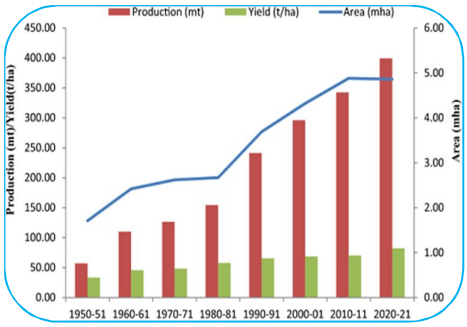
REVIEW OF RESEARCH
ISSN: 2249-894X
IMPACT FACTOR : 5.7631(UIF)
VOLUME - 10 | ISSUE - 8 | MAY - 2021

GROWTH AND TECHNICAL CHANGE IN INDIAN SUGARCANE PRODUCTION: EVIDENCE FROM MALMQUIST PRODUCTIVITY INDEX

Parashuram Arjanal S/O Malakappa
Research Scholar

Dr. Dinesh Kumar
Guide
Professor, Chaudhary Charansing University Meerut.

ABSTRACT



This study examines total factor productivity (TFP) growth and its underlying components in Indian sugarcane production using the Malmquist Productivity Index (MPI) for the period 2017–18 to 2021–22 across ten major sugarcane-producing states. State-level data on output, land, and labour were analyzed using an input-oriented Data Envelopment Analysis framework to compute technical efficiency, pure efficiency, scale efficiency, and technological change. Results indicate that overall TFP increased during the study period with a geometric mean MPI of 1.197, while technological progress was the primary driver of growth and technical efficiency improvements were marginal. States such as Uttar Pradesh, Maharashtra, Gujarat, and Karnataka recorded higher productivity growth, whereas Andhra Pradesh, Punjab, Haryana, Tamil Nadu, and Uttarakhand showed limited gains. The findings highlight regional disparities in productivity performance and emphasize the importance of technology adoption, efficient resource utilization, and policy interventions to sustain long-term productivity growth in Indian sugarcane cultivation. The study demonstrates the utility of the Malmquist Index in capturing both efficiency change and technological progress, providing insights for policymakers and stakeholders seeking to enhance productivity and competitiveness in the sugarcane sector.

KEYWORDS: *Total Factor Productivity, Malmquist Productivity Index, Technical Efficiency, Technological Change, Indian Sugarcane, Productivity Growth.*

INTRODUCTION :

Sugarcane is one of India's most vital cash crops, contributing significantly to the country's agricultural economy, rural employment, and the sugar and ethanol industries. As the world's largest producer of sugarcane, India has seen steady growth in sugarcane production over the years. However, despite an increase in input use, such as land, labor, and fertilizers, the rate of output growth has not always kept pace with input expansion. This suggests that the productivity growth in Indian sugarcane production may not be as efficient or sustainable as it should be, leading to concerns over the sector's long-term competitiveness and economic viability. In the context of agricultural production, total factor productivity (TFP) serves as a comprehensive measure of efficiency by accounting for all inputs used in production and the output generated. The growth in TFP is essential for ensuring that agriculture

remains competitive while maintaining sustainability. However, traditional methods like partial productivity analysis, such as yield per hectare, do not adequately capture the efficiency with which multiple inputs are used together. Hence, there is a need to adopt more sophisticated tools to assess productivity. One such method is the Malmquist Productivity Index (MPI), which measures the change in total factor productivity over time and decomposes it into two primary components: technical efficiency change and technological change. The MPI is particularly useful for assessing the impact of both improvements in input usage and advancements in technology on overall productivity. By applying the MPI, it is possible to quantify the sources of growth in sugarcane production, whether driven by technological improvements (shifts in the production frontier) or by better utilization of resources (catch-up to the frontier). In India's sugarcane sector, where regional disparities in production, resource availability, and technological adoption exist, the use of the MPI allows for a deeper understanding of productivity dynamics at the state level.

AIMS AND OBJECTIVES:

The primary aim of this study is to examine the growth and technical change in Indian sugarcane production using the Malmquist Productivity Index (MPI), with a focus on understanding the sources of total factor productivity (TFP) growth across major sugarcane-producing states from 2017–18 to 2021–22. By applying the Malmquist Index, the study seeks to decompose the productivity growth into its components of technical efficiency change and technological change, and to identify regional disparities in productivity performance.

