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RESEARCH ARTICLE :

Determinants of total factor productivity growth of cotton in Telangana state

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SUMMARY : Growth of total factor productivity indicates the long term performance of the sector. The growth of TFP indicates that part of the output growth of sector which remains unexplained by the growth of basic inputs of production. An attempt was made in the present paper to estimate the performance of TFP growth of cotton crop and its determinants in Telangana state. Cotton has occupied a significant part in the Telangana agriculture in the last three decades as evident from 7.20% annual growth of area under cultivation of cotton from 1979-80 to 2012-13. The production of the crop also increased at an annual rate of 12.80% during the same period. The significant increase in the growth of production of cotton was made possible due to area expansion and productivity gain with introduction of Bt. cotton coupled with better farm management practices. TFP indices of cotton in Telangana were calculated to reveal the long term performance of the sector. It was revealed that TFP of cotton in Telangana increased at 6% annually during 2000-01 to 2012-13 mainly due to rapid growth of output index (12% annually). Government expenditure in agricultural research, education and extension and average annual rainfall were identified to be the major determinants of TFP growth of cotton the Telangana.

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BACKGROUND AND OBJECTIVES

Cotton is the most important crop in terms of total area sown among all the crops in Telangana state. Total area under cultivation of cotton in the state was estimated to be to the extent of 1773 thousand hectares during 2015-16 (DES) which occupied more than 30% of the gross cropped area of the state. The share of cotton in the GCA of Telangana was merely 3% during 1980s which increased to more than 30% in the present years. This depicts the growing interest for cotton cultivation among the farmers of Telangana. The huge shift in the area under cotton cultivation in the state was at the cost of decreased cultivation of traditional crops like jowar, groundnut and other pulses. Increased cultivation of cash crops like cotton increases the farmers' income in one hand, but increases the concerns for nutritional and food security on the other hand. The significant increase in

the area and production of cotton necessitates the need to look at the performance of the crop in the state. The significant increase in area under cotton was triggered by the introduction of Bt. Cotton hybrids namely MECH-12 Bt., MECH-162 Bt. and MECH-184 Bt. by M/S Mahyco Limited in 2002. Hence an attempt was made in the present paper to look the TFP growth of cotton in the state and the factors influencing its performance. This will help in pointing out various sources of long term growth of the sector and thus will help the policy makers in choosing policies for long term development of the sector.

RESOURCES AND METHODS

Total factor productivity (TFP) is the portion of output not explained by the amount ofinputs used in production. Growth in TFP is therefore the growth rate in total output less the growth rate in total inputs (Rosegrant and Evenson, 1995). As such, its level is determined by how efficiently and intenselythe inputs are utilized in production. The calculation of TFP in a multi-product and multi-input situation raises many conceptual and computational issues (Reddy, 1997). There are many methods documented in literature for calculation of TFP (Christensen, 1975 and Coelli *et al.,* 2005). Tornqvist index is a superior index for calculation of total factor productivity (TFP) index (Rosegrant and Evenson, 1995).

Estimation of total factor productivity for the state of Telangana was based on data of thirteen years starting from 2000-01 to 2012-13. The entire state of Telangana was classified into three different sub-divisions each comprising of three districts.These three sub-divisions are as follows, northern Telangana (Adilabad, Nizamabad and Karimnagar),central Telangana (Medak, Rangareddy and Warangal) and southern Telangana (Khammam, Mahaboobnagar and Nalgonda).The total value of output of cotton was derived by summing up the values of main product and the by-product in Rupees. This gross value of the output was then divided by the area under cotton to get the price of the product. The selected inputs of production for the present study were family human labour (in hours), paid human labour (in hours), animal labour (in hours), machine hours, seeds (in kg.), nitrogen fertiliser (in kg.), phosphorous fertilises (in kg.), potassium fertiliser (in kg.), farm yard manure (FYM) (in quintals), insecticide and irrigation machine (in hours). These data were collected for the period of 2000-01 to 2012-13 from the published documents of Comprehensive Scheme on Cost of Cultivation of Principal Crops in India.The district, as well the state level data were compiled from the unit level data from Cost of Cultivation Scheme.The time series data from 2000-01 to 2012-13 on the variables like average rainfall in state, crop wise irrigated area in the state and rural literacy rate (%) were collected from various statistical year books published by the Directorate of Economics and Statistics, Government of Telangana, Hyderabad. Data on the government expenditure on agricultural research, education and extension was collected from the office of the Accountants General, Government of Andhra Pradesh and Telangana.

