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YIELD GROWTH AND THE ROLE OF INPUTS AND POLICY VARIABLES INFLUENCING THE YIELD: A CROP-WISE STUDY FOR WEST BENGAL

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Abstract : *The present paper measures yield rates and the impact of liberalization policies on yield growth of seven major crops — Aus, Aman, Boro, Jute, Wheat, Mustard, and Potato– in West Bengal, India, over the period 1980-81 to 2002-03. A multivariate regression analysis is also, done to find the crop-specific determinants of yield which includes some crop-specific factors and some policy parameters also. Presence of inter-crop disparity in yield growth rate is evident from the study. factors like various forms of public expenditure, Gini coefficient, credit facilities and infrastructures like roads & state warehouses are found to have positive effects on yield growth for different crops. However, the set of significant factors varies from crop to crop.*

Keywords: *Yield, Crops, West Bengal, Policy-parameters, public expenditure, credit, infrastructures, Gini coefficient.*

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1 INTRODUCTION:

Among the Indian states West Bengal shows a quite impressive agricultural performance from 1980s onwards. With a successful Land Reforms programme and implementation of HYV technologies the state acquires an important position in the agricultural scenario of the country as is evident from the fact that the rate of growth in foodgrains production for the period 1981-91 was the highest in this state (Saha and Swaminathan, 1994). A few studies [like Boyce (1987), Saha and Swaminathan (1994), Rawal and Swaminathan (1998)] focused solely on West Bengal agriculture. These studies analyzed the changes in growth performance that took place between the pre- & post –Green Revolution periods and focussed on the major crop-categories like Rice / Oilseeds / Pulses/ Foodgrains / non-Foodgrains / total output.

The substantial improvement in agricultural production in West Bengal, after 1980s, is attributable to, apart from rice, production of crops like Oilseeds & Potato. In this context, a crop-specific analysis of growth performance, on which not much study has been done in the context of West Bengal, can be useful.

Also there is a dearth of studies focusing on yield of different crops produced in West Bengal. Not only that yield is an important determining factor for the output of a crop, but also the factors affecting the growth rate of yield of different crops need to be addressed. Proper identification of these factors can provide a guideline for selecting appropriate crop - specific measures for promoting growth of different crops and thus maintaining a balanced growth structure of the agricultural sector. The present study aims at filling up these gaps in the existing literature.

The objectives of the paper is –

i) to analyse the growth of yield of different crops in West Bengal,

ii) to examine whether there are shifts in the growth path of yield of major individual crops between pre- and post - Liberalisation period in West Bengal.

iii) to determine the factors affecting the yield of various crops.

The present paper presents a growth analysis for seven major crops of West Bengal like Aman, Aus, Boro, Jute, Wheat, Rapeseed - Mustard and Potato. The crops are selected on the basis of proportion of area under them and their contribution to production. The reference period is selected from 1980 onwards, because, as is often pointed out, West

Bengal is a late starter in the process of adoption of modern technology in agriculture. Further, to take care of the effects of economic liberalization the reference period is further sub-divided into two phases — Period I or the pre-Liberalisation period (1980-81 to 1990-91) and Period II or the post - Liberalisation period (1991-92 to 2009-10). The year 1990-91 is considered as the break point because various changes in economic policies aiming at liberalisation of the economy began to take place from this point onwards.

The paper is organized as follows. Section 2 presents the analysis of the growth rates of yield. Section 3 consists of a dummy variable analysis to see whether there is shift in the growth rates in the pre- and post - Liberalisation period. Section 4 details an analysis of the determinants of yield of different crops is carried out. Some concluding observations are made in final section 5.

2 MEASUREMENT OF GROWTH:

METHODOLOGY:

For the measurement of growth rate, the first methodological issue to be addressed is how to specify the appropriate trend type. To this end the paper considered two basic trend types, viz., linear and nonlinear (exponential) trend equations for yield. Other non-linear forms, like Gompartz etc., are kept out of the purview of the paper to keep the matter simple. The comparison between the two forms is done on the basis of simple correlation coefficient (Pearson's) between the actual value and the estimated value of yield for these two alternative specifications. The form that gives higher value of correlation is chosen as the best fit.

