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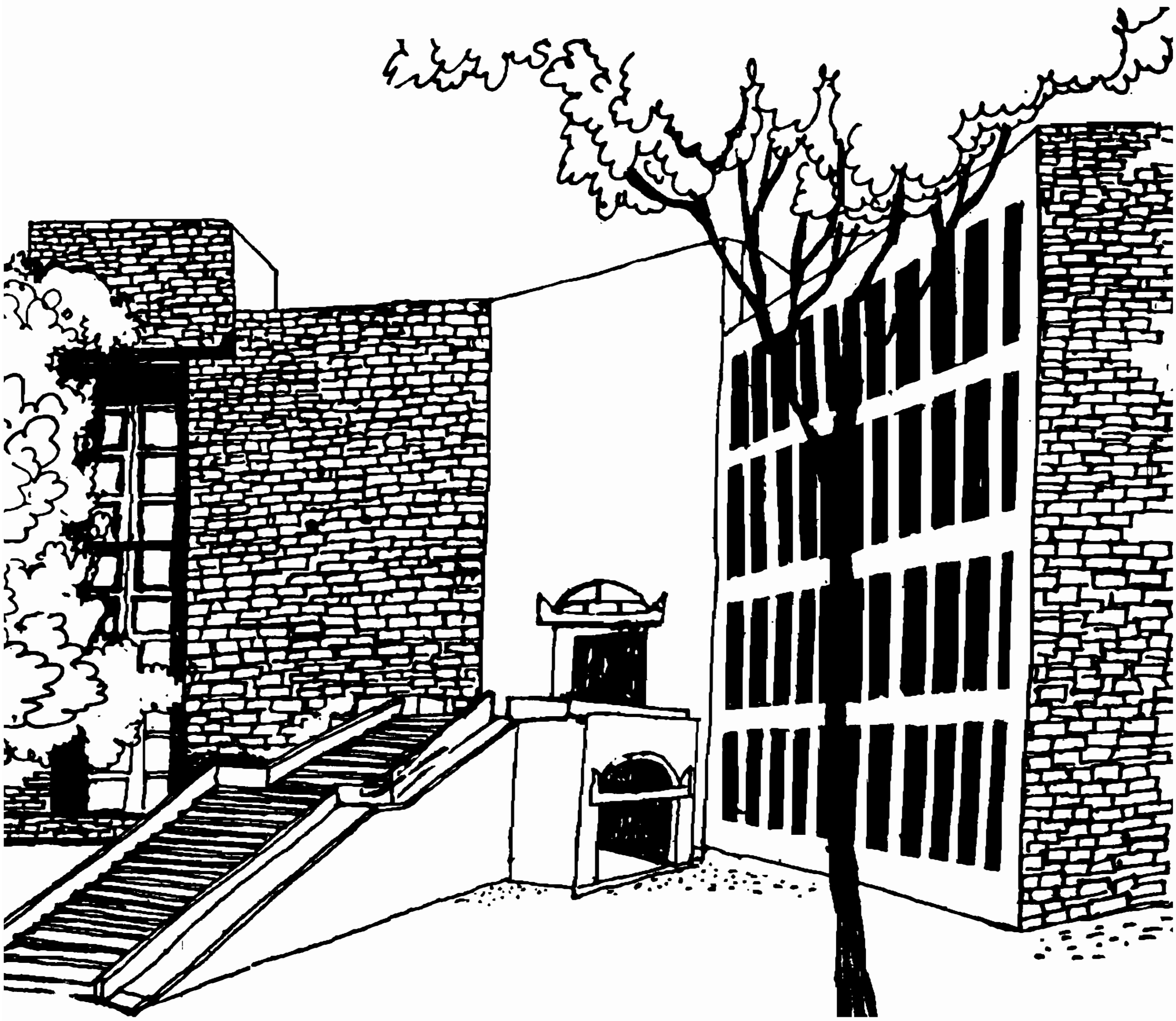

DETERMINANTS OF GROWTH IN RICE PRODUCTIVITY IN INDIA, 1980-95

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W.P. No.1414
November 1997

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DETERMINANTS OF GROWTH IN RICE PRODUCTIVITY IN INDIA, 1980-95

N.V.Namboodiri*

Introduction

Agricultural development is not just a necessary condition for meeting food and fibre requirement but a productive source of economic growth. There has been a shift away from the *industrial fundamentalism* to an emphasis on the significance of growth in agriculture for the total development of the economy.