The Divisia-Tornqvist index or translog index was used in this study for computing the total output, total input, and TFP indices.The total output, total input and TFP indices have been calculated as under,

Total output index (TOI),

$$\frac{TOI_t}{TOI_{t-1}} = \prod_j \left(\frac{Q_{jt}}{Q_{jt-1}}\right)^{\frac{(R_{jt}+R_{jt-1})}{2}} = A_t \quad \text{....(1)}$$

Or,

$$ln\left(\frac{TOI_t}{TOI_{t-1}}\right) = \frac{1}{2\sum_j (R_{jt}+R_{jt-1}) ln\left(\frac{Q_{jt}}{Q_{jt-1}}\right)} \quad \text{...(2)}$$

Total input index (TII),

$$\frac{TII_t}{TII_{t-1}} = \prod_i \left(\frac{X_{it}}{X_{it-1}}\right)^{\frac{(S_{it}+S_{it-1})}{2}} = B_t \quad \text{....(3)}$$

Or,

$$\ln\left(\frac{TII_t}{TII_{t-1}}\right) = \frac{1}{2\sum_i (S_{it}+S_{it-1}) ln\left(\frac{X_{it}}{X_{it-1}}\right)} \quad \text{.....(4)}$$

where,

R_{jt} is the share of j^{th} crop output in total revenue in year t,

Q_{jt} is the output of j^{th} crop in year t,

S_{it} is the share of input i^{th} the total input cost in year t and

X_{it} is the quantity of input i in year t.

For the productivity measurement over a longperiod of time, chaining indexes for successive timeperiods is preferable (Kumar *et al.,* 2008).

Total output index (TOI) and total input index (TII) for the year t computed from Eq. (5) and (6) as follows:

$$\mathbf{TOI\ (t) = TOI_1\ TOI_2 \ldots\ldots\ldots TOI_{t-1}} \quad \text{...(5)}$$

$$\mathbf{TII\ (t) = TII_1\ TII_2 \ldots\ldots\ldots TII_{t-1}} \quad \text{…6}$$

The total factor productivity (TFP) index is given as, $\mathbf{TFP_t = \{TOI\ (t) / TII\ (t)\}}$

$$= \frac{1}{2\sum_j (R_{jt} + R_{jt-1}) ln\left(\frac{Q_{jt}}{Q_{jt-1}}\right)} - \frac{1}{2\sum_i (S_{it} + S_{it-1}) ln\left(\frac{X_{it}}{X_{it-1}}\right)} \quad ....(7)$$

For constructing TFP index, chain index is preferred to fixed base index (Coelli *et al*., 2005). Chain index combines annual changes in productivity to measure changes in productivity over a period of time. In other words, let I (t+1, t) be an index for the period t+1 with the base period t. This index is applied to time series t=0 to T. A comparison between period t and fixed base 0 is made by following chain indexing of successive periods.

I(0,t) = I(0,1) x I(1,2) x I(2, 3) x.....x I(t -1, t) ...(8)

Multiple regression analysis was carried out in order to detect the main factors that were influencing the total factor productivity (TFP) growth in Telangana agriculture. For this purpose the crop wise indices of TFP in Telangana state was regressed on various identified variables that affect the TFP growth. Natural logarithm of all the variables including the TFP were taken for the regression analysis except those variables represented as ratios and percentages. The basic model for this purpose was as follows:

ln (TFP_{cotton}) = f{ln(Government expenditure on agricultural research, education and extension per hectare of cultivated land),

ln (Average rainfall in the state in millimetre),

Percent irrigated area under cotton

Rural literacy in percentage,

Cropping intensity in percentage}.

After running the regression analysis, the tests of regression analysis were applied. The final selection of the variables to be included in the analysis was done based on no multicollinearity assumption, *i.e.*, the variables having high multicollinearity problem were dropped from the model. Then the selected models were tested for the presence of heteroskedasticity and autocorrelation problems. All the analyses for this purpose were carried out in R software package.

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads:

Growth rate of area, production and yield of cotton in Telangana :

Cotton got an utmost importance in the state of Telangana over the period of time as revealed by the compound growth rate analyses. Area under cotton and its yield has shown a significant improvement in the state over the period of time. It can be seen from the below table that growth of area, production and yield in the last three decades have been significantly high during the last three decades. Annual growth rates of area, production and yield of cotton in Telangana were 7.20%, 12.80% and 5.60%, respectively. All the three regions of the state have witnessed the similar trend during the same period.

