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TOTAL FACTOR PRODUCTIVITY GROWTH OF SUGARCANE CROP IN MAHARASHTRA

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Abstract- Total factor productivity is the multifactor productivity it is a true measure of economic efficiency. It is computed as the ratio of an index of aggregate output to an index of aggregate inputs. Growth in TFP is therefore the growth in total output less than the total increase in inputs. The present study measures trends in production and total factor Productivity growth of sugarcane crop in sub-sector of Maharashtra State. The compound growth rates and Cuddy Della instability index were used for studying trends, the Tornquist-Theil chained Divisia index approach was applied for the measurement of total factor productivity using output and input data of sugarcane crop. Farm-level data on yield, level of inputs use and their prices for the period 1989-90 to 2008-09 were collected from the state funded cost of cultivation scheme. The multi-variable model was estimated to know the determinants of total factor productivity growth by assuming total factor productivity as the dependent variable. Beside the double sown area, other explanatory variables include the total amount of the loan, net cropped area, area under irrigation, area under high yielding variety, annual rainfall, villages electrified, the number of tractors, number of pump sets, road density were also considered. The results indicated that though an area and production of sugarcane crop increased productivity growth was very less in Marathwada as well as in the Maharashtra region. There was no substantial growth recorded in sugarcane output in the region. Use of chemical fertilizers *viz* nitrogen 1.53 %, phosphorous 2.92 %, potash 11.33 % and the number of irrigations 10.96 % in sugarcane cultivation, increased in the region. Use of other inputs fluctuated around some constant mean value over the period. There is a growth in total factor productivity of sugarcane crop of sub sector in Maharashtra state. Area under irrigation, area under high yielding varieties, a number of tractors and road density had a positive and significant impact on total factor productivity of sugarcane crop in Maharashtra.

Key words: Total Factor Productivity, Tornquist-Theil Index, Productivity, Sugarcane

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Introduction

The sugarcane industry in India plays a vital role toward socio-economic development in the rural areas by mobilizing rural resources and generating higher income and employment opportunities. Sugarcane cultivation is done in around 5 million ha of land in India and its production has fluctuated between 320 - 360 million tons in the past several years. India is the largest consumer of sugar and second largest producer in the world. 60% of total sugarcane and sugar production in the country is with Maharashtra and Uttar Pradesh alone, accounting for 60% of India's total production. As against an average annual rise of 2.5% in the world during the past ten years, global sugar consumption has grown by about 2% per annum, while in India the consumption has been higher at about 3.5% per annum 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 [4], 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 [5]. Hence, the main focus of study was to measure the growth in total factor productivity of the Sugarcane crop in Maharashtra and its determinants.

The analytical inadequacies of the Single Factor Productivity (SFP) measures led economist to evolve the TFP measures, the TFP index is a 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 [2] But the most recent literature of TFP [3] 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 [4], 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 [5]. Hence, the main focus of study was to measure the growth in total factor productivity of the Sugarcane crop in Maharashtra and its determinants.

Methodology

The Data

The study was based on time series secondary data for the period 1989-90 to 2008-09. The study period was further divided into two sub-group as Period-I comprises 1989-90 to 1998-99 and Period-II i.e. 1999-00 to 2008-09. "Secondary data related sugarcane information was obtained from govt. offices" Farm-level data on yield, the 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, This data set provided a rich source for measuring and analyzing the agricultural productivity. The time series data on infrastructural variables (road density, number of villages electrified, number of pump sets, number of tractors), cropping intensity, total loan amount disbursed, annual rainfall, area under irrigation, area under high yielding variety, land-use pattern etc were collected from various publications of the government of Maharashtra

Compound growth rate

The growth rate of area, production, productivity, input and output of major crops were estimated for the period 1989-90 to 2008-09. The growth rate of area, production, productivity, input and output of Sugarcane crop was estimated by using semi log trend equation.

$$Y = ab^t$$

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 a meaningful measurement of instability, CV is modified as proposed by Cuddy and Della [6] called as the Cuddy and Della instability index and given by the 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 the 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 an 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 a linear programming methodology. In Growth Accounting Approach (GAA), TFP is measured as a residual factor, which is attributed 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 has gained prominence since Douglas (1976; 1978) [7] 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 the specified year "t" by for selected crop i.e. Sugarcane

Total output index (TOI)

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

Total input index (TII)

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

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 the 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 from time t = 0 to t = T) and the separate index was then multiplied together.

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

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

Total factor productivity index (TFP) is given by equation

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

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 Sugarcane 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 the model was analyzed by incorporating all the nine independent variable, but results of the 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.

Results And Discussion

Performance of Sugarcane crop in Marathwada and Maharashtra Region.

