergence for the combined districts fell from 0.001 to 0.0004.

Summary and Conclusions

In Punjab-Haryana in the production of wheat there had been an outward shift of the production frontier during the post-green revolution period. But this parametric shift in the production frontier was not accompanied by an increase in the rate of growth of production. In most of the districts and, thus in Punjab-Haryana as a whole, the average linear growth rate of the production of wheat did not rise in the second sub-period compared with the first, which means there was no significant rotational shift of the trend line. However, there are definite signs of diminishing year-to-year fluctuations in the production of wheat in Punjab-Haryana, particularly for the districts of Punjab.

In contrast, in West Bengal there was a fall in the rate of growth of production of rice in a number of districts, particularly in the three northern districts of the State. Except for three or four districts, the remaining districts of the State, however, registered only marginal increase in the rate of growth of production during the post-green revolution period compared to the pre-green revolution period. What is much more disturbing is the widening year-to-year fluctuations in the production of rice in the districts of West Bengal during the second sub-period.[5]

Almost all the studies addressed to growth and stability in agriculture emphasised the importance of 'irrigation' to ensure growth as well as stability in production. The elaborate network of irrigation in Punjab-Haryana, independent of the vagaries of the monsoon rainfall, along with the development of private tubewell irrigation on a substantial scale, particularly during the post-green revolution period, may have effectively narrowed down the year-to-year fluctuations in the production of wheat. It also permitted the introduction of a second crop, rice, which has been growing at a much faster rate compared to that in West Bengal. Irreparable damage done to the ancient irrigation network in Bengal during the colonial rule, on the other hand, has not been compensated by the development of irrigation during the era of planned development since Independence in West Bengal. Water control in West Bengal constitutes the 'binding technological constraint'.

"The chief objects of water control, as far as the rice farmer is concerned, are to reduce the risk of flood and drought, to ensure an adequate and regular supply of water which can be let in and out of the fields as required, ..." (Bray, 1986). Water control thus covers three interlinked categories: irrigation, drainage and flood control. The rice plant requires maximum water for its growth during the period of its flowering to ripening. The HYV varieties require continuous submergence from planting to maturity within a fairly narrow band of the water regime. Since rice has to be planted during monsoon rains, its period of

maximum growth may well extend to the dry season. Hence, rice requires supplemental irrigation and drainage and flood control for growth and stability in production. The gravity-fed irrigation network, dependent on the south-west monsoon in West Bengal, poses serious constraint to growth and stability in rice production in the State. The fluctuations in the production of rice in West Bengal are thus to be traced to the variability in the water regime, spatially as well as temporally.

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NOTES

1. For earlier studies on the subject, see, in particular, Sen (1971); Bandyopadhyay (1977); Vaidyanathan (1977 *a, b*); Srinivasan (1979); Mehra (1981); Hazell (1982); Dhawan (1983); Chattopadhyay (1983); Boyce (Chapter 3, 1987). This paper suggests an alternative measure of instability.

2. Minhas and Srinivasan asserted the use of harmonic mean to get the linear growth rate. See Minhas (1966).

3. t-test for the coefficients, F-test for goodness of fit, R^2, Durbin-Watson test for serial correlation, etc.

4. In a number of cases in the second sub-period, 't' turns out to be positive, but the value of 't' for all these cases is less than 3.07. Considering the period as a whole, we have branded the pairs of lines as divergence. The districts are: Burdwan, West Bengal; (Hisar + Gurgaon + Mahendragarh), (Ambala + Hoshiarpur) and (Bhatinda + Ferozepur). See Tables III (A) and III (B).

5. To cite the results of one of the earlier studies, Hazell (1982) found: In Punjab, during the period 1967-68 to 1977-78, the coefficient of variation of total cereal production fell, although the fluctuations in wheat production were slightly on the increase (compared to the period 1954-55 to 1964-65); Haryana exhibited increasing fluctuations in all the cereal crops; and in West Bengal, while the coefficient of variation of total cereal production had increased, the coefficient of variation of rice production had declined in the post-green revolution period.

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