International Journal of Agriculture Sciences
ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 10, Issue 23, 2018, pp.-7586-7588.
Available online at https://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

TOTAL FACTOR PRODUCTIVITY OF MAJOR CROPS IN ANDHRA PRADESH

DIVYA K.*[1], BHAVANI DEVI I.[2], VISHNU SANKAR RAO D.[3] AND LAVANYA KUMARI P.[4]

[1]Department of Agricultural Economics, S.V. Agricultural College, Tirupati, 517502, Acharya N. G. Ranga Agricultural University, Lam, 522034, Andhra Pradesh
[2]Professor, Department of Agricultural Economics, Institute of Agribusiness Management, Tirupati, 517502, Acharya N. G. Ranga Agricultural University, Lam, 522034
[3]Professor, College of Food Science and Technology, Acharya N. G. Ranga Agricultural University, Lam, 522034, Andhra Pradesh
[4]Scientist, Department of Statistics, Regional Agricultural Research Station, Tirupati, 517502, Andhra Pradesh, India
*Corresponding Author: Email - divya.kathula@gmail.com

Received: December 01, 2018; Revised: December 11, 2018; Accepted: December 12, 2018; Published: December 15, 2018

Abstract: This study examines productivity growth of major crops in Andhra Pradesh. For study, time-series data on cost of cultivation of selected crops were collected from the reports of Commission on Agricultural Costs and Prices for the period 1996-97 to 2014-15. A nonparametric data envelopment analysis (DEA) programming method was used to compute Malmquist productivity indices. The study has explored the role of efficiency change in improving the productivity of crops in Andhra Pradesh. The results showed that the decomposition of the TFPch for the corresponding years into EFFch and TECHch revealed that 72.6 percent increase in TFPch is due to largely 68 percent improvement in the efficiency.

Keywords: Total factor productivity, Malmquist Index, Efficiency change, Technical change

Citation: Divya K., *et al*., (2018) Total Factor Productivity of Major Crops in Andhra Pradesh. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 10, Issue 23, pp.- 7586-7588.

Introduction

In agriculture, productivity growth as measured by Total Factor Productivity (TFP) reflects improvements in the efficiency with which farmers combine inputs to produce outputs. Productivity improvements have driven considerable growth in agricultural production in recent decades, enabling farmers to produce affordable food, feed, fuel and fibre for a rapidly growing population. Andhra Pradesh is one of the states to implement economic reforms vigorously, particularly after 1995 in addition to the reforms of the Central Government. The growth of agricultural production in the state is said to be lower than that at the all-India level. The growth rate in food grains during 1990-91 to 1998-99 in the state was only 1.5 percent per annum. After two decades of good performance, the state witnessed a deceleration in agricultural growth during the 1990s from 3.4 to 2.3 percent per annum. The growth rates of all the major crops declined during this decade in the state [1]. With this background, it was considered useful to study the variations in total factor productivity in agriculture of Andhra Pradesh. Growth rate of agricultural production simply depict performance of agriculture but does not revealed anything about efficiency of the performance. However, factor productivity reveals efficiency with which the factors inputs are converted into output with in production processes. This will help in reorienting of the programmes and priorities of agricultural development so as to achieve higher growth of agriculture for economic prosperity.

Material and Methods

Six major agricultural crops were selected for the present study, namely paddy, maize, groundnut, cotton, sugarcane and red gram. These six crops accounted for the 75 to 80 percent of the gross cropped area in the state of Andhra Pradesh. Estimation of total factor productivity for the state of Andhra Pradesh was based on the secondary data pertaining to cost of cultivation of the selected crops were collected for a period starting from 1996-97 to 2014-15. The state level data were compiled from the unit level data on cost of cultivation.

The unit level data on the cost of cultivation of the major crops were available for the above said period. The Malmquist model was selected to estimate total factor productivity in agriculture. This model was first introduced by Caves, *et al*, (1982) [2]. They defined the TFP index using Malmquist input and output distance functions, and thus the resulting index came to be known as the Malmquist TFP index. The period 't' Malmquist productivity index is given by

$$M^t = D_o^t (X^{t+1}, Y^{t+1}) / D_o^t (X^t, Y^t) \quad (1)$$

i.e., they define their productivity index as the ratio of two output distance functions taking technology at time t as the reference technology.

$$M^{t+1} = D_o^{t+1} (X^{t+1}, Y^{t+1}) / D_o^{t+1} (X^t, Y^t) \quad (2)$$

Fare *et al* (1994) attempt to remove the arbitrariness in the choice of benchmark technology by specifying their Malmquist productivity change index as the geometric mean of the two-period indices [3], that is,

$$M_o(X^{t+1}, Y^{t+1}, X^t, Y^t) = \left[\left(\frac{D_o^t(X^{t+1},Y^{t+1})}{D_o^t(X^t,Y^t)}\right)\left(\frac{D_o^{t+1}(X^{t+1},Y^{t+1})}{D_o^{t+1}(X^t,Y^t)}\right)\right]^{\frac{1}{2}} \quad (3)$$

