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TOTAL FACTOR PRODUCTIVITY GROWTH OF COTTON CROP IN MAHARASHTRA

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Abstract- Measurement of productivity growth is very essential to take appropriate policy decisions for the development of the agriculture sector. Present study measures trend in production, total factor Productivity growth of cotton crop in Maharashtra State. The Tornquist-Theil chained Divisia index approach was applied for the measurement of total factor productivity using input and output data of Cotton. Farm-level data on yield, inputs use level and their prices for the period from 1989-90 to 2008-09 were taken from the State funded Cost of Cultivation Scheme. The multi-variable model was estimated to know the determinants of total factor productivity growth taking total factor productivity as dependent variable. Beside double sown area, other explanatory variables included total amount of loan disbursed, net cropped area, area under irrigation, area under high yielding variety, annual rainfall, villages electrified, number of tractors, number of pump sets and road density. The results indicated that highest total factor productivity figures was recorded 163.89 in the year 2008-09 whereas lowest 80.51 in the year 1993-94. The agriculture year 2008-09 was best year for Cotton production in the region whereas 1993-94 was the worst agriculture year for Cotton production. The results also reported that, out of 20 agriculture year, 11 agriculture years were favorable for Cotton production in the region in which growth in total factor productivity of Cotton was recorded in Maharashtra. Area under irrigation, area under high yielding varieties, rainfall, and road density has positive and significant impact on total factor productivity of cotton crop in Maharashtra.

Keywords- Total Factor Productivity, Tornquist-Theil Index, Productivity, Cotton.

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Introduction

The analytical inadequacies of the Single Factor Productivity (SFP) measures led economist to evolve the TFP measures, the TFP index is composite measure of productivity, which relates output to all inputs simultaneously and the change in TFP index can be used as one measure of technological change. Earlier Laspyeres arithmetic indices were used most commonly to measure TFP [1] But most recent literature of TFP [2] has advocated and employed Tornqvist - Theil or translog index in their study because of its superiority.

TFP is influenced by changes in technology, institutional reform, infrastructure development, human resource development, investment in research and development, level of technology adoption and other factors. Recent experience shows a slowdown in productivity growth of various crops or even some setbacks indicating that all is not well. This has given rise to some pertinent questions viz; what is the direction of productivity? Are inputs efficiently utilized? What is the growth in inputs and outputs? This needs elaboration from the TFP studies. Empirical studies of the TFP on developing countries in agriculture are becoming increasingly important in providing a complex picture of technological change. The TFP for Indian crop sector was measured [3] , but the results of the sectoral approach cannot be used precisely for policy decisions with respect to individual crops because technological change varies across crops. Thus TFP growth has to be examined for individual crops [4]. Hence, the main focus of study was to measure the growth in total factor productivity of cotton crop in Maharashtra and its determinants.

Methodology

The Data

Farm-level data on yield, level of input use and their prices for the period 1989-90 to 2008-09 were collected from the "Scheme for the study of cost of cultivation of principal crops" Government of Maharashtra. Around 85 per cent area of Marathwada region comes under assured rainfall zone. In all 8 districts viz; Aurangabad, Jalna, Parbhani, Nanded, Hingoli, Beed, Latur and Osmanabad were selected from Marathwada region. Most of the soils of the region are black cotton soils or *regur* derived from the Deccan trap volcanic rocks. Farmers of the region are harvesting available water through micro irrigation system. This situation favours the cultivation of cotton crop in the region. Hence, for the study purpose, cotton was selected on the basis of relative importance in rural economy of the region.

Analytical Tools

Compound growth rate

The growth rate of area, production, productivity, input and output of cotton crop was estimated by using semi log trend equation.

$$Y = ab^t$$

$$\text{Compound growth rate} = (b - 1) \times 100$$

Cuddy and Della instability index (CDI)

The coefficient of variation is generally used as a measure of instability. But time series data often contain a trend component. In order to take care of this trend component and for meaningful measurement of instability, CV is modified as proposed by Cuddy and Della [5] called as the Cuddy and Della instability index and given by formula

$$CV_t = CV\sqrt{1-R^2}$$

Where,

CV = Coefficient of variation

R^2 = Coefficient of determination of trend

A linear trend was fitted to a time series data on area, production and productivity and wherever the trend was significant, the coefficient of variation (CV) for unadjusted data were multiplied by the square root of unexplained portion of variation in the trend.