This tremendous increase in the area of cotton was at the cost of other competing crops like millets and other pulses. The share of crops like millets and pulses have

Table 1. Compound annual growth rates of area, production and yield of cotton in Telangana from 1979-80 to 2012-13

Period		Northern Telangana	Central Telangana	Southern Telangana	Telangana
Period I (1979-80 to 1989-90)	Area	3.30*	33.00*	25.90*	8.90*
	Production	8.20	45.70*	29.70*	19.00*
	Yield	4.90	12.70***	3.80	10.20**
Period II (1990-91 to 2000-01)	Area	2.70*	10.10*	12.90*	7.50*
	Production	7.50*	14.20*	11.90*	11.00*
	Yield	4.80**	4.10**	-1.00	3.50**
Period III (2001-02 to 2012-13)	Area	10.70*	9.30*	10.70*	10.40*
	Production	13.80*	12.60*	12.60*	13.10*
	Yield	3.10	3.30***	1.90	2.80
Overall period (1979-80 to 2012-13)	Area	4.30*	12.40*	13.50*	7.20*
	Production	11.00*	15.50*	16.60*	12.80*
	Yield	6.80*	3.00*	3.10*	5.60*

*, ** and *** significance of values at P=0.01. 0.05 and 0.10, respectively values in parentheses indicate R^2

reduced significantly due to shift of cultivable area to cotton, given inelastic supply nature of land.

Tornqvist total factor productivity indices of cotton:

The indices of total output, total input and total factor productivity were calculated and the results were presented in the Table 2. The average values of TOI, TII and TFP index in the state were 187.70, 120.30 and 149.50, respectively over a period of thirteen years. The CAGR of these indices in Telangana were 12.0% (significant at 1% level), 7.0% (significant at 1% level) and 6.0% (significant at 1% level), respectively. This implied that the index of total output grew at much faster rate than that of annual growth of the total input, which in turn led the TFP in the state to grow at higher rate. In Telangana the index total output reached its peak and trough in the years 2012-13 (399.80) and 2002-03 (68.60) respectively when compared to the base year *i.e.*, 2000-01. On the other hand, the index of total input was highest and lowest 2012-13 (207.10) and 2003-04 (70.80), respectively as compared to the base year. The value of the total factor productivity index was highest in Telangana in the year 2007-08 (207.40).

The growth of the TFP index was at same pace annually in the all three regions with CAGR value of 5.00% (significant at 1% level). But the growth rate of index of total output was highest in southern Telangana (12.0%, significant at 1% level) followed by central Telangana (11.0%, significant at 1% level) and northern Telangana (1.40%, significant at 1% level). On the other hand the growth of the TII was highest in northern Telangana (9.0%, significant at 1% level). In the northern Telangana region the average values of TOI, TII and TFP index were 255.10, 149.20 and 164.50 respectively. The values of TOI and TII were highest in the year 2012-13 (446.60 and 29.60 respectively), but the value of the TFP index reached at its peak in the year 2007-08 as compared to the base year indices.

The graphical representation of these three indices of the state as well as the three regions was given the illustration 4.4. A quick review of the figure revealed that the index of total output started to show a significant rise from the year 2006-07. But the index of total input on the other hand, had increased at a much lower pace as compared to the TOI. In most of the years, the TFP index in all the regions has remained above 100, implying that the TOI was over and above the TII for most of the years.

The above results revealed that there were significant productivity gains for cotton in Telangana. This was mainly due to significant rise in the area under cultivation and favourable market prices for the crop. This was in confirmation with the findings of Reddy and Reddy (2016) who stated that cotton output in the state was directly related with the increase in growth in area and lagged price of the crop. The productivity gain in

Table 2: Tornqvist total factor productivity indices of cotton in Telangana (Indices relative to first observation) from 2000-01 to 2012-13