Using simple arithmetic manipulation, the equation (3) can be written as the product of two distinct components- technical change and efficiency change.

$$M_o(X^{t+1}, Y^{t+1}, X^t, Y^t) = \frac{D_o^{t+1}(X^{t+1},Y^{t+1})}{D_o^t(X^t,Y^t)}\left[\left(\frac{D_o^t(X^{t+1},Y^{t+1})}{D_o^{t+1}(X^{t+1},Y^{t+1})}\right)\left(\frac{D_o^t(X^t,Y^t)}{D_o^{t+1}(X^t,Y^t)}\right)\right]^{\frac{1}{2}} \quad (4)$$

Where,

$$Efficiency\ change = \frac{D_o^{t+1}(X^{t+1},Y^{t+1})}{D_o^t(X^t,Y^t)} \quad (5)$$

$$Technical\ change = \left[\left(\frac{D_o^t(X^{t+1},Y^{t+1})}{D_o^{t+1}(X^{t+1},Y^{t+1})}\right)\left(\frac{D_o^t(X^t,Y^t)}{D_o^{t+1}(X^t,Y^t)}\right)\right] \quad (6)$$

Hence the Malmquist productivity index is simply the product of the change in relative efficiency that occurred between periods t and t+1, and the change in technology that occurred between periods t and t+1.

Results and Discussion

An attempt was made in this section to decompose the productivity growth of the selected crops in the present study into various efficiency measures using the Malmquist productivity indices. The technique used in this purpose allowed decompose the productivity growth into two mutually exclusive and exhaustive components namely, efficiency change (EFFch) or shifts in technology over time and technical change (TECHch). These two components of the productivity growth help in the identification of catching up and the identification of innovation respectively [3]. As compared to the Tornqvist index as propounded by Caves *et al*., Malmquist indices are more general in the sense that it allows inefficient performances and does not presume the underlying functional form of the technology. Besides the Malmquist productivity index estimation unlike the parametric Tornqvist approach, requires data only on the quantities of output and inputs but does not require price data. Non-parametric programming methods were used to calculate the component distance functions of the Malmquist index. This technique constructs a grand frontier over the data on all the regions and compares each of the regions to the frontier. How close a country is as compared to the frontier is termed as "catching up" and how much the grand frontier shifts at each region input mix is termed as "technical change" or "innovation". Any value of the indices so calculated, more than 1 implies an improvement in the performance and value less than 1 implies regress or deterioration in the performance. DEAP version 2.1 was used for the calculation purposes. Technical change (TECHch) and efficiency change (EFFch) indexes are obtained under the assumptions of constant returns to scale (CRS), *i.e*., it is assumed that all the firms operate in an optimum scale. But in reality, the firms could face inefficiencies due to increasing and decreasing returns to scale (IRS and DRS). The TECHch index of the firms can further be decomposed into pure efficiency change (PEch) and scale efficiency change (SEch) by relaxing the assumptions of CRS to variable returns to scale (VRS). PEch component of TECHch measures the changes in closeness of the firm to the grand frontier, devoid of the scale effects. Whereas the SEch index indicates if the movement inside the frontier is in the right direction to attain the scale efficiency or CRS point. From the foregoing discussion it can be generalised that,

TFPch =TECHch × EFFch

EFFch = PEch × SEch

So,

TFPch = TECHch × PEch × SEch.

Pure technical inefficiency of a firm is also called as the "managerial inefficiency" which occurs due to inefficient management of the inputs to produce certain level of output. SEch reflects the efficient levels of input and output. Malmquist productivity index or the total factor productivity change (TFPch) as well as the efficiency-change (EFFch), technical-change (TECHch), pure efficiency change (PEch) and scale efficiency change (SEch) components for the state as a whole were estimated and summary presentation of the annual level performance was given in this study [4-10].