Analysis of total factor productivity (TFP)

Total Factor Productivity (TFP) sometimes referred as multifactor productivity, is a true measure of economic efficiency. TFP measures the extent of increase in output, which is not accounted by increase in total inputs. There are three main approaches for estimating the TFP, viz; the production function approach (PFA), growth accounting approach (GAA) and non parametric approach. The Production Function Approach (PFA) is associated with various problems like multicollinerity, autocorrelation and degree of freedom, whereas non- parametric approach like Data Envelope is very sophisticated and uses linear programming methodology. In Growth Accounting Approach (GAA), TFP is measured as a residual factor, which attributes to that part of growth in the output that is not accounted for by the growth in the basic factor inputs. Amongst three approaches, growth accounting approach is popular mainly because it is easy to implement, requiring no econometric estimation.

The use of TFP indices gained prominence since Douglas (1976; 1978) [6] proved that the Theil-Tornqvist discrete approximation to the Divisia index is consistent in aggregation and superlative for a linear homogeneous translogarithmic production function. In the present study, Divisia-Tornqvist index has been used for computing the total output, total input and TFP for specified year "t" by for selected crop i.e. cotton.

Total output index (TOI)

$$TOI_t / TOI_{t-1} = \pi_j(Q_{jt}/Q_{jt-1})^{(R_{jt}+R_{jt-1})1/2} \quad ...[1]$$

Total input index (TII)

$$TII_t / TII_{t-1} = \pi_j(X_{it}/X_{it-1})^{(S_{it}+S_{it-1})1/2} \quad ...[2]$$

Where,

R_{jt} is share of the j[th] output in total revenue

Q_{jt} is output of the j[th] commodity

S_{it} is share of the i[th] input in total input cost

X_{it} is quantity of the i[th] input

t is the time period

For productivity measurement over a long period of time, chaining indexes for successive time period is preferable. With chain liking, an index was calculated for two successive periods t and t-1 over the whole period 0 to T (samples form time t = 0 to t = T) and the separate index was then multiplied together.

$$TOI\ (t) = TOI\ (1).\ TOI\ (2)\ldots\ldots\ TOI\ (t-1) \quad ...[3]$$

$$TII\ (t) = TII\ (1)\ .TII\ (2)\ldots\ldots\ TII\ (t-1 \quad ...[4]$$

Total factor productivity index (TFP) is given by equation

$$TFP_t = (TOI_t\ /\ TII_t) \quad ...[5]$$

Chain-linking index takes into account the changes in relative values/costs throughout the period of study. This procedure has the advantage that no single period plays a dominant role in determining the share weights and biases are likely to be reduced.

Factors influencing TFP

To know the influence of infrastructural, socio-economic and technological variable on the productivity of cotton crop, a multi-variable model in the form of log linear was estimated. The time series data from the year 1989-1990 to 2008-2009 were considered for the present study. Initially model was analyzed by incorporating all the nine independent variable but results of best fit model which has six independent variables were presented in the results sections. Pooled regression analysis was done for this purpose.

$$\ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + \ldots\ldots\ldots\ldots + b_n \ln X_n + e_i$$

Where,

Y = TFP

b_i = Elasticities

X_1 = Total amount of loan (short term + medium term + long term loans) sanctioned by commercial banks, regional rural banks, cooperative banks, primary agricultural cooperative societies and land development banks per thousand hector of net cultivated area (in Rs. lakhs).

X_2 = Proportion of double sown area.

X_3 = Proportion of net cropped area under irrigation.

X_4 = Proportion of net cropped area under high yielding varieties.

X_5 = Annual rainfall (mm)

X_6 = Number of villages electrified per 000' ha of net cultivated area

X_7 = Number of tractors per 000' ha of net cultivated area.

X_8 = Number of pump sets per 000' ha area of net cultivated area

X_9 = Road density kilometer per 000'ha of net cultivated area.

Result and Discussion

Performance of Cotton in Marathwada and Maharashtra Region.

It can be seen from [Table-1]. The area, production and productivity of cotton in Marathwada as well as Maharashtra region show positive growth over the study period. In Marathwada region the production of cotton shows 6.32 per cent growth rate over the study period as in case of Maharashtra it was found 3.02 per cent. This increase in production is because of increase in area under cotton cultivation and use of improved varieties, technologies in cotton cultivation such as INM and IPM results in increase in productivity of cotton.

Input share

[Table-2] depicts input share in cost structure of Cotton crop in Marathwada region. farmers utilized more energy in the form of male labour, female labour, and bullock labour. The share of seed cost in cotton (7.00 %). Maximum cotton area was under hybrids [in past decade] and that to Bt hybrid in recent years, which were costlier than the earlier released varieties. Nutrients especially nitrogen, phosphorous and potash are required in different quantum hence differences have been observed in nutrient cost.

Input and output growth

Growth rate figures highlighted in [Table-3] shows the trend in input use and output are the time. Output growth in cotton was 3.37 per cent; which was statistically significant. Introduction of Bt technology in cotton reduced the incidence of major pest problem [Pink bollworm].

