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# Total Factor Productivity Growth of Rice and Maize in Andhra Pradesh, India

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**A B S T R A C T**

This paper examines the trends in rice and maize productivity growth in Andhra Pradesh. A nonparametric data envelopment analysis (DEA) programming method is used to compute Malmquist productivity indices. 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. The results revealed that the decomposition of the TFPch for the corresponding years into EFFch and TECHch revealed that 48.8 per cent increase in TFPch was due to improvement in the technology used. The EFFch did not affect the TFPch in overall study period i.e., there was no catching up. For the maize, the highest improvement in the performance was observed in the year 1998-99 where the TFPch was 115.9 per cent and the entire improvement was due to TECHch. This implied that there was significant improvement in the "innovation" in this year.

**Keywords**

Rice, Maize, Total factor productivity, Malmquist index, Efficiency change, Technological change

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## Introduction

Agriculture plays an important role in the livelihoods of people as 63% of the population in Andhra Pradesh live in rural areas and depend on agriculture and related livelihood opportunities. Agriculture Sector contribute 27% share in State GDP. The agriculture plays an important role not only in the economy but also for achieving the food security for the state and also for the country.

According to the estimates of Economic Survey of Andhra Pradesh, 2016-17, the food grains production was 156.85 lakh tonnes, and oilseeds production was 24.62 lakh tonnes, an increase from the previous year of 9.09% and 12.9% respectively. 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 (Rao, 2005) [8]. The growth rate in food grains during 1990-91 to 1998-99 in the state was only 1.5 per cent 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 per cent per annum.

Among the food grains; rice, bajra, maize, ragi, and pulses production increased a little, whereas jowar, other millets and wheat fell. In the oilseeds segment, the production of groundnut and castor saw a drop while sesamum production improved. Cereals account nearly 76 per cent of the total food grains area in Andhra Pradesh. Rice, maize, sorghum, Bajra, Ragi, Korra, Varugu, Samai etc. Rice, the Major Staple food grain crop, which is predominantly irrigated, is grown in both Kharif and Rabi seasons in all the Districts of the state. It accounted for 28.38 % of the total cropped area in the state during 2016-17. Maize crop is mostly grown in the Districts of West Godavari, Vizianagaram Kurnool and Guntur and are predominantly growing this crop which accounted for 65.97 % of the total area under the crop in the state during 2016-17. West Godavari District alone accounted for 23.29 % of the State Area.

## Materials and Methods

Estimation of total factor productivity for the state of Andhra Pradesh was based on the secondary data pertaining to cost of cultivation of the rice and maize 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, Christensen and Diewert (1982) [3]. 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

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

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

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

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, that is,

$$M_O(\mathbf{x}^{t+1}, \mathbf{y}^{t+1}, \mathbf{x}^t, \mathbf{y}^t) = \left[\left(\frac{D_O^t(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})}{D_O^t(\mathbf{x}^t, \mathbf{y}^t)}\right)\left(\frac{D_O^{t+1}(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})}{D_O^{t+1}(\mathbf{x}^t, \mathbf{y}^t)}\right)\right]^{\frac{1}{2}} \quad (3)$$

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,

$$\text{Efficiency change} = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \quad (5)$$

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 (Fare *et al.*, 1994). 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 regions 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.

## Malmquist productivity indices of rice

Malmquist indices of productivity growth of rice were calculated to study and decompose the productivity growth into various efficiency measures. As per the results reported in Table 1, the geometric mean (GM) of the efficiency change (EFFch) was 1.000.

This is the product of pure technical efficiency change (PEch) and scale efficiency change (SEch). The mean PEch and SEch were 1.000 each respectively. The total factor productivity change (TFPch) is the product of EFFch and technological change (TECHch). The mean TFPch was 1.000, which was the product of (EFFch and TECHch) i.e., 1.000 and 1.000.

This implied that over the period of years on a geometric average basis, the performance of rice in the State was stable. During the entire 18 years (from 1997-98 to 2014-2015) the highest mean change occurred in the year 2010-11 (1.488) and the lowest mean TFPch was in the year 2011-12 (0.696).

The decomposition of the TFPch for the corresponding years into EFFch and TECHch revealed that 48.8 per cent increase in TFPch was due to improvement in the technology used. As far as the technical change (TECHch) is concerned, the positive change occurred in eleven years i.e., 1998-99, 1999-2000, 2002-03, 2003-04, 2004-05, 2005-06, 2006-07, 2007-08, 2008-09, 2010-11, and 2012-13. The EFFch did not affect the TFPch in overall study period i.e., there was no catching up.

## Malmquist productivity indices of maize

Decomposition of the productivity of maize into various efficiency measures was done using the Malmquist decomposition procedure and the results are presented in Table 2. It is revealed that the geometric average of annual means of the TFPch was 1.077 i.e., average change of Malmquist total factor productivity index of maize over the period of 18 years was 7.7 per cent.

This implied that the over the period on a geometric average basis the performance of maize in the State was unstable. On an overall basis, efficiency change (EFFch) did not have any implication in the TFPch of maize.

The year wise performance of the means of the productivity indices revealed that the TFPch was positive in almost all the years except 1997-98 (-4.2 per cent), 2002-03 (-34.6 per cent), 2007-08 (-5.7 per cent), 2008-09 (-63.5 per cent), 2010-11 (-14 per cent), 2012-13 (-5.7 per cent) and 2013-14 (-6.5 per cent).

The highest improvement in the performance was observed in the year 1998-99, where the TFPch was 115.9 per cent and the entire improvement was due to TECHch. This implied that there was significant improvement in the "innovation" in this year.

"Catching up" or EFFch was almost nil in all the years. The results revealed that the productivity gains were completely due to improvement in innovation i.e., TECHch (Belloumi and Matoussi, 2009).

**Table.1** Malmquist index summary of annual means of rice in Andhra Pradesh From 1997-98 to 2014-15

| S. No. | Year | EFFch | TECHch | PEch | SEch | TFPch |
|---|---|---|---|---|---|---|
| **1** | 1997-98 | 1.000 | 0.874 | 1.000 | 1.000 | 0.874 |
| **2** | 1998-99 | 1.000 | 1.091 | 1.000 | 1.000 | 1.091 |
| **3** | 1999-00 | 1.000 | 1.001 | 1.000 | 1.000 | 1.001 |
| **4** | 2000-01 | 1.000 | 0.969 | 1.000 | 1.000 | 0.969 |
| **5** | 2001-02 | 1.000 | 0.872 | 1.000 | 1.000 | 0.872 |
| **6** | 2002-03 | 1.000 | 1.024 | 1.000 | 1.000 | 1.024 |
| **7** | 2003-04 | 1.000 | 1.021 | 1.000 | 1.000 | 1.021 |
| **8** | 2004-05 | 1.000 | 1.165 | 1.000 | 1.000 | 1.165 |
| **9** | 2005-06 | 1.000 | 1.078 | 1.000 | 1.000 | 1.078 |
| **10** | 2006-07 | 1.000 | 1.023 | 1.000 | 1.000 | 1.023 |
| **11** | 2007-08 | 1.000 | 1.050 | 1.000 | 1.000 | 1.050 |
| **12** | 2008-09 | 1.000 | 1.045 | 1.000 | 1.000 | 1.045 |
| **13** | 2009-10 | 1.000 | 0.851 | 1.000 | 1.000 | 0.851 |
| **14** | 2010-11 | 1.000 | 1.488 | 1.000 | 1.000 | 1.488 |
| **15** | 2011-12 | 1.000 | 0.696 | 1.000 | 1.000 | 0.696 |
| **16** | 2012-13 | 1.000 | 1.096 | 1.000 | 1.000 | 1.096 |
| **17** | 2013-14 | 1.000 | 0.970 | 1.000 | 1.000 | 0.970 |
| **18** | 2014-15 | 1.000 | 0.900 | 1.000 | 1.000 | 0.900 |
| | **Mean** | **1.000** | **1.000** | **1.000** | **1.000** | **1.000** |

**Table.2** Malmquist index summary of annual means of maize in Andhra Pradesh from1997-98 to 2014-15

| S. No. | Year | EFFch | TECHch | PEch | SEch | TFPch |
|---|---|---|---|---|---|---|
| **1** | 1997-98 | 1.000 | 0.420 | 1.000 | 1.000 | 0.420 |
| **2** | 1998-99 | 1.000 | 2.159 | 1.000 | 1.000 | 2.159 |
| **3** | 1999-00 | 1.000 | 0.902 | 1.000 | 1.000 | 0.902 |
| **4** | 2000-01 | 1.000 | 1.241 | 1.000 | 1.000 | 1.241 |
| **5** | 2001-02 | 1.000 | 1.499 | 1.000 | 1.000 | 1.499 |
| **6** | 2002-03 | 1.000 | 0.346 | 1.000 | 1.000 | 0.346 |
| **7** | 2003-04 | 1.000 | 2.149 | 1.000 | 1.000 | 2.149 |
| **8** | 2004-05 | 1.000 | 1.069 | 1.000 | 1.000 | 1.069 |
| **9** | 2005-06 | 1.000 | 1.425 | 1.000 | 1.000 | 1.425 |
| **10** | 2006-07 | 1.000 | 1.885 | 1.000 | 1.000 | 1.885 |
| **11** | 2007-08 | 1.000 | 0.943 | 1.000 | 1.000 | 0.943 |
| **12** | 2008-09 | 1.000 | 0.365 | 1.000 | 1.000 | 0.365 |
| **13** | 2009-10 | 1.000 | 1.989 | 1.000 | 1.000 | 1.989 |
| **14** | 2010-11 | 1.000 | 0.853 | 1.000 | 1.000 | 0.853 |
| **15** | 2011-12 | 1.000 | 1.651 | 1.000 | 1.000 | 1.651 |
| **16** | 2012-13 | 1.000 | 0.570 | 1.000 | 1.000 | 0.57 |
| **17** | 2013-14 | 1.000 | 0.935 | 1.000 | 1.000 | 0.935 |
| **18** | 2014-15 | 1.000 | 2.290 | 1.000 | 1.000 | 2.29 |
| | **Mean** | **1.000** | **1.077** | **1.000** | **1.000** | **1.077** |

In the case of rice, the decomposition of the TFPch for the corresponding years into EFFch and TECHch revealed that 48.8 per cent increase in TFPch was due to improvement in the technology used. The EFFch did not affect the TFPch in overall study period i.e., there was no catching up.

For the maize, the highest improvement in the performance was observed in the year 1998-99 where the TFPch was 115.9 per cent and the entire improvement was due to TECHch. This implied that there was significant improvement in the "innovation" in this year.

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