The specific objectives of the study are:

- To measure the total factor productivity growth in Indian sugarcane production over the study period (2017–18 to 2021–22), utilizing the Malmquist Productivity Index (MPI).
- To decompose the total factor productivity change into the two key components: technical efficiency change (EFFCH) and technological change (TECHCH) using the MPI approach.
- To analyze the regional variation in productivity growth by comparing the TFP growth rates across major sugarcane-producing states (Uttar Pradesh, Maharashtra, Gujarat, Karnataka, Tamil Nadu, etc.).
- To evaluate the role of technological change in driving productivity growth and its influence on the shifts in the production frontier in Indian sugarcane cultivation.
- To identify the factors affecting technical efficiency and assess the extent of efficiency improvements (or lack thereof) in various states, highlighting potential areas for operational enhancements.

REVIEW OF LITERATURE:

Several studies have examined productivity growth and technical change in Indian sugarcane production, employing various methods including Data Envelopment Analysis (DEA), Stochastic Frontier Analysis (SFA), Tornqvist-Theil index, and Malmquist Productivity Index (MPI). Sanap, More, and Yadav (2015) analyzed sugarcane production in Maharashtra using farm-level data from 1989–90 to 2008–09. Their study found that although area under cultivation and production increased, total factor productivity growth was uneven across regions, with higher input use in fertilizers, irrigation, and machinery contributing to output but not always to efficiency. The study indicated positive TFP growth overall, with variables like irrigation, adoption of high-yielding varieties, tractor usage, and road infrastructure having significant influence on productivity.

Arora (2013) investigated the Indian sugar industry over the period 1974/75–2004/05 using Malmquist Index and non-parametric methods. The study revealed that TFP growth in the pre-reform era was driven mainly by efficiency change (catch-up), whereas in the post-reform era, technological progress became the dominant factor. The research highlighted that technical efficiency improvements were often limited, suggesting the need for managerial and operational improvements alongside technological adoption.

Bhopala, Dhandhalya, and Parmar (2023) analyzed sugarcane productivity in Gujarat using TFP measures based on Tornqvist-Theil index for 2018–20. They observed negative TFP growth for both planted and ratoon crops, with total input growth outpacing output growth. Changes in cost structure, including rising labor and irrigation costs and declining rental value of land, were identified as contributing factors.

RESEARCH METHODOLOGY:

The study on growth and technical change in Indian sugarcane production applies the Malmquist Productivity Index (MPI) using a non-parametric Data Envelopment Analysis (DEA) approach to measure total factor productivity (TFP) changes over time. The analysis focuses on ten major sugarcane-producing states of India—Uttar Pradesh, Maharashtra, Gujarat, Karnataka, Tamil Nadu, Andhra Pradesh, Bihar, Haryana, Punjab, and Uttarakhand—covering the period 2017–18 to 2021–22. Each state is considered a decision-making unit (DMU), with productivity measured relative to the most efficient states in the dataset. The study uses secondary data. Output is measured as total sugarcane production (million tonnes), while inputs include land under sugarcane cultivation (lakh hectares) and labor employed in sugarcane cultivation (total man-hours). Data sources include the Directorate of Economics and Statistics, Department of Agriculture and Farmers Welfare, the Indian Institute of Sugarcane Research, and Indiastat. An input-oriented DEA model with constant returns to scale (CCR model) is applied to estimate technical efficiency, which reflects the ability of a state to produce a given level of output with minimal inputs. Technical efficiency scores are calculated for each state and year by solving linear programming problems based on observed input-output combinations. MPI values greater than one indicate total factor productivity growth, values equal to one indicate no change, and values less than one indicate a decline. This methodology provides a detailed analysis of productivity dynamics in Indian sugarcane production, distinguishing between gains due to better input utilization and those due to technological advancement.