Bt cotton which is more input responsive and have less pest attack increased output of cotton continuously. Input growth figures indicated that, share of land, value of pesticide, use of female labour, bullock labour, machine labour, phosphorous and potash increased in cotton cultivation practices. Negative growth in seed rate [which was statistically significant] implies that the use of

Table-1 *Growth and instability in cotton of Marathwada region (1989-90 to 2008-09)*

Parameter	Marathwada			Maharashtra		
	Area	Production	Productivity	Area	Production	Productivity
a	7259.61	3991.11	85.387	27114.4	18623.4	**29.87**
b	1.03	1.06	1.05	1.01	1.03	**1.06**
r	0.854**	0.885**	0.754**	0.546**	0.718**	**0.737****
CGR (%)	2.54	6.32	5.25	0.73	3.02	**5.54**
Mean	9555.2	9113.55	153.525	29280.7	25857.5	**167.15**
CV (%)	17.343	39.085	36.899	7.91	24.496	**40.044**
Instability	**9.36**	**21.19**	**27.17**	**6.77**	**17.55**	**29.89**

Note: *** Indicate significance at 1% level; **Indicate significance at 5% level;* Indicate significance at 10% level of probability; Area in 00 ha, Production in 00 tones and productivity in Kg/ha

Table-2 *Input share in total input cost of Cotton crop in Marathwada region (1989-90 to 2008-09).*

Sr. No	Particulars	Cotton	
		Cost (Rs./ha)	Share (%)
A	Total Input cost	17549.77	100.00
B-1	Male	2061.98	11.75
B-2	Female	2854.72	16.27
B-3	Bullock labour	2249.78	12.82
B-4	Machine labour	537.47	3.06
B-5	Seed / Set	1228.53	7.00
B-6	Manure	1325.28	7.55
B-7	Nitrogen	674.73	3.84
B-8	Phosphorous	500.17	2.85
B-9	Potash	159.85	0.91
B-10	Insecticide	1262.57	7.19
B-11	Irrigation	--	--
B-12	Rental value of land	3035.85	17.30
B-13	Other	1603.67	9.14
C	Total	17549.77	100.00

Note: Other includes interest on fixed and working capital

Table-3 *Input-Output growth rate of Cotton crop in Marathwada region.*

Sr. No.	Particulars	Period I (1989-90 to1998-99)	Period II (1999-00 to 2008-09)	Overall (1989-90 to 2008-09)
1.	Output Input	0.61^{NS}	7.62*	3.37*
2.	Male	3.13^{NS}	5.98*	1.8^{NS}
3.	Female	6.56*	5.52*	2.91*
4.	Bullock labour	4.83*	8.34*	4.37*
5.	Machine labour	0.67^{NS}	-1.8^{NS}	4.92**
6.	Seed	-2.46^{NS}	-6.45*	-4.06*
7.	Manure	-9.52^{NS}	2.69^{NS}	-0.09^{NS}
8.	Nitrogen	0.74^{NS}	3.72^{NS}	0.27^{NS}
9.	Phosphorous	2.44^{NS}	4.02**	2.68*
10.	Potash	-1.13^{NS}	7.94**	2.96**
11.	Insecticide	5.27^{NS}	2.46^{NS}	4.36*
12.	Irrigation	--	--	--
13.	Rental value	8.89*	6.85^{NS}	4.84*

Note: *** Indicate significance at 1% level; ** Indicate significance at 5% level; * Indicate significance at 10% level of probability.

seed was reduced after introduction of *Bt* technology in cotton crop. The use of nitrogen and male labour were stagnated to their mean level over the years.

Total factor productivity

Sustainable growth in agriculture led to development, which in turn was critically dependent upon the productivity growth, technological change, economics of scale and efficiency of factor used [7] [8]. The productivity behaviors were examined for two separate decades and overall, the obtained results were presented in [Fig-1] and [Table-4,5] Highest total factor productivity figures was recorded 163.89 in the year 2008-09, whereas lowest 80.51 in the year 1993-94. The agriculture year 2008-09 was best year for cotton production in the region whereas 1993-94 agriculture was the worst year for cotton production. The results say that, out of 20 agriculture year, 11 agriculture years were favorable for cotton production in the region.