It can be seen from [Table- 1] that the production of sugarcane in Marathwada region as well as the Maharashtra region has been increased significantly with the growth rate of 4.23% and 2.86% respectively. Area of sugarcane also shows

an increasing trend in Marathwada and Maharashtra by 8.14% and 3.62% respectively. But the productivity of sugarcane shows declining trend in Marathwada as well as Maharashtra. This is because of cultivating the sugarcane crop on the same piece of land year after year with excess use of irrigation water, which has led to the saline condition of the soil.

Input share

Share of input in cost of cultivation showed the importance of that input in total cost structure. [Table=2] depicts input share in the cost structure of sugarcane in Marathwada region. Rental value of land was having a major share in cost of cultivation of sugarcane in all the time span of research. Energy component was second important input into the cost structure of sugarcane. Farmers were adopted conservative agricultural production technologies to cultivate sugarcane crop which were not suitable for using modern inputs and mechanization; hence farmers utilized more energy in the form of male labour, female labour, and bullock labour. The output of sugarcane fetches comparatively more prices; hence sugarcane sets required for planting were also costlier. Irrigation cost (8.05 %) was important in sugarcane cultivation. 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 the trend in input use and output achievement over the time are presented in [Table-3]. There was no substantial growth recorded in sugarcane output in the region. Use of chemical fertilizers *viz* nitrogen 1.53 %, phosphorous 2.92 %, potash 11.33 % and the number of irrigations 10.96 % in sugarcane cultivation increased in the region. Use of other inputs fluctuated around some constant mean value over the period.

Table- 1. *Growth and instability in sugarcane area of Marathwada region for the period (1989-90 to 2008-09)*

Parameter	Marathwada			Maharashtra		
	Area	Production	Productivity	Area	Production	Productivity
a	738.057	6184.12	66217.8	3731.38	328012	**86083.5**
b	60.127	2618.32	13.992	135.24	9384.83	**-540.05**
r	0.598**	0.734**	0.0218	0.642**	0.967**	**-0.448***
Growth rate over initial (%)	8.146	4.231	0.021	3.624	2.861	**-0.627**
Growth rate over average (%)	4.305	2.929	0.021	2.625	2.2	**-0.671**
Mean	1369.4	89376.5	66364.3	5151.35	426553	**80413**
CV (%)	43.438	23.6	5.691	24.189	13.458	**8.861**
Instability	**35.77**	**16.45**	**5.84**	**19.05**	**3.51**	**8.13**

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

Sr. No	Particulars	Sugarcane	
		Cost (Rs./ha)	Share (%)
A	**Total Input cost**	48431.50	100.00
B-1	Male	9222.90	19.04
	Female	3064.53	6.33
B-3	**Bullock labour**	2964.35	6.12
B-4	**Machine labour**	--	--
B-5	**Seed / Set**	6216.35	12.84
B-6	**Manure**	3079.90	6.36
B-7	Nitrogen	2431.40	5.02
B-8	Phosphorous	1725.60	3.56
B-9	Potash	525.35	1.08
B-10	**Insecticide**	--	--
B-11	**Irrigation**	3897.00	8.04
B-12	**Rental value of land**	9284.60	19.16
B-13	**Other**	6019.92	12.45
C	**Total**	**48316.08**	100.00

Note: Other includes interest on fixed and working capital

Table- 3: *Input-Output growth rate of Sugarcane 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	1.10 NS	-0.31 NS	1.72 NS
2.	Male	-0.90 NS	-1.045 NS	-2.08 NS
3.	Female	3.17 NS	-3.50 NS	3.23 NS
4.	Bullock labour	-0.96 NS	2.071 NS	0.94 NS
5.	Machine labour	--	--	--
6.	Seed	0.52 NS	2.916**	0.32 NS
7.	Manure	6.46 NS	-5.312 NS	-3.57NS
8.	Nitrogen	4.21**	-0.60	1.53
9.	Phosphorous	3.13	1.581	2.92***
10.	Potash	-12.78	13.7	11.33**
11.	Insecticide	--	--	--
12.	Irrigation	5.81*	6.12*	10.96**
13.	Rental value of land	13.33*	-0.64	4.8*

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

able 4: *Tornquist-Theil Divisia Index of Output, Input and TFP of Sugarcane crop in Marathwada region*

Year	Output Index	Input Index	TFP Index
1990-91	100.00	100.00	100.00
1991-92	61.04	65.07	93.81
1992-93	98.90	74.58	132.61
1993-94	71.00	88.30	80.40
1994-95	62.13	88.51	70.20
1995-96	81.32	85.63	94.96
1996-97	100.03	82.61	121.10
1997-98	120.11	92.11	130.41
1998-99	115.45	87.66	131.69
1999-00	110.66	81.98	134.99
2000-01	184.85	111.20	166.22
2001-02	112.26	70.24	159.82
2002-03	121.47	105.88	114.72
2003-04	124.07	90.02	137.82
2004-05	139.01	86.71	160.31
2005-06	88.21	80.05	110.19
2006-07	88.99	79.88	111.40
2007-08	138.84	95.48	145.41
2008-09	116.66	85.98	135.67

Total factor productivity

Sustainable growth in agriculture led to the development, which in turn was critically dependent upon the productivity growth, technological change and economics of scale and efficiency of the factor used [8] [9]. The productivity behaviors were examined for two separate decades and the results were presented in [Fig-.1] and [Table- 4,5]. During last two decades, the highest total factor productivity was observed in the year 2000-01 (166.22 %) and the lowest total factor productivity (80.40 %) was in the year 1993-94. The climatic conditions of agriculture year 1993-94 were unfavorable for sugarcane cultivation.