Linear specification*:*

$Y = \alpha + \beta t$ + error term (1)

where, Y denotes the yield of the selected crops. 't' refers to the time period. The estimated slope coefficient 'β' measures change in 'Y' overtime, i.e., $\widehat{\boldsymbol{\beta}} = \frac{dY}{dt}$. Rate of growth, '$g$', say in the linear model is measured as $g = \frac{1}{Y}\widehat{\boldsymbol{\beta}} = \frac{1}{\bar{Y}}\frac{dY}{dt}$

Exponential Specification:

The exponential growth model takes the form $Y = \alpha \beta^t$ (2)

Taking logarithmic value on both sides, the linear transformation takes the form

$\ln Y = \ln\alpha + (\ln\beta)t$ + error term (3)

Here, rate of growth of Y is given by antilog (estimated coefficient of 't')-1.

Data Sources:

All the data on yield are collected from the different issues of the Economic Review, the Statistical Abstract published by the government of West Bengal, Bulletin of Food Statistics published by the government of India.

RESULTS OF ESTIMATION OF GROWTH RATES:

The linear specification has turned out to be the best –fitted one for Aus, Aman, Boro, Jute, Potato and Rapeseed and Mustard while the exponential form gives the best –fit only for wheat. The results of estimation of rates of growth of yield (Y) for each of the selected crops like Aman, Aus, Boro, Jute, Wheat, Rapeseed-Mustard and Potato for the period 1980-81 to 2009-10 are presented in Table 1. There exist inter-crop disparities as regards the growth paths. The yield growth of Aus (2.85 per cent) surpasses that of all other crops.

TABLE 1: RESULTS OF ESTIMATION OF TREND EQUATION FOR MAJOR CROPS

Coeff.	AMANY	AUSY	BOROY	JUTEY	MSTY	WHTY	PTOY
(Constant)	1187.90 (21.17*)	901.49 (19.74*)	2704.14 (40.98*)	1461.75 (33.39*)	651.79 (19.08*)	7.58 (183.15*)	20.03 (11.98*)
TIME	45.50 (14.40*)	45.95 (17.86*)	16.16 (4.35*)	38.53 (15.27*)	7.78 (4.04*)	0.01 (2.99*)	0.12 (1.26)
Growth rate	2.40	2.85	0.55	1.87	1.01	0.70	0.54
Adj. R-Sq.	0.877	0.916	0.382	0.892	0.346	0.215	0.020

* ⇒1% level of significance

3 MEASUREMENT OF SHIFT OF GROWTH PATH:

METHODOLOGY:

This section focuses on the issue of shift of growth path of yield of different crops. More specifically, it seeks to explain the impact of liberalization on the growth of yield of the selected crops. For this purpose the analysis is carried out on the basis of the sub-periods — (i) the pre-Liberalisation period (1980-81 to 1990-91) and (ii) the post - Liberalisation period (1991-92 to 2009-10).

The shift in the growth path is measured by incorporating changes in both intercept and slope of the trend function in the form of intercept and the slope dummies. Thus, the final regression equation looks like

$$LnY = \alpha_0 + \alpha_1 D + \beta_0 t + \beta_1 Dt + \text{error term} \quad (4)$$

D=0 for the period 1980-81 to 1990-91

=1 for the period 1991-92 to 2009-10

Here, α_0 is the intercept term; the rate of growth of period-I is given by β_0 whereas the rate of growth of period-II is given by $\beta_0 + \beta_1$, if β_1 is statistically significant. If $\beta_1 > 0$, it implies acceleration of growth rate in period-I. On the other hand, if $\beta_1 < 0$, it implies deceleration of growth rate in period-II.

RESULTS OF ESTIMATION:

Table 2 reports the results of estimation of the dummy variable analysis. The coefficient of β_0 is positive and significant for Aman, Aus, Boro, Jute, Rapeseed-Mustard and Potato yield implying positive growth rate of yield for these crops. On the other hand, the slope dummy coefficients (β_1) for yield of Aman, Aus, Boro, Jute, Rapeseed-Mustard and Potato are negative and significant. Taken together, these results imply deceleration in yield growth rates of Aman, Aus, Boro, Jute, Rapeseed-Mustard and Potato. The highest deceleration in yield is noticed for Rapeseed-Mustard (-0.043) and the lowest deceleration is recorded for Jute yield (-0.02). The positive and significant constant terms for all the crops imply positive yield level for the crops. The intercept dummy terms are positive and significant for Aus, Boro, Potato and Mustard and positive but insignificant for Aman and Jute. For Wheat the intercept dummy term is negative but insignificant. The implication is that there has been an increase in the level of yield, in period-II, for Aus, Boro, Potato and Mustard while for Aman, Jute and Wheat it has remained unchanged. So for crops like Aus, Boro, Rapeseed-Mustard and Potato a deceleration in yield growth rate is accompanied by an increase in the level of yield between two periods. On the other hand, Aman, Jute have deceleration in yield growth rate with no change in level of yield from period I to period II. Only Wheat recorded no significant change in either growth rate or level of yield between the sub-periods.