Year	Northern Telangana			Central Telangana			Southern Telangana			Telangana		
	TOI	TII	TFP	TOI	TII	TFP	TOI	TII	TFP	TOI	TII	TFP
2000-01	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2001-02	137.6	101.3	135.8	94.5	132.0	71.6	114.3	118.6	96.4	113.2	102.8	110.1
2002-03	89.3	97.6	91.5	51.4	74.7	68.8	71.2	83.6	85.2	68.6	75.5	90.9
2003-04	141.2	83.7	168.8	84.1	79.6	105.6	101.8	75.4	135.1	106.0	70.8	149.8
2004-05	130.3	130.4	100.0	91.2	108.9	83.7	130.9	131.9	99.3	115.5	108.9	106.1
2005-06	192.6	118.2	163.0	114.7	110.6	103.6	123.1	110.7	111.2	139.3	99.8	139.5
2006-07	207.7	129.5	160.3	110.6	104.8	105.6	138.5	104.6	132.4	147.1	100.1	146.9
2007-08	390.7	143.6	272.0	157.6	112.6	140.0	221.8	137.5	161.3	244.4	117.8	207.4
2008-09	377.1	192.7	195.7	188.5	127.6	147.8	215.6	132.8	162.3	250.4	134.9	185.7
2009-10	370.5	164.1	225.8	158.0	127.6	123.8	196.3	129.3	151.8	230.3	126.5	182.1
2010-11	432.0	198.2	217.9	200.4	155.9	128.5	301.4	156.1	193.1	299.1	151.2	197.9
2011-12	300.6	221.1	135.9	205.5	169.7	121.1	187.3	183.7	102.0	226.0	168.3	134.3
2012-13	446.6	259.6	172.1	302.0	197.3	153.1	473.1	237.9	198.9	399.8	207.1	193.0
Average	255.1	149.2	164.5	143.0	123.2	111.8	182.7	130.9	133.0	187.7	120.3	149.5
CAGR (%)	1.4*	9.0*	5.0**	11.0*	6.0*	5.0*	12.0*	6.0*	5.0*	12.0*	7.0*	6.0*

TOI= Total output index TII= Total input index TFP= Total factor productivity CAGR= Compound annual growth rate

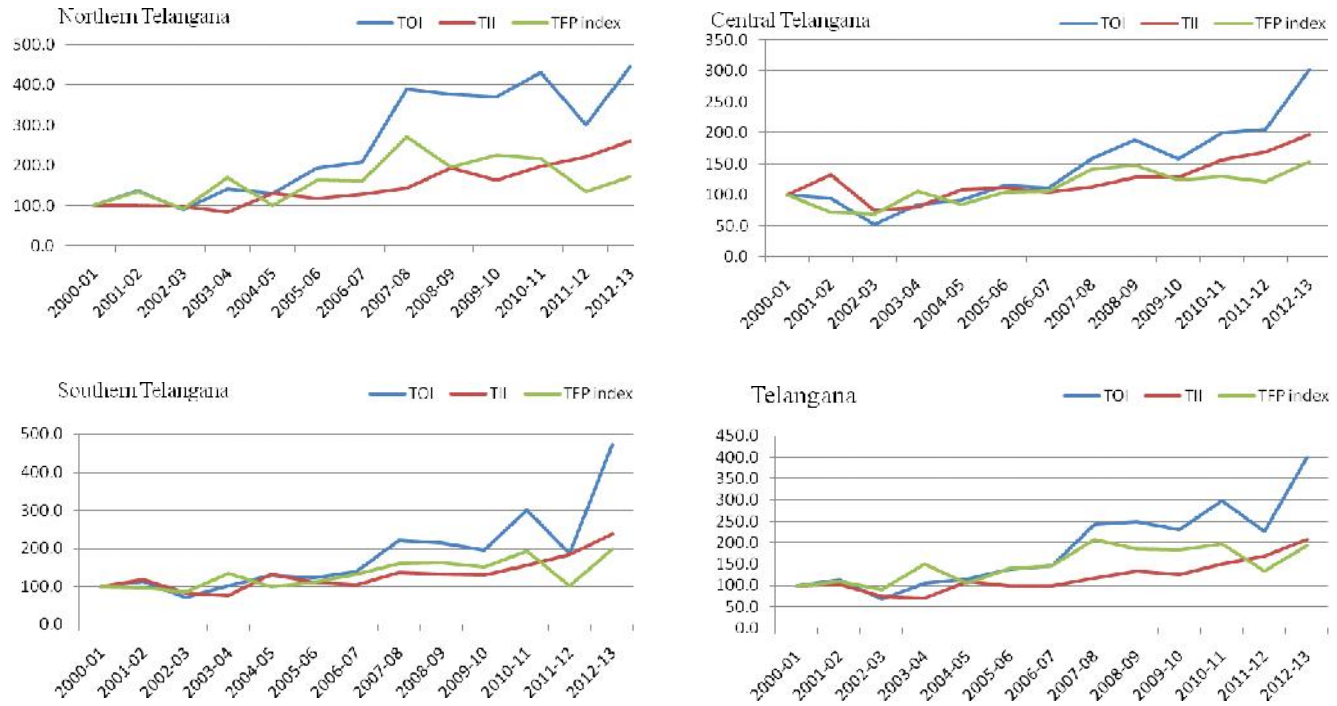

Fig. 1: Illustration1:Tornqvist total factor productivity indices of cotton in Telangana (indices are transitive and relative to first observation)