Development programmes emphasizing the increased use of traditional inputs in agriculture have contributed only modestly to agricultural output gains and hence recognized technical change as the major *engine of growth* (Peterson, 1971). With limited land area and inexorable law of diminishing returns to the use of non-land inputs, technological change is a necessary condition for increased supply of agricultural commodities. Virtually under all circumstances, increasing agricultural productivity may have important contributions to general economic development. Land productivity is emphasized in this paper as in a land scarce country like India it is this productivity which needs sustained acceleration.

Technical change is invariably embodied in new inputs like HYV seeds, fertilizers etc. and services like appropriate timing and methods of their application (for details see Desai and Namboodiri,1997). Ideally technical change should be defined as growth in output associated with both of these. In practice it is defined as growth in output that is not accounted for the growth in all inputs, which is nothing but total factor productivity growth.

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The author is grateful to Prof. Bhupat M Desai for his valuable comments.

A study on total factor productivity of rice in India using cost of cultivation data found that the contribution of total factor productivity is 1.03 per cent. This accounts for one-third of output growth during 1971-88(Praduman Kumar and Rosegrant, 1994). Since this study on a single crop for which relevant data to estimate total factor productivity being not available considers land productivity as a proxy for technical change.

Rice is chosen because it is the single largest crop from both production and consumption angles in the country. Its cultivation exceeds 40 million hectares accounting for 40 per cent of total cereals area and over 46 per cent of cereals production. Although India accounts for over 28 per cent of the area under rice in the world, the share in production is merely 15 per cent. Rice is grown under diverse agro-climatic conditions. For example it is being cultivated in semi-arid tracks of Rajasthan and Gujarat to very wet areas of Assam and Kerala. In many of these wet areas it is mainly sown in three seasons namely autumn, winter and summer and these coincide with the harvesting seasons. The relative shares of total rice area in these three seasons are respectively 50 per cent, 45 per cent and 5 per cent. But in semi-arid tracks it is largely grown in autumn season. In 9 out of 15 major rice growing states rice cultivation spreads over two to three seasons (multi-season states) and in the remaining 6 states it is confined to the autumn season (mono-season states). Former states accounts for about three-fourth rice area in the country, while the latter accounts for the rest one-fourth.

This paper analyses the influence of various price and non-price factors that induce rice productivity. While the role of price incentive to induce technical change is obvious, the importance of non-price factors arises from the structural change in the agricultural sector. Non-price factors include technology(HYV), rainfall(IR), commercialization (MA), government support programme(PT), and average operational farm size(FS)as a proxy for land reforms. Prices considered are farm harvest prices of rice(FHP), nitrogen price(PF), and wage rate(AW). The relevance of each of these variables is discussed below.

Analytical Framework, Methodology and Data Base

Agricultural research develops new knowledge and/or improves materials and processes which are utilized by the farmers as new technology. The technology is defined as a combination of various inputs including HYVs, use of fertilizer and other chemicals, irrigation etc. as these are complementary to each other. As with any interacting input, a complete separation of the effects of irrigation, nitrogen and HYVs is not possible (Small L., 1978). Based on pooled data from 15 major rice growing states during 1980-81 to 1994-95 it was observed that the share of HYVs in total rice area and per cent of area irrigated under rice are highly correlated (correlation being 0.75). Similarly the same between HYVs and fertilizer consumption was also as high as 0.72. These prompted us to consider the share of area under rice covered by high yielding varieties(HYV) as a proxy for the technology variable. As of now only about 45 per cent of the total area under rice is irrigated and therefore rice cultivation, particularly in traditionally rice growing states, largely depends on the rainfall pattern. Rice is a crop which requires abundant water during the growth period. 30 cm or more rainfall is needed per month for three to four consecutive months and traditionally such areas are the major rice growing areas. About 60 per cent of the total area falls in these tracks. As a result major fluctuation in annual rainfall would affect the productivity level. We have used the rainfall variable in an index form where actual annual rainfall is expressed as per cent of normal rainfall(IR).

Commercialization in agriculture would have significant positive effects on productivity as easy access to exchange produce would have strong incentive to allocate resources for enhancing productivity. Improvement of agricultural marketing to increase efficiency of inter-farm and inter-regional exchange is recognized as an investment with high pay offs in increasing productivity of agriculture at the national level (von Oppen, 1980). The degree of commercialization is measured by market arrival as a per cent of production(MA).