TABLE 2: RESULTS OF DUMMY VARIABLE ANALYSIS

Crops / Var.s	AUS Y	AMAN Y	BORO Y	JUTE Y	POT Y	MSTY	WHT Y
(Const.)	6.707 (149.211*)	6.991 (91.236*)	7.805 (255.444*)	7.201 (173.965*)	9.755 (177.682*)	6.233 (104.418*)	7.65 (98.15*)
Intercept dummy	0.424 (3.748*)	0.307 (1.593)	0.174 (2.269**)	0.177 (1.702)	0.24 (1.737***)	0.265 (1.766**)	-0.015 (0.076)
Time	0.052 (7.858*)	0.045 (3.952*)	0.02 (4.421*)	0.037 (6.055*)	0.028 (3.423*)	0.052 (5.963*)	-0.006 (0.545)
Slope dummy	-0.032 (3.642*)	-0.027 (1.822***)	-0.017 (2.879*)	-0.02 (2.474**)	-0.025 (2.298**)	-0.043 (3.659*)	0.011 (0.695)
Adj. R-Sq.	0.936	0.742	0.664	0.857	0.493	0.665	0.058
DW	1.97	1.93	2.309	2.435	1.662	2.407	1.219

* ⇒1% level of significance; ** ⇒ 5% level of significance;

*** ⇒10%level of significance

4 DETERMINANTS OF YIELD:

The yield growth has varied impact on the changes (acceleration/ deceleration) in output for different crops. So, the present study attempts to highlight the inter-crop variation in the yield growth and to look for the factors that are responsible for such variation. Primarily, the yield of a crop is a function of various factors like price, human labour, pesticides, fertiliser etc. To take into account the crop-specific influences, factors like the farm harvest price of the relevant crop, price risk for the relevant crop, the per acre requirement of various inputs like human labour, pesticides and fertiliser are selected as independent variables in the yield function of the selected crops.[1] Besides, a wide range of policy variables is also considered as yield determinants. These variables account for those factors that remain outside the control of the farmer. These policy variables include some forms of public expenditure like State plan expenditure on irrigation and flood control (Rs.crores), State plan expenditure on agriculture and rural development (Rs.crores), expenditure on education and research in West Bengal (Rs. crores), credit facilities taken care of by the loan advances from the Agricultural Credit Societies in West Bengal (Rs.crores), irrigation captured in terms of area irrigated by the government canals (hectares), total number of river lift irrigation in the State and total number of shallow tube wells in the State, and some infrastructural variables like the warehouse facility as measured by the storage capacity provided by West Bengal State Warehousing Corporation (Metric tones), and length of roads in the state maintained by the zilla parishad (Km.) in West Bengal. The present study has also included Gini coefficient to account for the existing inequality in the distribution of operational land holding.

METHODOLOGY AND DATA:

The analysis of factors affecting the yield of various crops involves running a series of stepwise regressions. As before, in this case also, no a-priori assumption is made about the type of specification. While carrying out the regression for each crop alternative combinations of explanatory variables are tried out. The model having the highest value of simple correlation between the actual and the predicted value of the dependent variable is taken to be the best fit.

[1] In the present study, the yield function for each crop includes the farm harvest price (FHP) • current as well as lagged values • of the relevant crop as independent variables.

For the policy variables, aggregated state level data are used. All the input data used in the study are collected from the different issues of the Farm Management Survey Reports of Government of West Bengal, Directorate of Agriculture. Data on other variables are collected from various issues of Statistical Abstract published by the Government of West Bengal and Bulletin of Food Statistics published by the Government of India. Data on inequality in the distribution of land holding is not directly available and is computed using the Gini coefficient. For this purpose, data on the number of farmers and the area of holding for the different size- classes, viz., marginal (less than 1 hectare), small (1-2 hectares), semi-medium (2-4 hectares), medium (4-10 hectares) and large (10 hectares and above) are taken from the West Bengal Agricultural Census for different years.

