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# Total factor productivity and returns to investment in wheat crop research in Western Maharashtra

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**Abstract**
Total factor productivity indicates the contribution of non inputs to the growth of agricultural productivity. In this study, estimation of total factor productivity in wheat crop and returns to investment in wheat research in Western Maharashtra is attempted. The result indicates the output index of wheat increased from0.88 in 1993 to 1.17 in 2013. The highest output index was observed in 2006(2.16).The average input index of wheat was 0.79 for twenty one years. TFP mean of wheat (2.47) increased over first decade indicates productivity increased. The average TFP index for 21 years was 1.92.The contribution of research and non-input factors were significant from the 2005 onwards. Over the entire period of study (1993-94 to 2013-14), TFP grew at the rate of 5.45 per cent per annum The TFP index witnessed an impressive growth of 6.68 per cent per annum during period I. The improvement in total factor productivity is due to non-inputs such as research, rainfall, road density and net irrigated area etc. Non-input factors such as public research (0.29), rural literacy (2.01) has significantly contributed to TFP growth in wheat. The rainfall (0.08) is a crucial determinant of TFP in wheat. An additional investment of one rupee in Wheat research generated additional income of ₹ 15.56 indicating very high rates of return to public investment in wheat research. The estimated value of research expenditure flexibility was 3.45 which means that to achieve one per cent increase in TFP, the investments in wheat research needs to be increased by 3.45 per cent. The internal rate of return to investment in Wheat research during the period 1993-94 to 2013-14 estimated to be 23.92.

**Keywords:** Total factor productivity, wheat, estimated value of marginal product, internal rate of return

## Introduction
Wheat is a close second to rice as the most important source of calories for humans. In general, wheat is more adaptable to a wide range of growth conditions than other major cereal crops, and is thus the most widely cultivated food plant in the world. The cereals are the staple food for India as well as Maharashtra. India stands second in area and production after China. Uttar Pradesh ranks first in area and production while Punjab becomes leading state in productivity. Wheat grains are grounded into flour (atta) and consumed in the form of chapatees i.e. 80-85 per cent.

The area, production and productivity of wheat in Maharashtra during 1960-61 was 907 ('000'ha), 401 ('000' MT) and 442 (Kg/ha) while in 2016-17 it was 1272 ('000'ha), 2214 ('000' MT) and 1740 (Kg/ha). Per cent change in area, production and productivity of wheat showed positive growth in area by 40.24per cent, production by 452.11per centand productivity by 293.66 per cent, respectively.

Area under wheat in Maharashtra was 960 ('000' ha), while in India it was 30645 ('000' ha). In comparison with India area under wheat in Maharashtra was 3.1 per cent. (Area under principal crops, average for years 2012-13 to 2014-15, Economic Survey of Maharashtra, 2017-18).

A total 209 new varieties/hybrids tolerant to various biotic and abiotic stresses with enhanced quality have been developed for Cereals, Pulses, Oilseeds, Commercial and Forage crops. 117 high yielding varieties/ hybrids of cereals comprising 65 of rice, 14 of wheat, 24 of maize, 5 of finger millet, 3 of pearl millet, 1 each of sorghum, barley, foxtail millet, Kodomillet, little millet and Proso-millet were released for cultivation in different agro-ecologies of the country during 2017.(Economic Survey, 2017-18).

## Methodology
### Methodologies of Measuring (TFP) total factor productivity
### Growth accounting approach (GAA)
The TFP index is measured as the ratio of the index of net output and the index of total factor inputs. The index of total factor inputs is derived as weighted average of indices of labour

inputs, capital inputs and land inputs with relative income shares of the three factors as respective weights. The key feature of the GAA is separation of change in production on account of changes in the quantities of factors of production from residual influences, which include technological progress, learning by doing, *etc.* Basically there are three main indices used in the GAA: (i) Kendrick Index (KI), (ii) Solow Index (SI), and (iii) Translog Index (TLI).

Total factor productivity concept implies an index of total output per unit of total factor inputs. TFP growth measures the increase in output i.e. not accounted for by the increase in total inputs. Thus total factor productivity index that measure the growth in net output i.e. not accounted for by the growth in basic factor input such as land, labour, capital. It is superior to partial approach as it is composite measure of productivity, which related output to all inputs, simultaneously.