The central government supports rice through assured market and prices(PT). The former results from procurement for public distribution and the latter from procurement price for this. As a result the government support could influence the rice output growth. Moreover the procurement policy may lead to an increase in average price received by farmers in the short and long run (Hayami, et al., 1982). Therefore procurement of rice as a per cent of production(PT) is considered government support. Over 60 per cent of the rice cultivators operate less than 1 hectare. These small holdings are mainly concentrated in the traditionally rice growing tracks. In many such areas land reform measures have been actively pursued. In order study its influence on rice productivity we have considered operational farm size in different states over time as one of the explanatory factors(FS).

Prices of both inputs and output influence productivity growth directly or indirectly. A principal distinction between modern and traditional rice varieties emphasized by the rice scientists is the greater yield response of the modern varieties to fertilizer (David C.C and R.Barker, 1978). This is particularly important in view of the land constraint that impedes agricultural growth in many developing countries. Therefore response of farmers to change in price of fertilizer is one of the major factors determining productivity growth. We have considered the real price of nitrogen, i.e, nominal price deflated by agricultural NDP deflator(PF) as one of the explanatory factors. In traditional technology wage rates are determined more by institutional factors rather than by the market mechanisms. But this aspect of labour market seems to have changed since the introduction of technological change with consequent closer relationship between marginal productivity of labour and wage rates(Ranade C.G., and R.W.Herdt, 1978). Therefore it is important to examine the influence of real agricultural wage rate, i.e, nominal wage rate deflated by agricultural NDP deflator(AW), in determining the productivity growth.

The rice price policy is designed to support prices for producers to protect their incentives for technical change. Since the government's procurement is largely concentrated in only two states using procurement price has little relevance. The support price of rice (common variety) has increased from Rs.1010 per tonne in 1980-81 to Rs.2150 per tonne in 1990-91 and further rose to Rs.3600 per tonne 1994-95. The ratio of procurement to average farm harvest prices remained around 0.8 during the early to mid-80s but it improved to 0.9 during 1990-91 and by 1994-95 it reached to almost one. Therefore we have considered farm harvest prices(FHP) to capture the response of the producers to change in rice prices.

Thus the multi-variate model that may explain growth in rice productivity is:

$IY_{it} = f(HYV_{it}, FS_{it}, IR_{it}, MA_{it}, PT_{it}, PF_{t}, FHP_{it}, AW_{it}, T)$; where

IY	=	Index of rice yield with triennium ending 1969-70 = 100
HYV	=	Percent area under rice covered by high yielding varieties.
FS	=	Operational farm size in hectares
IR	=	Index of annual rainfall where actual annual rainfall expressed as percent of normal rainfall
MA	=	Market arrival of rice as per cent of total rice production
PT	=	Government procurement of rice as per cent of production
PF	=	Real price of nitrogen fertilizer per quintal
FHP	=	Farm Harvest price of rice (real) per quintal with one year lag.
AW	=	Agricultural wages (real) of field labour per day
T	=	Time variable

The above multi-variate model is estimated by Ordinary Least Squares method considering both time-series and cross section data for the multi-season and mono-season states separately for the period 1980-81 to 1994-95. The Chow's F-test showed that the estimated functions for these two samples are statistically different and hence we present the results separately. Both linear and double-log form of function were estimated but the latter is used as it has better statistical properties.

Before presenting the results of the estimation of this multi-variate model, it would be useful to discuss briefly some of the major features of multi-season and mono-season states as regards some of the selected explanatory variables.

Table 1 shows that in 1994-95 the multi-season states accounted for about three-fourth of the total rice area with an average yield of 1864 kgs/ha . In these states over 68 per cent of the area under rice is covered by high yielding varieties(HYVs) and it varied from a low of 35 per cent in Kerala to a high of 93 per cent in Tamil Nadu. On an average the market arrival as a per cent of production is 23.4 per cent. It is the lowest in Orissa (5.3 per cent) and highest in Andhra Pradesh(42.4 per cent). Rice procurement by the central government expressed as a per cent of rice production is roughly 10 per cent for all these states together. Virtually there was no procurement of rice from three states namely Assam, Bihar and Kerala. The average daily wage rate varied from Rs. 16.8 in Karnataka to a high of Rs.39.6 in Kerala with an overall average of Rs.23.9 during 1991-92. The average farm size for all these states together was 1.15 hectares with a range of 0.33 hectare in Kerala and 2.13 hectares in Karnataka.