TABLE 3: THE CROP – SPECIFIC DETERMINANTS OF YIELD

CROPS / Variables	AMAN	AUS	BORO	JUTE	MST	POT	WHT
(Constant)	1537.967 (1.455)	-468.081 (0.577)	314.678 (9.033*)	2432.051 (10.492*)	6.862 (100.376*)	10.691 (25.362*)	1012.222 (1.958***)
Human labour	-395.448 (1.518)	-406.021 (2.941*)	-4.866 (2.854**)	-23.762 (4.426*)	-0.030 (5.385*)	-0.316 (3.467*)	
Current Period Price			0.134 (3.591*)				
Price lagged by one year	223.458 (1.801***)	560.699 (7.145*)		0.623 (3.471*)			
Price lagged by two years							201.032 (2.202**)
Fertiliser	506.041 (2.356**)		67.758 (1.148)	111.070 (1.051)		0.132 (2.094**)	
Pesticides		100.757 (1.895***)			1.034 (5.416*)		
Price risk				-525.240 (3.582*)		-0.081 (3.378*)	
Adjusted R-Sq	0.780	0.866	0.665	0.825	0.589	0.607	0.149

* ⟹1% level of significance; ** ⟹ 5% level of significance; *** ⟹ 10% level of significance

RESULTS OF ESTIMATION WITH CROP –SPECIFIC DETERMINANTS OF YIELD:

The results of estimation are presented in Table III. The linear model gives the best fit for Boro and Jute. The specification with the log yield values as a function of the absolute values of the explanatory variables is the chosen functional form for Mustard. The specification with absolute yield as function of the log –values of the explanatory variables gives the best fit for Aman, Aus, and Wheat. The log model is the best fit only for Potato.

Now, coming to the set of variables explaining the yield of the crop, it is clear that human labour appears in the regression equation for all crops except wheat. The variable is statistically significant for all these cases and also bears the expected negative relation to the yield of the related crop. Except Aman, Mustard and potato, the price factor is statistically significant in all other cases. The role of the price risk factor as a statistically significant factor for yield levels of Jute and Potato deserve special mention. Both these crops face volatile prices. Hence, the resulting price risk is also likely to hamper the yield of these two crops. All the variables have appeared with the expected signs. The coefficients of human labour and price risk are negative. The predominance of surplus labour force in the agricultural sector of a developing economy supports the negative relationship between yield of a crop and human labour. The negative relationship between the price risk variable and the yield suggests risk aversion on the part of the farmers.

The level of yield of Aman depends significantly on the rate of growth of farm harvest price lagged by one year and fertilizer. Rate of growth of Human labour, farm harvest price lagged by one year and pesticides together explain a variation in Aus yield. Boro yield level depends on the levels of human labour and current period price. Jute yield level depends on the levels of human labour, farm harvest price lagged by one year and price risk. Rate of growth of yield of Mustard depends on the levels of human labour and pesticides. Rate of growth of human labour, fertilizer and price risk together explains variation in the rate of growth in Potato yield. The level of Wheat yield depends only on the rate of growth of farm harvest price lagged by two years.

Table 4 depicts the influence of policy variables on yields of different crops. For Aman, the rates of growth of expenditure on agriculture and rural development, the Gini ratio, area irrigated by the government canals and length of roads explain the variation in the yield level of the crop. The variation in Aus yield level gets explained by the levels of factors like expenditure on agriculture and rural development, advances from the scheduled commercial banks, the Gini ratio and area irrigated by the government canals. Rates of growth of factors like advances from the land development banks and the Gini ratio taken together explain the variation in yield level of Boro. The model for Jute incorporates levels of factors like the warehouse facility and the advances from the scheduled commercial banks. For Mustard, the rates of growth of inputs like expenditure on education and

research, expenditure on agriculture and rural development and the Gini ratio explain the variation in the yield level of the crop. The model for Potato includes factors like expenditure on agriculture and rural development and the Gini ratio. For Wheat, the rate of growth of factor like plan expenditure on irrigation and flood control explains the rate of growth of yield.