TFP is defined as the ratio of an index of aggregate output to an index of aggregate input. One of the most defensible methods of aggregation in productivity measurement is Divisia aggregation-Divisia indices have two important attractive properties: (i) they satisfy the time reversal and factor reversal tests for index numbers, and (ii)it is a discrete of the components, so that aggregate could be obtained by the aggregation of sub aggregates. For discrete data, the most commonly used approximation to the (continuous) Divisia index is the Tornqvist approximation. The Divisia Tornqvist 'or' translog index of TFP is commonly used for computing the total output, total input and TFP indices by commodity/farm system/sector, etc. under different locations as outlined below. For the productivity measurement over a long period of time, chaining indexes for successive time periods is preferable. With chain-linking, an index is calculated for two successive periods, t and t-1, over the whole period 0 to T (sample from time t=0 tot=T) and the separate indexes are then multiplied together. The output index, input index and TFP index are constructed separately for Wheat crop. To construct output index the time series data (1993-94 to 2013-14) on main product, by product and prices used, where as to construct input index, the time series data with regard to inputs like seeds, manure, chemical fertilizer (NPK), human labour, bullock labour, machine labour, plant protection chemicals, irrigation and prices of inputs are used. Finally the TFP index is computed by dividing output index by input index. We have specified that the index is equal to 1.00 in a particular year i.e. here we considered 1993-94 as base year and TFP chain index constructed as it provides annual changes in productivity over a period of time.

The 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. The TFP indices computed using the software TFPIP version 1.0, which developed by Tim Coelli, Centre for Efficiency and Productivity Analysis, University of Queensland, Australia. Time series data on Costs and returns of wheat crop for the years 1993-94 to 2013-14 collected and compiled from the cost of cultivation scheme, Department of Agricultural Economics, MPKV, Rahuri. All the data was calculated in real terms by deflating the time series data on investment using the consumer price index with 2011-12 as a base year.

TFP indices computed as follows

**Total output index**

$(TOI) = TOI_t/TOI_{t-1}=\prod_j(Q_{jt}/Q_{jt-1})^{(Rjt+Rjt-1)1/2}$

**Total input index**

$(TII) = TII_t/TII_{t-1}=\prod_j(Xjt/Xjt-1)^{(Sjt+Sjt-1)1/2}$

Total factor productivity index (TFPI) of $t^{th}$ year is 100 times the ratio of TOI, to the TII and is given by,

**$TFPI_t= (TOI_t/TII_t) \times 100$**

Input price index is given by,

$$\frac{IPI_t}{IPI_{t-1}} = \prod_j \left[ \frac{P_{it}}{P_{it-1}} \right]^{\left(S_{jt}+S_{jt-1}\right)\frac{1}{2}}$$

**Where**

Rjt = Share of jth output in total revenue
Qjt = Output 'j'
Sjt = Share of ithinput in total input cost
Xit = input 'i'
Pit = Price of ith in Period 't'

By specifying TOI t-1, TIIt-1 and IPIt-1 equal to 100 in the initial year, the above equation provides the total output, total input, total factor productivity and input price indices for the specified period 't'. 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. The above equations provide the indices of total output, total input, and TFP for the specified year 't'.

**Estimated value of marginal return**

The time series data from the different years was used. Using the elasticity of TFP with respect to research and development investment, one can estimate the value of marginal product of research and development investment.

EVMP(R) = b*(V*TFP share/R)

**Where**

| | | |
|---|---|---|
| R | : | Research investment |
| b | : | TFP Elasticity of research investment |
| V | : | Value of production associated with TFP |
| EVMP | : | Estimated value of marginal product |

**Internal rate of return to cereal research and development**

In economic terms, the IRR "is the interest rate earned on the unrecovered balance over an investment's life so that the unrecovered balance at the end of that time is zero. 'IRR' is the discount rate at which the NPV (Net present worth) of an investment becomes zero. In other words discount rate which equates the present value of future cash flows of an investment with the initial investment. It is one of the several measures used for investment appraisal.

Formula used for internal rate of return:

IRR = (Lower Discount Rate)+(Difference Between The Two Discount Rates)* (Present Worth of Cash Flow At The Lower Discount Rate/Absolute Difference Between The Present Worth of the Cash Flow At The Two Discount Rates)

**Results and Discussion**

**Indices of input, output and TFP index of wheat**

Total Factor Productivity (TFP) is the portion of output not explained by the amount of inputs used in production. As

such, its level is determined by how efficiently and intensely the inputs are utilized in production. The output, input and TFP indices of wheat crop are presented in Table 1.