The share of mon-season states in total rice area is about 25 per cent. The coverage of HYVs was as high as 74 per cent. On an average the market arrival to production was 52 per cent and it varied from over 15 per cent in Madhya Pradesh to over 80 per cent in

Punjab. The central government procured more than 43 per cent of the rice production during 1994-95 from these states. As opposed to the multi-season states the wage rates in these states are higher by 25 per cent. The average farm size is 2.97 hectares which is larger by two and half times of the multi-season states.

Analysis of Results

Three features of the chosen model are discussed. These are their statistical properties, significance of estimated parameters and their relative importance in determining the growth in rice productivity. The model is applied to two sets of data, viz., for states where rice is a multi-season crop (covering 9 states), and for those states where rice cultivation is confined to a single season (covering 6 states). Mean and standard deviation of the explanatory factors and the dependent variable, i.e., the index of yield for these two categories are given in Table 2. On an average the mono-season states have relatively high mean values for almost all variables. This is significant for the index of yield(IY), farm size(FS), marketed surplus(MA) and procurement(PT) of rice.

Multi-Season States

All the explanatory factors have expected signs. Operational farm size(FS) emerges as the most important factor explaining the growth in rice productivity. But the efficiency of relatively small farms is indicated by the strong and negative association between farm size and rice productivity. While the price of fertilizer(PF) which has a negative influence ranked second, the degree of commercialization(MA) and technology factors(HYV) occupy the third and fourth places respectively with positive association. Both farm harvest prices and wage rates have the expected relationship but they are least important.The time factor which explains the structural changes is positively associated with rice productivity though it is statistically non-significant.

Mono-Season States

For mono-season states the technology variable(HYV) emerged as the most important explanatory factor with strong positive association with productivity. This is followed by the price of fertilizers(PF) with an inverse relationship. Time variable is the third most important determinant and it is negatively associated with rice productivity perhaps on account of reaching a plateau in the new production function. The index of rainfall(IR) positioned the fourth place. This is understandable because all except two states largely depend on the rainfall pattern during the kharif season. Farm size is the next most important determinant and it has a positive sign. This is partly explained by the fact that in states like Punjab, Haryana and Gujarat even large farms have a better share in total rice area compared to predominantly small farms in most of the other states where rice is a multi-season crop. In other words, large farmers in mono-season states have an edge over small ones for enhancing rice productivity. As expected the government support programmes (PT) for rice in these states is more important than the commercialization(MA) perhaps because agriculture is at a higher stage of market orientation in majority of these states. But both farm harvest prices (FHP) and wage rates (AW) are least important as in the case of multi-season states.

Conclusions and Implications

Among the price and non-price factors considered, the influence of non-price factors is more important in determining rice productivity; the only exception being that of the price of fertilizer.

Among the three price factors, viz., price of fertilizers, farm harvest price of rice and wage rate, fertilizer price turned out as the second most important determinant among all factors in both multi-season and mon-season states. This suggests that fertilizer price must be maintained at an affordable level for enhancing rice productivity. The positive association of real wage rate with rice productivity in the mono-season states suggests that marginal rise in real wages may not hamper rice productivity as mechanization of labour intensive operations of rice cultivation are being adopted by these states. The limited role of output price to enhance rice productivity is revealed by the least importance of farm harvest price among all factors considered. This holds true for both the groups of states. This suggests limited role of price support for encouraging growth in rice productivity.

Unlike price factors, the relative importance of non-price factors differed between multi-season and mono-season states. Technology is the most important determinant in mono-season states but it ranks fourth in the multi-season states . This implies that the new rice technology may not be equally suited for all rice growing areas. Though the relative efficiency of small farms in the multi-season states demands egalitarian land reform measures radical ceiling may not be feasible to satisfy the demand of those land hungry. However, egalitarian tenancy reforms and implementation of existing land ceiling may be promoted. In the mono-season states the large farms have an edge over small farms for enhancing rice productivity. But even in these states liberal land ceiling is unwarranted to protect the threshold of viability of smaller farmers. The degree of commercialization is relatively less important in the mono-season states compared to multi-season states. The government's rice procurement programme is equally important in these two categories of states. Though the rice cultivation is more wide spread under rainfed conditions in the multi-season states, the influence of rain fall in determining rice productivity is equally important in the mono-season states as well. Finally, the negative association of time trend with rice productivity in the mono-season states is perhaps due to plateau in the rice production function. This suggests the need for evolution of superior rice varieties with high yield potential than the existing varieties.