STATEMENT OF THE PROBLEM:

Sugarcane is one of India's most important commercial crops, contributing significantly to agricultural income, rural employment, and the raw material base for the sugar and ethanol industries. Despite India being one of the largest producers of sugarcane globally, growth in output has not always corresponded proportionally to increases in inputs such as land, labor, irrigation, and fertilizers. Rising input costs, fluctuations in yield, regional disparities, and declining efficiency in resource use have created concerns about the sustainability and competitiveness of sugarcane production. Traditional measures of productivity, such as yield per hectare or output per worker, do not fully capture the combined effect of multiple inputs, making it difficult to assess whether growth is driven by efficient resource use or technological progress. While some states show high production growth due to expansion in cultivated area or intensive input use, others experience stagnation or decline in productivity, reflecting inter-state differences in technology adoption, irrigation facilities, mechanization, and farm management practices. Therefore, the problem addressed in this study is to evaluate the extent and sources of total factor productivity growth in Indian sugarcane cultivation using the Malmquist Index. The study aims to identify whether productivity growth is primarily driven by improvements in technical efficiency or by technological progress and to assess regional disparities in productivity performance across major sugarcane-producing states. This information is crucial for designing targeted policies and interventions to enhance sustainable and efficient sugarcane production in India.

FURTHER SUGGESTIONS FOR RESEARCH:

Future research on growth and technical change in Indian sugarcane production using the Malmquist Productivity Index could expand the analysis in several directions to provide deeper insights. Extending the time horizon to include a longer panel of data would allow the study to capture structural changes associated with policy reforms, climate variability, and technological diffusion over

time. Incorporating district-level or farm-level panel data instead of aggregated state-level data would improve the precision of efficiency measurements and help identify micro-level determinants of productivity differences. Future studies could include additional inputs such as irrigation intensity, fertilizer consumption, mechanization, energy usage, capital investment, and seed quality to obtain a more comprehensive measurement of total factor productivity and reduce potential bias from omitted variables. Applying alternative model specifications, including variable returns to scale and output-oriented DEA models, would allow comparison of results and robustness checks for the Malmquist Productivity Index. Integrating stochastic frontier analysis with the Malmquist framework could help distinguish random shocks from inefficiency effects and improve the interpretation of productivity change. Decomposition of total factor productivity growth into pure technical change, scale efficiency change, and technological diffusion across regions would provide more detailed insights into the sources of productivity improvement. Inclusion of environmental variables such as rainfall variability, groundwater availability, soil health indicators, and climate change parameters could enable an assessment of sustainable productivity growth. Further research could also evaluate the impact of government policies, such as minimum support prices, irrigation schemes, mechanization subsidies, and ethanol blending policies, on productivity dynamics.

SCOPE AND LIMITATIONS

The scope of the study on growth and technical change in Indian sugarcane production using the Malmquist Productivity Index encompasses the measurement and analysis of total factor productivity (TFP) growth across major sugarcane-producing states of India over the period 2017–18 to 2021–22. The study focuses on state-level decision-making units and considers primary inputs such as land under sugarcane cultivation and labor employed in production, with output measured as total sugarcane production in million tonnes. The methodology allows decomposition of TFP change into technical efficiency change, pure efficiency change, scale efficiency change, and technological change, providing insights into whether productivity growth is driven by efficiency improvements or technological progress. The study also enables inter-state comparisons of productivity performance and highlights regional disparities in efficiency and technology adoption in sugarcane cultivation. The limitations of the study arise primarily from data availability and methodological constraints. The analysis is restricted to major sugarcane-producing states and does not include smaller producing regions, limiting the generalizability of the findings. Only selected inputs, primarily land and labor, are considered, while other factors such as irrigation intensity, fertilizer application, mechanization, energy use, capital investment, and seed quality are not explicitly included, which may underestimate total factor productivity. The DEA-Malmquist approach assumes accurate measurement of inputs and outputs and does not account for random shocks, measurement errors, or exogenous factors affecting production.

DISCUSSION:

The analysis of growth and technical change in Indian sugarcane production using the Malmquist Productivity Index (MPI) reveals significant variation in total factor productivity (TFP) across major sugarcane-producing states during the period 2017–18 to 2021–22. The overall geometric mean MPI for all states was 1.197, indicating a positive growth in TFP over the study period. Decomposition of the MPI shows that technological change was the primary contributor to productivity growth, with an average technical change of 1.201, while technical efficiency change was relatively stagnant at 0.996. This suggests that improvements in sugarcane production were largely driven by advancements in technology, such as adoption of high-yielding varieties, mechanization, and improved irrigation practices, rather than gains from more efficient use of inputs. The technical efficiency component indicates that most states were near the efficiency frontier but had limited scope for further improvements through input optimization. Scale efficiency and pure efficiency changes contributed marginally to overall TFP growth, confirming that productivity gains were largely attributable to technological advancement rather than operational improvements. Inter-state differences in

productivity growth can be associated with the varying levels of access to irrigation infrastructure, mechanization, adoption of improved sugarcane varieties, and extension services. States with higher productivity growth generally exhibited greater access to modern technologies and better farm management practices, whereas low-growth states faced constraints in technology adoption and resource utilization.