cotton was also due to introduction of Bt. Cotton hybrids namely MECH-12 Bt., MECH-162 Bt. and MECH-184 Bt. by M/S Mahyco Limited in 2002. Despites the report of negative performances of these hybrids in the initial years after introduction (various reports of the State Department of Agriculture and report of Centre for Sustainable Agriculture, 2005), there were productivity gains with the introduction of Bt. Cotton in the state. The gain in productivity of cotton with the introduction of cotton was in the form of reduced application of plant protection chemicals and reduced cost of cultivation. This was in lines of findings of Maharana *et al.* (2011) who reported significant positive impacts of introduction of Bt. cotton in state agriculture. The results from the section 4.4.3 in this chapter also revealed that the government expenditure on agricultural research, education and extension and average rainfall in state had significant influence in the productivity gain of the crop in the state during the study period.

Determinants of TFP of cotton in Telangana state from 2000-01 to 2012-13 :

In order to identify the determinants of TFP of cotton in Telangana state from the period 2000-01 to 2012-13, the TFP index of cotton in Telangana was regressed on

Table 3: Determinants of TFP of cotton in Telangana state from 2000-01 to 2012-13

Dependant variable : TFP index of cotton in Telangana state expressed in natural logarithm

Variable	Regression co-efficient	Standard error	t- ratio	p-value
Constant	0.951	2.028	0.469	0.652
Government expenditure on Agricultural research, education and extension (per Ha)	0.379*	0.112	3.381	0.009
Average rainfall (mm)	0.411***	0.222	1.845	0.10
Percentage irrigated area	0.015	0.029	0.519	0.618
Rural literacy (%)	-0.029	0.018	-1.595	0.149
R^2		0.776*		
D-W statistics		3.22		

All the variables are expressed in natural logarithms expect those calculated as percentages

*,** and *** indicate significance of values at P=0.01.0.05 and 0.10 respectively

the selected variables. The goodness of fit (R^2) of the regression model was 0.776 (significant at 1% level). There was no problem of heteroskedasticity and autocorrelation in the selected regression model. The results of the analysis were presented in the table 3. The results revealed that all the selected variables appeared with the expected signs expect for rural literacy. But the negative coefficient of rural literacy was not significant. Government expenditure on Agricultural research, education and extension (per Ha) was found to be the most important factor influencing the TFP growth of the cotton in Telangana state with regression co-efficient 0.379 (significant at 1% level). This implied that every 1% increase in the government investment, the increase in the TFP was 0.379 per cent in the study period. The coefficient of average rainfall was 0.411 (significant at 10% level). Percent of irrigated area under cotton also had a positive impact on the productivity of the crop.

Conclusion:

The TFP performance of cotton has increased significantly in Telangana during the study period. The CAGR of TFP index in Telangana was 6.0 per cent and the average value of the index was 149.5. The index reached as high as 207.40 in 2007-08 and was above 100 for almost all the years of study. The growth rate of the index was same for all the regions. The highest average value of the index was observed in northern Telangana region.The TFP of cotton in Telangana over the years was largely affected by the government expenditure on agricultural research, education and extension (per Ha) and average rainfall in the state with regression co-efficients 0.379 and 0.411 respectively. Percentage irrigated area under cotton was also found to be positively influencing the TFP in the state over the years. The R^2 of the regression model was 77.60 per cent. The significant growth in the area and production of cotton in the state was propelled by the introduction of Bt-cotton and due to higher returns from cotton. But there have been cases of farmers' suicides and crop holidays in the state of Telangana which has deteriorated the conditions of cotton farmers in the state. Thus, it is important to formulate agriculture policies that is all inclusive in nature and considers all the pros and cons of cultivating certain crops. Rapid spread of cotton in the state was at the cost of significant reduction in the areas under many nutri-rich cereals like pulses and millets. This poses a serious concern regarding the food and nutritional security of the peoples of the state. Thus, the state government should reorient the state agricultural policy that maintains the balance between the cash and food crops.

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