Table 1: Some Basic Features of Rice Cultivation in Multi-Season and Mono-Season States, 1994-95

State	Area Under Rice 000 ha	Yield kg/ha	HYV Share (%)	Market Arrival as a % of Production	Procurement as a % of Production	Daily wage rate of agri. Labour[1]	Average operational farm Size[2]
Multi-Season States:							
1.Andhra Pradesh	3520	2583	91.0	42.4	37.2	21.1	1.56
2. Assam	2501	1330	47.6	14.2	0.0	27.2	1.31
3. Bihar	4611	1134	48.1	15.7	0.0	22.2	0.93
4. Karnataka	1319	2340	79.2	23.2	4.3	16.8	2.13
5. Kerala	517	2074	34.8	10.9	0.0	39.6	0.33
6. Orissa	4484	1363	62.7	5.3	5.1	17.4	1.34
7. Tamil Nadu	2311	3006	92.6	32.5	12.3	17.6	0.93
8. Uttar Pradesh	5408	1840	82.4	29.0	9.8	25.2	0.90
9. West Bengal	5744	2068	62.0	15.4	1.1	28.2	0.90
Above States	30414	1864	68.4	23.4	9.9	23.9	1.15
Mono-Season States:							
1. Gujarat	595	1462	86.0	47.7	2.1	22.6	2.93
2. Haryana	750	2731	57.5	72.7	69.5	41.8	2.43
3.Madhya Pradesh	5043	1141	65.0	15.7	10.9	20.1	2.63
4. Maharastra	1542	1566	83.4	22.6	3.0	22.9	2.21
5. Punjab	2172	3427	92.6	84.2	78.3	43.2	3.51
6. Rajasthan	147	1113	31.0	29.9	12.2	31.1	4.11
Above States	10249	1824	73.8	51.7	42.7	30.3	2.97
All States	40663	1854	69.8	30.4	18.0	26.5	1.88

[1] Relates to 1991-92 [2] Relates to 1990-91

Sources: *Bulletin on Food Statistics*, Directorate of Economics and Statistics, 1995
Fertilizer Statistics, Fertilizer Association of India, 1996

Table 2 : Mean and Standard Deviation of Dependent Variable and Explanatory Factors in Multi-Season and Mono-Season States based on pooled data during 1980-81 to 1994-95.

Item	Multi-Season States		Mono-Season States	
	Mean	Standard Deviation	Mean	Standard Deviation
1. IY	137.49	0.246	161.30	0.269
2. HYV	56.59	0.396	60.70	0.423
3. FS	1.08	0.499	3.07	0.208
4. IR	99.54	0.192	100.95	0.302
5. MA	18.19	0.658	37.48	0.677
6. PT	1.60	1.899	7.15	2.145
7. PF	317.5	0.251	317.5	0.251
8. FHP	120.46	0.163	131.42	0.156
9. AW	8.59	0.708	11.41	0.633

Table 3 : Determinants of Growth in Rice Yield in Multi-Season and Mono-Season States, 1980-81 to 1994-95

Variables	ß-Coefficient	t - Value	Standard-ized ß[1]	Rank Based on Stand-ardized ß
a. Multi-Season States:				
1. HYV	.1323	2.54*	.2127	4
2. FS	-.2579	-7.27*	.5221	1
3. IR	.0945	1.42***	.0735	7
4. MA	.0983	2.22*	.2622	3
5. PT	.0272	4.32*	.2092	5
6. PF	-.2743	-1.60**	.2792	2
7. FHP	.0852	0.94	.0565	8
8. AW	-.0083	-0.32	.0246	9
9. T	.0314	0.45	.0767	6
		F- Value for (9,125)=30.7	R^2 =.706	D.W.S =1.81
b. Mono-Season States:				
1. HYV	.3339	4.37*	.5260	1
2. FS	.2530	1.71**	.1954	5
3. IR	.1987	3.27*	.2233	4
4. MA	.0315	0.39	.0793	9
5. PT	.0230	1.99*	.1836	6
6. PF	-.5492	-2.30*	.5125	2
7. FHP	.1740	1.32***	.1007	8
8. AW	.0848	0.92	.2006	7
9.T	-.1416	-2.41*	.3164	3
		F-Value for (9,80)=22.6	R^2 = .718	D.W.S= 1.92

[1] Standardized ß is ß × (standard deviation of x_i ÷ standard deviation of y) where x_i is the ith explanatory factor, and y is the dependent variable.

* Significant at 1%; ** Significant at 5%; *** Significant at 10 %

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