RESEARCH ARTICLE

TOTAL FACTOR PRODUCTIVITY GROWTH IN SUGARCANE CROP OF MAHARASHTRA STATE

D.J. Sanap*, S.S. More and N.R. Bonkalwar

Abstract

Measurement of productivity growth is very essential to take appropriate policy decisions for the development of the agriculture sector. The present study measures trends in production and Total factor Productivity growth (TFP) of sugarcane crop in sub-sector of Maharashtra State. The compound growth rates and Cuddy Della instability index were used for studying trends and the Tornquist-Theil hained 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 dependent variable. Beside double sown area, other explanatory variables include total amount of loan, 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 though area and production of sugarcane crop increased, productivity growth was very less in Marathwada as well as in Maharashtra region. There was no substantial growth recorded in sugarcane output in the region. Use of chemical fertilizers viz. nitrogen, phosphorous, potash and number of irrigations increased by 1.53%, 2.92%, 11.33% and 10.92% respectively in the region. Use of other inputs fluctuated around some constant mean value over the period. There is growth in total factor productivity of sugarcane crop of sub-sector in Maharashtra state. Area under irrigation, area under high yielding varieties, number of tractors and road density had positive and significant impact on total factor productivity of sugarcane crop in Maharashtra.

Key words : Total factor productivity, Tornquist-Theil Index, productivity, sugarcane

Introduction

The sugar 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 is cultivated in around 5 M ha of land in India and its production has fluctuated between 320 - 360 million tonnes in past several years. India is the largest consumer of sugar and second largest producer in the world. About 60% of total sugarcane and sugar production in the country is with Maharashtra and Uttar Pradesh alone. As against an average annual rise of 2.5% in the world during the past 10 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 (Dwivedi 2010).

The analytical inadequacies of the Single Factor Productivity (SFP) measures led economists to evolve the Total Factory Productivity (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

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commonly to measure TFP (Maurvi Pandya and Shiyani 2002). But most recent literature of TFP (Kumar and Mruthyunjay 1992; Kumar and Rosegrant 1994) has advocated and employed Tornqvist - Theil or translog index in their study because of its superiority. TFP trend indicates whether production growth is taking place in a cost effective and sustainable manner or not.

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 namely what is the direction of productivity? Are inputs efficiently utilized? What is the growth in inputs and outputs? These questions need elaboration from the TFP studies. Empirical studies of the TFP in agriculture are becoming increasingly important in providing a complex picture of technological change in developing countries. The TFP for Indian crop sector was measured by Rosegrant and Evenson (1992) but the results of the sectorial 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 (Kumar and Rosegrant, 1994). The main focus of the present study was to measure the growth in total factor productivity of sugarcane and its determinants in the State of Maharashtra.

Materials and methods

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, 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 government of Maharashtra.

Compound growth rate

The growth rate of area, production, productivity and input and output of major crops were estimated by using semi log trend equation.

$$Y = ab^t$$

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

Analysis of (TFP)

TFP sometimes referred to 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, namely the production function approach (PFA), growth accounting approach (GAA) and non-parametric approach. PFA is associated with various problems like multicollinerity, autocorrelation and degree of freedom, whereas non-parametric approach like Data Envelope Analysis is very sophisticated and uses linear programming methodology. In 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, GAA is popular mainly because it is easy to implement, requiring no econometric estimation.

The use of TFP indices gained prominence since Diewert (1976, 1978) 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 crops.

Total output index (TOI)

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

Total input index (TII)

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

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 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)……TOI (t-1) …[3]
TII (t) = TII (1) .TII (2)…….. TII (t-1) …[4]

Total factor productivity index (TFP) is given by the equation … [5]

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

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. For constructing the total input index, 10 important inputs viz. human labour, bullock labour, machine labour, farm yard manure (FYM), nitrogen, phosphate and potash fertilizers, irrigation, plant protection and land were included.

Factors influencing TFP

To know the influence of infrastructural, socio-economic and technological variables on the productivity of major crops, a multi-variable model in the form of log linear was estimated as follows. The time series data from the year 1989-1990 to 2008-2009 were considered for the present study.

$$LnY = Ln\ a + b_1 \ln X_1 + b_2 \ln X_2 + \ldots\ldots + b_n \ln X_n$$

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 hectares 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

In all there were nine factors studied, the step wise regression analysis which gave only more significant variables in the model was run.

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 Maharashtra region has increased significantly with the growth rate of 4.23% and 2.86% respectively. Area of sugarcane also showed increasing trend in Marathwada and Maharashtra by 8.14% and 3.62% respectively. But productivity of sugarcane showed declining trend in Marathwada as well as Maharashtra. This is because of continuous cultivation of the crop on the same piece of land year after year with excess use of irrigation water which has led to saline condition of the soil.

Input share

Share of input in cost of cultivation showed the importance of inputs in total cost structure. Table 2 depicts input share in cost structure of sugarcane in Marathwada region. Rental value of land had major share in cost of cultivation of sugarcane . Energy component was the second most important input in cost structure of sugarcane. Farmers adopted conservative agricultural production technologies to cultivate sugarcane crop which was not suitable for using modern inputs and mechanization; hence farmers utilized more energy in the form of male, female and bullock labour.