**Table 1:** Total Factor Productivity of wheat during 1993 to 2014

| Sr. No. | Year | Input | Output | TFP |
|---|---|---|---|---|
| 1 | 1993 | 1.00 | 1.00 | 1.00 |
| 2 | 1994 | 1.10 | 0.88 | 0.80 |
| 3 | 1995 | 1.03 | 1.17 | 1.13 |
| 4 | 1996 | 1.01 | 1.25 | 1.25 |
| 5 | 1997 | 0.99 | 1.33 | 1.34 |
| 6 | 1998 | 0.90 | 1.26 | 1.41 |
| 7 | 1999 | 0.84 | 1.43 | 1.71 |
| 8 | 2000 | 0.76 | 1.38 | 1.80 |
| 9 | 2001 | 0.83 | 1.35 | 1.62 |
| 10 | 2002 | 0.68 | 0.89 | 1.30 |
| **Period I** | **Mean** | **0.91** | **1.19** | **1.34** |
| 11 | 2003 | 0.79 | 1.43 | 1.81 |
| 12 | 2004 | 0.82 | 1.53 | 1.87 |
| 13 | 2005 | 0.66 | 1.68 | 2.56 |
| 14 | 2006 | 0.65 | 2.16 | 3.33 |
| 15 | 2007 | 0.70 | 1.96 | 2.79 |
| 16 | 2009 | 0.76 | 1.82 | 2.39 |
| 17 | 2010 | 0.67 | 1.75 | 2.61 |
| 18 | 2011 | 0.66 | 1.77 | 2.69 |
| 19 | 2012 | 0.65 | 1.80 | 2.74 |
| 20 | 2013 | 0.64 | 1.51 | 2.36 |
| 21 | 2014 | 0.58 | 1.17 | 1.99 |
| Period II | Mean | 0.69 | 1.69 | 2.47 |
| Overall | Mean | 0.79 | 1.45 | 1.92 |

The output, input and TFP indices of wheat crop are presented in Table 1. From the table it is observed that, the TFP for wheat increased from 0.8 in 1993 to 1.99 in 2014.The highest TFP index was observed in 2005-06 (3.33). The average TFP index for 21 years was 1.92.The output index of wheat increased from0.88 in 1993 to 1.17 in 2013. The output growth fell to1.1in 1995 and reached the lowest in the year 2010 (0.58). The highest output index was observed in 2006(2.16).The average output index for twenty one years was 1.45. In the case of input index, there were heavy fluctuations, decreasing from 1.1 in 1993-94 to 0.58 in 2013-14. The average input index of wheat was 0.79 for twenty one years. TFP mean of wheat (2.47) increased over first decade indicates productivity increased. However, it may take longer gestation period to reflect in compound growth rates of input, output and TFP of wheat.

### Share of input and TFP in total output of wheat

Share of input calculated by dividing input index to output index gives input share. When we subtract input share from 100 it gives TFP share. The share of input and TFP in output presented in Table 2. It is revealed from the Table 2 that, the contribution of TFP was low during the year 1994 to 2004. However, it was increased from 2005 onwards. It indicates that the contribution of research and non-input factors were significant from the 2005 onwards.

**Table 2:** Share of input and TFP in total output of wheat

| Year | (%) | | |
|---|---|---|---|
| | Input Share | TFP share | Total |
| 1993 | 100.00 | 0.00 | 100 |
| 1994 | 125.51 | -25.51 | 100 |
| 1995 | 88.30 | 11.70 | 100 |
| 1996 | 80.27 | 19.73 | 100 |
| 1997 | 74.47 | 25.53 | 100 |
| 1998 | 71.06 | 28.94 | 100 |
| 1999 | 58.45 | 41.55 | 100 |
| 2000 | 55.57 | 44.43 | 100 |
| 2001 | 61.54 | 38.46 | 100 |
| 2002 | 76.89 | 23.11 | 100 |
| 2003 | 55.15 | 44.85 | 100 |
| 2004 | 53.54 | 46.46 | 100 |
| 2005 | 39.11 | 60.89 | 100 |
| 2006 | 30.03 | 69.97 | 100 |
| 2007 | 35.83 | 64.17 | 100 |
| 2009 | 41.93 | 58.07 | 100 |
| 2010 | 38.35 | 61.65 | 100 |
| 2011 | 37.17 | 62.83 | 100 |
| 2012 | 36.43 | 63.57 | 100 |
| 2013 | 42.29 | 57.71 | 100 |
| 2014 | 50.15 | 49.85 | 100 |