Higher input growth than output growth is the characteristics of first decade, which resulted into negative TFP growth [-0.19%]. After introduction of Bt technology in cotton, output growth of cotton increased substantially. The output growth which was more than double on input growth led to high positive TFP growth [5.99%] in the second decade. In general, output growth [4.56] was more than input growth rate [1.35 %] in cotton which recorded positive TFP growth in cotton i.e., 3.20 per cent. Nasir [9] reported similar type of results. The positive TFP growth in cotton was recorded because; adoption of Bt cotton hybrid seed, use of micro irrigation system for protective irrigation and fertigation, aggressive and proper extension strategies from state government, KVKs, agricultural universities etc., to popularize integrated nutrient management, integrated pest management, integrated diseases management and soil water conservation technologies in rain fed agriculture.

Factors influencing total factor productivity growth

In order to examine the effect of different factors on total factor productivity growth, log linear regression equation was fitted. The step down multiple regression method was used to identify significant parameters by avoiding problem of multicollinearity. The crop wise results obtained are presented in [Table-6] Proportion of area under high yielding varieties, proportion area under irrigation, number of villages electrified, number of tractor available for cultivation and road density were the important factors which influenced total factor productivity in cotton.

Table 4 *Tornquist-Theil Divisia Index of Output, Input and TFP of Cotton crop in Marathwada region*

Year	Output Index	Input Index	TFP Index
1990-91	100.00	100.00	100.00
1991-92	97.23	98.81	98.40
1992-93	109.58	96.19	113.92
1993-94	93.18	115.74	80.51
1994-95	106.88	127.13	84.07
1995-96	108.03	122.08	88.49
1996-97	109.17	105.27	103.71
1997-98	95.63	103.47	92.42
1998-99	109.65	106.76	102.71
1999-00	112.86	103.26	109.30
2000-01	101.02	102.40	98.66
2001-02	116.06	108.84	106.63
2002-03	137.32	127.45	107.74
2003-04	136.18	135.02	100.86
2004-05	132.93	121.60	109.32
2005-06	129.76	110.55	117.37
2006-07	152.08	126.73	120.00
2007-08	228.03	146.85	155.28
2008-09	201.22	122.77	163.89

Table 5 *Output, Input and TFP indices growth rates of Cotton in Marathwada*.

Period	Output Index	Input Index	TFP	TFP Share in output (%)
Period I	0.77	0.96	-0.19	-24.71
Period II	8.53	2.54	5.99	70.19
Overall	4.56	1.35	3.20	70.27

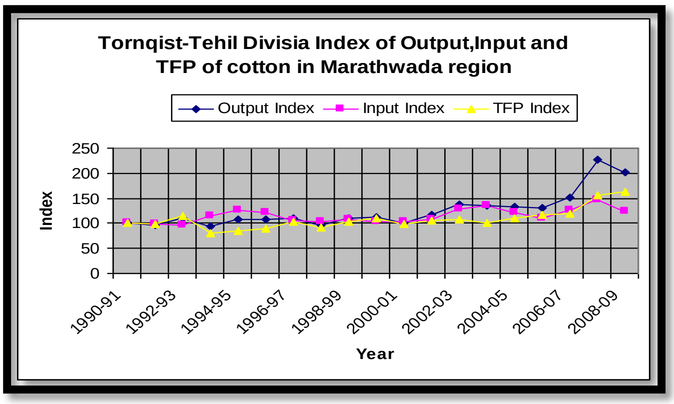

Fig-1. Tornqvist-Theil Divisia Index of Output, Input and TFP of cotton crop in Marathwada region of Maharashtra

Table 6 *Factors influencing total factor productivity growth of Cotton in Marathwada region*

Sr. No	Variables	Parameter estimate (b_i)
1.	Intercept (a)	-3.67^{NS} (2.84)
2	Proportion of double sown area	-0.76^{NS} (0.57)
3.	Proportion of area under irrigation	0.44** (0.12)
4.	Proportion of area under high yielding variety	1.49** (0.34)
5.	Number of villages electrified	1.65* (0.42)
6.	Number of tractors	0.70** (0.22)
7.	Road density (km/hr)	0.57** (0.12)
8.	R^2	0.74

Note: *** Indicate significance at 1% level; ** Indicate significance at 5% level; * Indicate significance at 10% level of probability.

Conclusion

Highest total factor productivity figures was recorded 163.89 in the year 2008-09, whereas lowest 80.51 in the year 1993-94. The agriculture year 2008-09 was best year for cotton production in the region whereas 1993-94 agriculture was the worst year for cotton production. The results say that, out of 20 agriculture year, 11 agriculture years were favorable for cotton production in the region. Production of cotton in Marathwada region of Maharashtra from the year 2000-01 was being found continuously good and this is only because of combination of improved technologies and optimum utilization of available resources for the cotton production. Also proportion of area under high yielding varieties, proportion area under irrigation, number of villages electrified, number of tractor available for cultivation and road density were the important factors which influenced total factor productivity in cotton.

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