The high output sugarcane fetches apparently governs the high input cost towards sugarcane setts required for planting . While irrigation cost (8.05%)

Table 1. Growth and instability in sugarcane area of Marathwada region (1989 to 2009)

Parameter	Marathwada			Maharashtra		
	Area ('00 ha)	Production ('00 t)	Productivity (kg/ha)	Area ('00 ha)	Production ('00 t)	Productivity (kg/ha)
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

** significant at 1% level; * significant at 5% level

was important in sugarcane cultivation, nutrients especially nitrogen, phosphorous and potash are required in different quantities which explain the differences observed in nutrient cost.

Input and output growth

Growth rate figures highlighted the trend in input use and output achievement over time. Results of input and output growth rates of sugarcane in the Marathwada sub-sector region of Maharashtra State are presented in Table 3. There was no substantial growth recorded in sugarcane output in the region. Use of chemical fertilizers viz. nitrogen, phosphorous and potash in sugarcane cultivation increased by 1.53%, 2.92% and 11.33% respectively in the region. Use of other inputs fluctuated around some constant mean value over the period.

Total factor productivity

Sustainable growth in agriculture led to development, which in turn was critically dependent upon the productivity growth, technological change and economics of scale and efficiency of factor used. The productivity behaviors were examined for two separate decades and the results were presented in Tables 4 and 5. In the 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.

Sugarcane output index was more than input index, hence the TFP growth was positive in sugarcane

Table 2. Input share in total input cost of sugarcane crop in Marathwada region

Input parameter	Sugarcane	
	Cost	Share
Total input cost	48431.50	100.00
Male labour	9222.90	19.04
Female labour	3064.53	6.33
Bullock labour	2964.35	6.12
Machine labour	—	—
Seed / Sett	6216.35	12.84
Manure	3079.90	6.36
Nitrogen	2431.40	5.02
Phosphorous	1725.60	3.56
Potash	525.35	1.08
Insecticide	—	—
Irrigation	3897.00	8.05
Rental value of land	9284.60	19.17
Other[#]	5904.10	12.19
Total input cost	48431.50	100.00

[#] Other includes interest on fixed, working capital, taxes and education cess etc.

crop (Table 5). 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. The output index growth was more than input index that led to positive total factor productivity. During the second decade, growth in input index and output index were negative. However, the lower negative output index growth than input index growth led to (-1.62 %) total factor productivity.

From 20 agriculture seasons, 14 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. Since sugarcane is a water loving plant and remains in the field almost for the year, production technologies which increase the water use efficiency directly benefit output growth. Due to this reason, Government of Maharashtra provided subsidy on micro-irrigation system to popularize it for providing irrigation and nutrients 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 crop residues to improve soil organic carbon are the important factors which bring the positive output growth leading to positive total factor productivity.

Factors influencing total factor productivity growth

In order to examine the effect of different factors on total factor productivity growth, log linear regression equations were fitted as given in methodology. The step down multiple regression

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

Parameter	Unit	Period I	Period II	Overall
Output /Input	Qt ha^{-1}	1.10 ^{NS}	-0.31 ^{NS}	1.72 ^{NS}
Male	days ha^{-1}	-0.90 ^{NS}	-1.045 ^{NS}	-2.08 ^{NS}
Female	days ha^{-1}	3.17 ^{NS}	-3.50 ^{NS}	3.23 ^{NS}
Bullock	days ha^{-1}	-0.96 ^{NS}	2.071 ^{NS}	0.94 ^{NS}
Machine	h ha^{-1}	—	—	—
Seed	kg ha^{-1}	0.52 ^{NS}	2.916**	0.32 ^{NS}
Manure	Qt ha^{-1}	6.46 ^{NS}	-5.312 ^{NS}	-3.57^{NS}
Nitrogen	kg ha^{-1}	4.21**	-0.60	1.53
Phosphorous	kg ha^{-1}	3.13	1.581	2.92***
Potash	kg ha^{-1}	-12.78	13.7	11.33**
Insecticide	Lit ha^{-1}	—	—	—
Irrigation	No.	5.81*	6.12*	10.96**
Rental value of land	Rs ha^{-1}	13.33*	-0.64	4.8*

***significant at 0.1% level; **significant at 1% level; * significant at 5% level ^{NS} not significant

Table 4. Tornquist-Theil Divisia Index of Output, input and TFP of sugarcane crop in Marathwada

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

method was used to identify significant parameters by avoiding 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, number of tractor available for cultivation and road density were the important factors with influence on total factor productivity sugarcane.

Table 5. Output, input and TFP indices growth rates of sugarcane crop 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

Table 6. Factors influencing total factor productivity growth of sugarcane in Marathwada

Variable	Parameter estimate (b_i)
Intercept	-1.52 ^{NS}
	(5.04)
Proportion of double sown area	0.80 ^{NS}
	(0.51)
Proportion of area under irrigation	1.55*
	(0.27)
Proportion of area under high yielding variety	2.18 **
	(0.59)
Number of villages electrified	0.43 *
	(0.09)
Number of tractors	1.58**
	(0.41)
Road density (km/hr)	2.79 **
	(0.76)
R^2	0.77

** significant at 1% level; * significant at 5% level; ^{NS} not significant

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