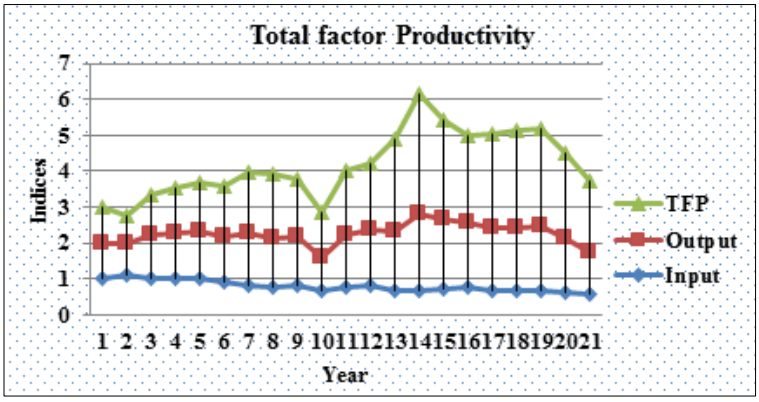


**Fig 1:** Growth of Total Factor Productivity of wheat

### Compound Growth Rates of Input, Output and TFP Index of Wheat

In order to assess productivity performance of TFP of wheat in western Maharashtra, the compound growth rates of output, input and TFP indices were estimated for 21 years from 1993-94 to 2013-14 and for two sub-periods, *viz*. period I (1993-94 to 2002-03) and period II (2003-04 to 2013-14).

A perusal of Table 3 reveals that over the entire period of study (1993-94 to 2013-14), TFP grew at the rate of 5.45 per cent per annum. During the same period, output index increased by 2.55 per cent per annum and input index decreased by 2.75 per cent per annum. In sub periods also the results are more revealing. The TFP index increased at the rate of 6.68 per cent during period I. During, period II, the input index continued to decline at the rate of 2.28 per cent per annum, whereas output index decreased at the rate of 1.27 per cent per annum. The TFP index witnessed an impressive growth of 6.68 per cent per annum during period I. The

improvement in total factor productivity is due to non-inputs such as research, rainfall, road density and net irrigated area etc.

**Table 3:** Compound growth rates of input, output and TFP of wheat

| Period | (%) | | |
|---|---|---|---|
| | Input | Output | TFP |
| Period I (1993-2002) | -4.5*** | 1.88 | 6.68*** |
| Period II (2003-2013) | -2.28*** | -1.27 | 1.04 |
| Overall period (1993-2013) | -2.75*** | 2.55*** | 5.45*** |

*,** and *** indicate significance at 10, 5 and 1 per cent level

**Sources of total factor productivity (TFP) growth of wheat**

The TFP is influenced by research, extension, human capital, intensity of cultivation, application of plant nutrient, infrastructural development and climatic factors. In order to assess the sources of TFP, the TFP index was regressed against the variables *viz*., research investment, rural literacy, rainfall, road density, N to P ratio and net irrigated area. The model specified in log-linear form as:

$\ln (TFP) = a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6$

**Where**

| | | |
|---|---|---|
| Y | = | Total factor productivity index (TFP) |
| a | = | Intercept/Constant term |
| X1 | = | Research (lakh rupees) |
| X2 | = | Rural Literacy (%) |
| X3 | = | Average rainfall (mm/year |
| X4 | = | Road density (km) |
| X5 | = | N to P ratio |
| X6 | = | Net irrigated area (%) |
| T | = | Time variable (years 1, 2, 3….n) |
| u | = | Error term |

**Table 4:** Total factor productivity (TFP) analysis of wheat

| Variables | Coefficients |
|---|---|
| Intercept | -9.01 (3.68) |
| ($X_1$) Research (`) | 0.29*** (0.08) |
| ($X_2$) Rural literacy (%) | 2.01** (0.75) |
| ($X_3$) Rainfall(mm) | 0.08** (0.03) |
| ($X_4$) Road Density (km) | 1.18* (1.12) |
| ($X_5$) N to P ratio | 0.70** (0.28) |
| ($X_6$) Net irrigated area (%) | -0.01 (0.01) |
| $R^2$ | 0.86 |
| F value | 14.96*** |
| N (No. of observations) | 21 |

*,** and *** indicate significance at 10,5 and 1 % level
Figures in parenthesis are standard errors

The growth rates in TFP was analyzed to quantify the contributions of various factors to TFP growth such as research expenditure, rural literacy, rainfall, road density, N to P ratio, net irrigated area on TFP of wheat and presented in Table 4.The results of Table 4 indicates that public research (0.29), rural literacy (2.01) has significantly contributed to TFP growth in wheat. The rainfall (0.08) is a crucial determinant of TFP in wheat. The ratio of nitrogen to phosphorus nutrients (0.70) was taken as proxy for the balanced use of fertilizer. The road density (1.18) was considered as a proxy for infrastructure. The coefficient of this variable was positive and significant. The estimated R square value was 0.86 indicating that 86 per cent of variation in TFP explained by the factors included in the model and 'F' value was statistically significant indicating a good fit of the model. The findings corroborated with the findings of [3, 11].