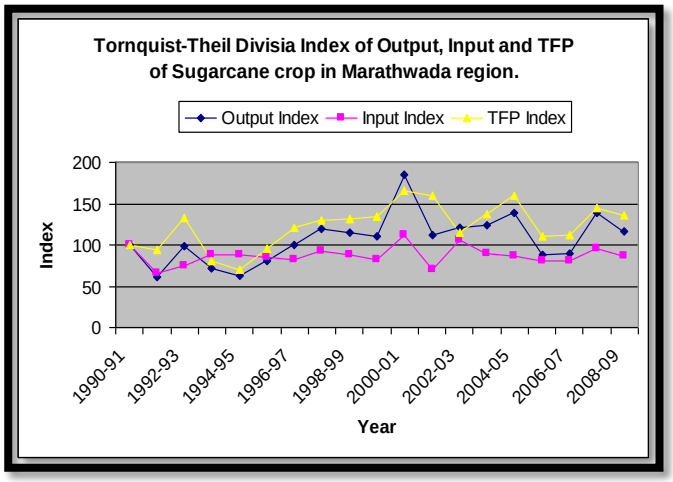

Fig-1 Tornqvist-Theil Divisia Index of Output, Input and TFP of Sugarcane crop in Marathwada region of Maharashtra

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

Period	Output Index	Input Index	TFP	TFP Share in output (%)
Period I	5.39	0.91	4.47	83.05
Period II	-2.35	-0.73	-1.62	69.06
Overall	2.28	0.32	1.95	85.79

Note: Period: 1989-90 to 1998-99; Period II: 1999-00 to 2008-09; Overall: 1989-90 to 2008-09.

The sugarcane output index was more than the input index hence the TFP growth was positive in sugarcane crop. The growth in input index was negative (0.32 %). Output index growth was positive (2.28 %). Total factor productivity growth was positive 1.95 %. In the first decade, input index (0.91 %), output index (5.39%) and total factor productivity growth (4.47 %) were positive. Nasir [10] reported similar type of results. The output index growth was more than the input index that led to positive total factor productivity. During the second decade, growth in the input index and output index was negative. However negative output index growth being less than input index growth leds to (-1.62 %) total factor productivity.

From 20 agriculture seasons, fourteen seasons were favorable for sugarcane cultivation in the region. The output growth in the first decade was achieved through spread of high yielding sugarcane varieties by sugar factories especially Co-86032, Co-94012 etc. sugarcane is a water loving plant, it remains in the field almost for the year. Production technologies which increase the water use efficiency is directly benefiting towards output growth. By this reason, Government of Maharashtra provided subsidy on a micro irrigation system to popularize it for providing irrigation and nutrient to the crop. The use of high yielding varieties, use of micro irrigation system for irrigation and nutrient applications, innovative planting system of sugarcane locally called as patta padhat and use of residue to improve soil organic carbon are the important factors which bring the positive output growth leads to positive total factor productivity.

Table- 6: *Factors influencing total factor productivity growth of Sugarcane crop in Marathwada region.*

Sr. No	Variables	Parameter estimate (b_i)
1.	Intercept (a)	-1.52 ^{NS} (5.04)
2.	Proportion of double sown area	0.80 ^{NS} (0.51)
3.	Proportion of area under irrigation	1.55* (0.27)
4.	Proportion of area under high yielding variety	2.18 ** (0.59)
5.	Number of villages electrified	0.43 * (0.09)
6.	Number of tractors	1.58** (0.41)
7.	Road density (km/hr)	2.79 ** (0.76)
8.	R^2	0.77

Factors influencing total factor productivity growth

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

Conclusion

The TFP growth rate was positive in crop sub-sector sugarcane in Maharashtra State. The highest total factor productivity was observed in the year 2000-01 (166.22 %) and lowest total factor productivity (80.40 %) was observed in the year 1993-94. The climatic conditions of agriculture year 1993-94 were unfavorable for sugarcane cultivation. From twenty agriculture seasons, fourteen seasons were favorable for sugarcane cultivation in the region. The positive TFP growth is because of technological and an infrastructural breakthrough in sugarcane production system. It was also realized that, an appropriate policy environment, infrastructure, institutions and favorable weather conditions were pre-conditions for a steady TFP growth in the crop sub sector.

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