Malmquist productivity indices of selected major crops in Andhra Pradesh

Malmquist indices of productivity growth of selected crops were calculated to study and decompose the productivity growth into various efficiency measures and the results have been presented in the [Table-1] and [Table-2]. As per the results reported in the [Table-1], the geometric mean (GM) the efficiency change (EFFch) is 1.024. This is the product of pure technical efficiency change (PEch) and scale efficiency change (SEch). The mean PTEC and SEC are respectively 1.014 and 1.010. The total factor productivity change (TFPCh) is the product of EFFch and technological change (TECHch). The mean TFPch is 1.006, which is the product of (EFFch and TECHch *i.e*., 1.024 and 0.982). During the entire 18 years (from 1997-98 to 2014-2015) the highest mean change occurred in the year 2007-08 (1.726) and the lowest mean TFPch was in the year 2008-09 (0.350). The decomposition of the TFPch for the corresponding years into EFFch and TECHch revealed that 72.6 percent increase in TFPCH is due to largely 68 percent improvement in the efficiency. But the lowest mean TFPch in the year was due to huge negative growth in both efficiency and technology of about 42.3 percent and 82.5 percent. As far as the efficiency change (EFFch) is concerned, the positive change occurred only in nine years *i.e*., 1999-2000, 2000-01, 2004-05, 2005-06, 2007-08, 2009-10, 2011-12, 2012-13 and 2014-15and highest positive EFFch was in 1999-2000 *i.e*., 79.1 percent. The positive change in EFFch is entirely due to scale efficiency change. In the case of technological change, the average change was negative *i.e*., 0.982. however, the specific years which showed positive technological changes were *i.e*., 1997-98, 1998-99, 2003-04, 2006-07, 2007-08, 2012-13 and 2013-14. Among these years, highest technological change occurred in the year 2006-07 (72.5 %) followed by 2013-14 (70.8 %). Since in many years there was deceleration in technological change, the average technological change showed deceleration. The pure technical change was neither improved nor decelerated. The study revealed that the recent yield stagnation in rice is not due to technology fatigue, but could be due to the sluggish input intensification.

Table-1 Malmquist Index Summary of Annual Means of Major Crops in Andhra Pradesh from1997-98 to 2014-15

Year	EFFch	TECHch	PEch	SEch	TFPch
1997-98	0.984	1.008	1.024	0.961	0.992
1998-99	0.757	1.107	1.258	0.602	0.839
1999-2000	1.791	0.826	1	1.791	1.48
2000-01	1.165	0.825	1	1.165	0.961
2001-02	0.995	0.938	1	0.995	0.933
2002-03	0.814	0.867	1	0.814	0.706
2003-04	0.712	1.607	0.964	0.739	1.145
2004-05	1.466	0.774	1.037	1.413	1.135
2005-06	1.318	0.76	1	1.318	1.002
2006-07	0.7	1.725	1	0.7	1.207
2007-08	1.68	1.027	1	1.68	1.726
2008-09	0.423	0.825	1	0.423	0.35
2009-10	1.153	0.825	1	1.153	1.058
2010-11	0.909	0.918	1	0.909	0.887
2011-12	1.282	0.856	1	1.282	1.097
2012-13	1.098	1.249	1	1.098	1.371
2013-14	0.788	1.708	1	0.788	1.346
2014-15	1.532	0.514	1	1.532	0.788
Mean	1.024	0.982	1.014	1.01	1.006

***Note: Malmquist index averages are geometric means*

Table-2 Crop wise Malmquist Index Summary of Annual Means in Andhra Pradesh from 1997-98 to 2014-15

Year	EFFch	TECHch	PEch	SEch	TFPch
Paddy	1.016	1.047	1.088	0.934	1.064
Maize	1.012	0.962	1	1.012	0.973
Groundnut	0.988	0.953	1	0.988	0.942
Cotton	1.056	0.933	1	1.056	0.986
Sugarcane	1	1.053	1	1	1.053
Redgram	1.076	0.95	1	1.076	1.022
Mean	1.024	0.982	1.014	1.01	1.006

***Note: Malmquist index averages are geometric means*

Crop wise malmquist index of crop means in Andhra Pradesh

The comparison of crop wise performance revealed that the total factor productivity change (TFPch) paddy production was highest as it averaged at 6.4 percent during 1997-98 to 2014-15. The decomposition of TFPch showed that the mean technical progress increased at 4.7 percent and mean technical efficiency indicated lesser increase of 1.6 percent during the corresponding period. The other crops to follow were sugarcane and redgram particularly for sugarcane the impressive growth of 5.3 percent was entirely due to technical progress. Maize, groundnut and cotton recorded a respective TFPch of -2.7, -5.8 and -1.4 percent during the period under study. On the whole the mean TFPch for all the crops had improved.

Conclusion

The estimation and decomposition of TFP index into various efficiency measures by applying data envelopment analysis (DEA) revealed thatcrops have witnessed positive growth in the TFP change. The improvement or deterioration in the performance of the TFPch of the selected crops was mainly driven by the change in efficiency change (EFFch) Scale efficiency change played an important role in changing the efficiency in the state agriculture.

Application of research: Research examines productivity growth of major crops in Andhra Pradesh

Research Category: Agriculture Production

Acknowledgement / Funding: Authors are thankful to S.V. Agricultural College, Tirupati, 517502, Acharya N. G. Ranga Agricultural University, Lam, 522034, Andhra Pradesh, India

***Research Guide or Chairperson of research: Dr I. Bhavani Devi**
University: Acharya N. G. Ranga Agricultural University, Lam, 522034
Research project name or number: PhD Thesis

Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript

Conflict of Interest: None declared

Sample Collection:

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

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