**Estimated value of marginal product of research investment and internal rate of return to research in Wheat in Maharashtra: 1993-94 to 2013-14**

The estimated value of marginal product of research investment and internal rate of return to wheat research is presented in Table 5. The results showed that an additional investment of one rupee in Wheat research generated additional income of ` 15.56 indicating very high rates of return to public investment in wheat research. The inverse of TFP elasticity with respect to research gives flexibility to research expenditure. The estimated value was 3.45 which means that to achieve one per cent increase in TFP, the investments in wheat research needs to be increased by 3.45 per cent. The Internal rate of return to investment in Wheat research during the period 1993-94 to 2013-14 estimated to be 23.92.

**Table 5:** Estimated value of marginal product of research investment and internal rate of return to research in wheat in western Maharashtra (1993-94 to 2013-14)

| Period | EVMP(`) | IRR (%) | Research expenditure flexibility (%) |
|---|---|---|---|
| 1993-94 to 2013-14 | 15.56 | 23.92 | 3.45 |

**Conclusions**

1. The contribution of research and non-input factors were significant from the 2005 onwards. The improvement in total factor productivity is due to non-inputs such as research, rainfall, road density and net irrigated area etc. Non-input factors such as public research (0.29), rural literacy (2.01) has significantly contributed to TFP growth in wheat.
2. An additional investment of one rupee in wheat research generated additional income of ` 15.56.Internal rate of return to investment in wheat research estimated to be 23.92 indicating wheat research generated substantial returns to the society.
3. In this context, government should emphasize on substantial release of funds for public research for improvement of productivity resulting in highest monetary returns to farming society as a prominent crop in western Maharashtra.

**References**


1. Ananth GS, Chengappa PG. Impact of research investment on technology development and total factor productivity in major field crops of peninsular India, Contributed poster paper prepared for presentation at the International Association of Agricultural Economists Conference, Gold Coast, Australia, August 12-18, 2006.
2. Chand R, Kumar P, Kumar S. Total Factor Productivity and Returns to Public Investment on Agricultural Research in India, NCAP, New Delhi, Agricultural Economics Research Review. 2012; 25(2):181-194.
3. Chandel BS. How sustainable is the Total Factor Productivity of Oilseed in India. Indian Journal of Agricultural Economics. 2007; 62(2):244-258.
4. Economic Survey. Agriculture and Food Management. Government of India, Ministry of Finance, Department of Economic Affairs. 2017; 2:116.

5. Evenson RE, Pray C, Rosegrant MW. Agricultural research and productivity growth in India. Research Report 109. International Food Policy Research Institute, Washington, D.C. U.S.A, 1999.
6. Kumar P, Jha D. Measurement of total factor productivity growth of rice In India: Implications for Food Security and Trade, NCAP Report, 2005, 25-34.
7. Kumar P, Mittal S, Hossain M. Agricultural growth accounting and total factor productivity in south Asia. A review and policy implications. Agricultural Economics Research Review, 2008, 145-172.
8. Kumar P, Mruthyunjaya. Measurement and analysis of total factor productivity growth in wheat, Indian Journal of Agricultural Economics. 1992; 47(7):451-458.
9. Rosegrant MW, Evenson RE. Total factor productivity and sources of long-term growth in India agriculture Paper Presented for IFPRI/IARI Workshop in Agricultural growth in India, May 1-6, New Delhi, India, 1994.
10. Rosegrant MW, Evenson RE. Agricultural productivity and sources of growth in South Asia. American Journal of Agricultural Economics. 1992; 74(3):757-761.
11. Suresh K, Chandrakanth MG. Total factor productivity and returns to investment in Ragi (finger millet) crop research in Karnataka state, India. Indian Journal of Economics and Development. 2015; 3(3):199-205.
12. Thorat AV, Tilekar SN, Dhekale SJ, Patil KH. Total factor productivity in horticultural crops in Konkan Region of Maharashtra. Agricultural Economics Research Review. 2006; 19:113-120.