TABLE 4: POLICY VARIABLES AFFECTING YIELD OF DIFFERENT CROPS

Crops / Var.s	AMANY	AUSY	BOROY	JUTEY	MSTY	POTY	WHTY
Constant	-9567.369 (4.705*)	6582.218 (3.726*)	1029.260 (2.651**)	6.715 (55.304*)	-312.284 (1.633)	12.093 (11.367*)	7.140 (41.971*)
Expenditure on agricultural education and research					107.894 (3.778*)		
Expenditure on agriculture & rural development	170.595 (2.797**)	0.264 (1.486)			29.014 (1.217)	0.0004 (5.402*)	
Expenditure on irrigation and flood control							0.106 (3.107*)
Advances from the commercial banks		0.297 (7.013*)		8.482E-05 (4.058*)			
Advances from the land development banks			147.161 (4.762*)				
Gini Ratio	-9255.247 (3.087*)	-7097.156 (3.461*)	-6771.780 (3.309*)		-2813.739 (2.377**)	-2.724 (2.116**)	
Warehouse				0.003 (5.425*)			
Area irrigated by government canals	528.153 (2.075***)	0.282 (1.451)					
Roads	477.167 (3.440*)						
Adj.R-Sq	0.850	0.937	0.684	0.890	0.694	0.701	0.282

* ⇒1% level of significance; ** ⇒ 5% level of significance; *** ⇒10%level of significance

Among different policy variables the Gini coefficient has appeared as a significant explanatory variable for all the crops except two viz., Jute and Wheat. This result implies that less inequality in distribution of land holdings, an outcome of a successful land reform programme in the state, has been a significant factor in augmenting the yield of most of the selected major crops, including the most important crop the state, viz., Rice. Analysing the

results from Table IV also shows that government expenditure in one form or the other has appeared as a significant factor in explaining the yield of Aman, Mustard, Potato and Wheat. Credit facilities in the form of advances from the scheduled commercial banks and advances from the land development banks play significant role as yield explaining factor for crops like Aus, Jute and Boro, respectively. The warehouse facility appears as a significant variable in the best fit equation for Jute only. This is expected as post-harvest the crop requires warehouse and storage facilities.

CONCLUSION:

The primary aim of this paper is to analyse the yield growth of major crops and to determine the factors influencing the yield of various crops using traditional regression technique. From the study it is clear that there exist conspicuous differences among the selected crops with respect to the yield growth. The disparities among the crops become even more prominent from the analysis of the yield determinants.

All the crops experienced positive rates of growth in yield for the period under study. Among the crops, the growth of Aus yield (2.85%) surpasses that of all other crops. Comparison of the sub-period growth rates shows a statistically significant decline in the rate of growth in Period –II for yield of Aman, Aus, Boro, Jute, Rapeseed-Mustard and Potato. While crops like Aus, Boro, Rapeseed-Mustard and Potato have experienced an increase in the intercept or level of yield between two periods, for Aman, Jute and Wheat there is no significant change in level of yield from period I to period II.

A regression analysis of the determinants of yield of the crops, with some policy parameters and some crop-specific factors incorporated separately as the explanatory variables, also reveal disparities among the crops not only with respect to the choice of functional form but also with respect to the variables explaining the yield of different crops.

Among the crop-specific inputs, human labour factor bears negative relation to the yield of all the crops except Aman and Wheat. The negative relation is justified given the existence of disguised family labour in Indian agriculture. Price risk bears the expected negative relation to the yield of Jute and Potato — crops which are subject to price fluctuations over the years. Other factors like i) farm harvest price, fertiliser and pesticides, show significant positive association with the yield of various crops.

Among the policy determinants, i) the Gini coefficient, ii) various forms of public expenditure, iii) credit facilities such as advances from the scheduled commercial banks and advances from the land development banks and iv) infrastructures like roads & state warehouses, bear significant association with the yield of various crops.

Among these determinants, the significance of the Gini coefficient in determining the yield of most of the crops is worth mentioning. The success of the land reform programme initiated in the state in the late 1970s resulted in lesser inequality in distribution of ownership holding. Results from the present study show that this factor has been an important determinant of yield of most of the major crops in the state. Another important factor is public expenditure like plan expenditure on agriculture and rural development, expenditure on education and research, plan expenditure on irrigation and flood control. Public expenditure in one form or the other plays a crucial in improving the yield of Aman, Mustard, Potato and Wheat. So, it follows from the analysis that this factor also plays a vital role in improving the yield of a few selected crops.

The decline in public sector's share in total capital formation in Indian agriculture since mid-1990s is held responsible by many like G.K. Chadha (2003) for the slowdown in agricultural growth since mid-1990s. So, there is need to put emphasis on public expenditure in the form of public investment.

As disparities among the crops are conspicuous with respect to the significant explanatory variables, the present study also suggests that policy measures aiming at yield improvement need to be crop-specific rather than general.

To put in a nutshell, for enhancement of yield of various crops policies should aim at

- increase in public investment in agriculture.
- Crop-specific measures.

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