RECOMMENDATIONS

The findings of the Malmquist Productivity Index analysis of Indian sugarcane production indicate that total factor productivity growth is primarily driven by technological change rather than improvements in technical efficiency. To sustain and enhance productivity, states with lower TFP growth should focus on adopting and disseminating modern sugarcane cultivation technologies, including high-yielding and disease-resistant varieties, mechanization of farm operations, precision irrigation systems, and improved agronomic practices. Strengthening agricultural extension services and farmer training programs can enhance knowledge of efficient resource use, helping reduce efficiency gaps between high- and low-performing states. Investment in irrigation infrastructure, particularly in rainfed regions, is crucial to improve input use efficiency and stabilize yields. Policy interventions that provide targeted subsidies or incentives for mechanization, quality seeds, fertilizers, and water-saving technologies can support cost-effective cultivation and productivity gains. Encouraging cooperative farming, contract farming arrangements, and access to credit can help smallholders adopt modern technologies and achieve higher efficiency. Continuous monitoring of productivity using tools like the Malmquist Index can inform evidence-based policymaking and identify regions requiring technical or institutional support. Research and development should focus on adapting technologies to local agro-climatic conditions and replicating best practices across states with lower productivity growth. Integrating environmental considerations such as soil health, groundwater management, and climate resilience measures into productivity programs will ensure sustainable growth in sugarcane cultivation.

CONCLUSION:

The analysis of total factor productivity growth in Indian sugarcane production using the Malmquist Productivity Index indicates that overall productivity has increased across major sugarcane-producing states during 2017–18 to 2021–22, with a geometric mean MPI of 1.197. Decomposition of productivity change shows that technological progress is the primary driver of growth, with average technical change at 1.201, while technical efficiency improvements are limited, with an average efficiency change of 0.996. States such as Uttar Pradesh, Maharashtra, Gujarat, and Karnataka recorded higher productivity growth, reflecting greater adoption of modern cultivation practices, mechanization, and irrigation, whereas Andhra Pradesh, Punjab, Haryana, Tamil Nadu, and Uttarakhand exhibited comparatively low TFP growth, indicating uneven technology adoption and efficiency across regions. In conclusion, Indian sugarcane production has experienced positive total factor productivity growth during the study period, but this growth is uneven across states and predominantly driven by technological progress rather than efficiency gains. Sustained and inclusive productivity enhancement will require targeted interventions to improve technical efficiency, encourage adoption of modern technologies, strengthen extension services, and promote optimal resource use. The Malmquist Productivity Index provides a robust framework for monitoring and analyzing productivity dynamics, offering valuable insights for policymakers and stakeholders to support sustainable growth and competitiveness in Indian sugarcane cultivation.

REFERENCES:

1. Sanap, D.J., More, S.S., & Yadav, D.B. (2015). Total Factor Productivity Growth in Sugarcane Crop of Maharashtra State.
2. Mohd.Fateh, Taj, M., & Ansari, M.K. (2024). An Efficiency Analysis of Sugarcane Farming in India:

3. Bhopala, U.D., Dhandhalya, M.G., & Parmar, H.B. (2023). Total Factor Productivity Growth and Changing Cost
4. Arora, N. (2013). Does Catching-up or Innovations Drive Total Factor Productivity Growth in Indian Sugar Industry?
5. Gupta, S., & Badal, P.S. (2023). Trends in Total Factor Productivity of Sugarcane in Maharashtra:
6. Charnes, A., Cooper, W.W., & Rhodes, E. (1978). Measuring the Efficiency of Decision Making Units.
7. Banker, R.D., Charnes, A., & Cooper, W.W. (1984). Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis.