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Profitability Determinants and Operational Efficiency of Sugar Mills in Maharashtra

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Abstract

The sugar industry plays a vital role in India's rural economy, particularly in Maharashtra, one of the leading states in sugarcane production and processing. However, the financial sustainability of sugar mills has been increasingly challenged by fluctuating input costs, volatile market prices, and operational inefficiencies. This study investigates the determinants of profitability and assesses operational efficiency among cooperative sugar mills in Maharashtra through a panel data analysis. Using data spanning from 2006–07 to 2015–16, the study applies Panel Least Squares regression models to identify the key factors influencing profitability. Variables such as cane cost, conversion cost, capacity utilisation, and mill age are included in the econometric model to explain profitability variations across mills and over time. The results indicate that cane cost and conversion cost significantly affect profitability, with higher input costs having a negative impact. In contrast, higher capacity utilisation is positively associated with profitability, underscoring the importance of efficient resource use. The study also finds that older mills tend to demonstrate lower operational efficiency, suggesting a need for technological upgrading and modernisation. These findings enhance the understanding of structural challenges in the sugar sector and provide valuable insights for policymakers aiming to improve the sector's sustainability. Strengthening operational practices and encouraging

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investment in modern technologies are identified as critical strategies for ensuring the long-term viability of cooperative sugar mills in Maharashtra.

Keywords: Capacity utilisation, Cane cost, Conversion cost, Operational efficiency, Profitability, Sugar mills

1. Introduction

The sugar industry is a critical component of India's agro-based economy, contributing significantly to rural employment, income generation, and regional industrial development. Among Indian states, Maharashtra occupies a pivotal position in sugarcane production and processing, playing a vital role in the national sugar economy. However, despite its prominent position, the financial sustainability of sugar mills in the state has increasingly come under scrutiny due to a combination of fluctuating input costs, volatile sugar prices, ageing infrastructure, and structural inefficiencies.

Existing literature on the Indian sugar sector has primarily concentrated on production trends, pricing policies, and broader economic reforms. While studies have addressed aspects such as production functions and economies of scale, fewer have examined the specific financial performance drivers of cooperative sugar mills. This gap is noteworthy, especially given the cooperative sector's substantial role in Maharashtra's rural economy, both as a source of employment and a mechanism for community development.

Profitability in the sugar industry is shaped by several interrelated factors, including raw material costs (particularly cane cost), conversion costs, capacity utilisation, asset ageing, and technology adoption. These variables directly impact the financial outcomes of sugar mills and influence their capacity to remain viable amidst increasing competition and regulatory changes. Understanding these determinants is essential for shaping both industrial and rural development policies aimed at revitalising the cooperative sector.

Cooperative sugar mills occupy a unique institutional space in India. Beyond their economic role, they have historically contributed to social mobilisation, community ownership, and regional empowerment. In Maharashtra, cooperatives have supported a range of allied rural enterprises and helped shape the trajectory of regional development. However, the evolving economic landscape—marked by liberalisation, deregulation, and rising operational costs—has posed significant challenges to these traditionally resilient institutions.

The strategic relevance of cooperative mills now extends beyond sugar production. They are key stakeholders in renewable energy generation through bioethanol, an area of growing importance as India moves toward cleaner energy solutions. With ethanol now being blended into petrol across the country, the operational and financial health of sugar mills has broader implications for national energy security and sustainable rural livelihoods.

This study seeks to address the existing research gap by empirically examining the determinants of profitability in Maharashtra's cooperative sugar mills. Drawing on a panel dataset from 2006–07 to 2015–16, it employs econometric techniques to analyse the impact of key operational variables—such as cane cost, conversion cost, capacity utilisation, and mill age—on financial performance. By shifting the analytical lens from production outputs to financial sustainability, the study offers policy-relevant insights that can inform strategic interventions at both institutional and governmental levels.

2. Literature Review

Profitability in agro-industrial sectors such as the sugar industry is shaped by a complex interplay of operational, economic, and structural factors. Scholars have consistently emphasised the importance of efficient input management, technological modernisation, and capacity utilisation in sustaining financial performance. These factors are particularly significant in regions where agriculture-based industries form the backbone of the rural economy, as in the case of Maharashtra, a major hub of sugar production in India.

One of the central themes in the literature is the impact of **input costs**—especially sugarcane procurement and processing expenses—on profitability. Outlaw et al. (2007) examined the sugarcane-based ethanol sector in Texas, noting that profitability was highly sensitive to raw material availability and operational efficiency. Their findings suggest that resource optimisation, including consistent cane supply, is essential for financial sustainability. Ganeshgouda, Hugar, and Satishkumar (2016), in a comparative study of Indian sugar industries, found that cooperative mills suffered disproportionately from rising cane costs and under-utilisation of installed capacity. These conditions led to considerable declines in financial returns, indicating that cost structure and capacity management are fundamental determinants of economic viability.

The role of **technological advancement and energy efficiency** has also received considerable attention. Macedo, Seabra, and Silva (2008), in their analysis of the Brazilian sugarcane industry, observed that mills adopting advanced technologies and improving energy efficiency were better positioned to achieve stable operational margins. Their work underscores how outdated equipment and poor process integration can erode profitability. Similarly, Smeets et al. (2008) advocated for diversification—such as bioethanol and cogeneration—as key strategies for improving the long-term sustainability of sugar mills in developing countries. These studies converge on the conclusion that technological upgradation is not merely optional but essential for enhancing competitiveness in a volatile market environment.

In the **Indian context**, several studies have explored the challenges facing the cooperative sugar sector, with a focus on operational and financial inefficiencies. Patil and Naik (2018) analysed cooperative mills in Maharashtra and reported that inconsistent cane supply, escalating conversion costs, and inadequate financial planning significantly undermined profitability. They called for a comprehensive approach to resource management and suggested policy-level interventions to stabilise cane pricing and logistics. Bhavani and Reddy (2017)

also examined cooperative mills and argued that cost rationalisation and the modernisation of processes were critical to sustaining profitability amid fluctuating market prices and government controls. Their findings resonate with earlier studies by Kulkarni (2014), who highlighted the financial stress resulting from delayed payments to farmers and inefficient governance structures within cooperatives.

From a **methodological standpoint**, many of the aforementioned studies adopt either descriptive or cross-sectional approaches, limiting their ability to capture temporal variations in performance. While these works have been instrumental in identifying key variables that influence profitability, few have employed panel data techniques to systematically examine trends across time and institutions. For example, although studies by Ramesh and Joshi (2015) identified capacity utilisation as a major factor affecting sugar mill efficiency, their analysis did not explore the dynamic interplay between variables over multiple years. Similarly, research by Deshmukh et al. (2016) touched upon the financial constraints of mills but lacked a longitudinal perspective necessary to draw causal inferences.

In terms of **policy implications**, the literature increasingly supports the notion that addressing profitability challenges in the sugar industry requires more than short-term fixes. Recommendations include restructuring the pricing mechanism for cane, incentivising energy-efficient practices, and integrating value-added by-products such as ethanol and bagasse. The Government of India's ethanol blending programme, which mandates the mixing of bioethanol with petrol across the country, has created new opportunities for sugar mills. However, the ability of cooperative mills to capitalise on this policy depends on their financial health and operational readiness—issues that remain underexplored in empirical research.

Despite the depth of existing literature, there remains a relative paucity of studies that specifically focus on the **profitability determinants of cooperative sugar mills in Maharashtra** using robust, panel data methodologies. Most current analyses are either sector-

wide or limited to specific years, overlooking the cumulative and time-dependent nature of profitability drivers. Moreover, few studies explicitly examine the role of mill age in operational performance, an area increasingly relevant given the ageing infrastructure of many cooperatives.

Addressing these gaps, the present study adopts a **panel data framework** to assess how key factors—namely cane cost, conversion cost, capacity utilisation, and the age of mills—affect profitability across cooperative sugar mills in Maharashtra over a ten-year period. This approach allows for a more nuanced understanding of the temporal and structural challenges facing the sector. By providing empirical evidence grounded in regional realities, the study aims to contribute both to the academic literature and to policy discussions on revitalising cooperative sugar industries in India.

3. Methodology

3.1 Research Design

This study employs a quantitative research design, using econometric methods to investigate the factors influencing profitability among cooperative sugar mills in Maharashtra. The focus on quantifiable operational and financial variables makes this approach suitable for establishing statistically significant relationships. A panel data framework is adopted, as it allows for the observation of multiple entities (sugar mills) over a series of time periods (2006–07 to 2015–16). This structure helps capture both the cross-sectional (between mills) and time-series (over years) dynamics of profitability, improving the robustness and generalisability of the findings. Moreover, panel data techniques help control for unobserved heterogeneity, reducing omitted variable bias and enabling more accurate inference.

3.2 Data Source and Sample Selection

The study is based on secondary data collected from the annual reports published by the Vasantdada Sugar Institute (VSI), Pune, a recognised authority in the Indian sugar industry.

The sample comprises 71 cooperative sugar mills that were operational for the full duration of the study period (2006–07 to 2015–16), thereby forming a balanced panel dataset. Mills with missing values or inconsistent reporting were excluded to ensure the reliability of the dataset.

Each selected mill represents a unit of observation across ten time periods, resulting in a total of 710 observations (71 mills × 10 years). The inclusion of only continuously operating mills was necessary to ensure consistency and reduce the likelihood of structural breaks in data. Inflation-adjusted financial figures are used for all monetary variables, applying the Consumer Price Index (CPI) for agriculture to maintain intertemporal comparability.

3.3 Variables and Model Specification

The study models Profitability, measured by Profit Before Interest and Tax (PBIT), as the dependent variable. PBIT is selected because it captures core operational performance before financing decisions distort results.

The following independent variables are included in the model, based on theoretical rationale and findings from prior studies:

- Cane Cost (CC): This refers to the total expenditure on raw sugarcane procurement, which forms the bulk of operating costs. A higher cane cost typically reduces profit margins.
- Conversion Cost (CV): This includes expenses incurred in the manufacturing and refining process, excluding cane procurement. It reflects operational efficiency and cost control.
- Capacity Utilisation (CU): Defined as the percentage of actual sugarcane crushed relative to the installed crushing capacity. Efficient utilisation is expected to positively influence profitability by spreading fixed costs over greater output.

- Age of Mill (AGE): This variable represents the number of years since the mill was established. Older mills may face higher maintenance costs and lower energy efficiency, which can negatively impact financial performance.

The empirical model is specified as:

- The regression model is specified as

  $Y_{it}=\beta_0 + \beta_1 X_{1it}+\beta_2 X_{2i\,t} + \beta_3 X_{3it}+ \beta_4 X_{4it}+u_{it}$

- Where,
- Y = Profit/Loss
- X_1 = Cane Cost
- X_2 = Conversion Cost
- X_3 = Capacity Utilisation
- X_4 = Age of Mill
- u = stochastic disturbance term

3.4 Estimation Technique and Analytical Procedure

The model is estimated using Panel Least Squares (PLS) regression, applying both Fixed Effects (FE) and Random Effects (RE) specifications to evaluate the relationship between the selected variables and profitability.

To determine the appropriate model specification, the Hausman test is performed. The null hypothesis assumes that RE is appropriate (i.e., individual effects are uncorrelated with the regressors). Rejection of this hypothesis indicates the presence of correlation between individual effects and explanatory variables, thus favouring the FE model.

In this study, the Hausman test results lead to the rejection of the null hypothesis, indicating that the Fixed Effects Model is more appropriate. This finding suggests that time-invariant characteristics unique to each mill (e.g., location, management structure, historical governance) may influence profitability and must be controlled for. By accounting for these

fixed characteristics, the FE model provides unbiased and consistent estimates, thereby enhancing the internal validity of the findings.

All statistical computations and econometric estimations are conducted using EViews software, a widely recognised tool for time-series and panel data analysis. Diagnostic tests, including checks for multicollinearity, autocorrelation, and heteroskedasticity, are also performed to validate the reliability of the results. Where necessary, robust standard errors are used to correct for heteroskedasticity, ensuring accurate statistical inference.

3.5 Ethical Considerations

The study is based entirely on secondary data obtained from published institutional reports. As there is no direct involvement of human subjects, issues such as informed consent and personal data confidentiality do not arise. However, the research follows accepted academic standards for responsible use of data. The sources are properly cited, and no proprietary or sensitive information is disclosed. Ethical clearance was therefore not required for this study.

3.6 Justification for Methodology

The decision to adopt a panel data econometric approach is rooted in the nature of the research problem, which involves dynamic processes and long-term structural patterns. Compared to cross-sectional or time-series analyses alone, panel data provides a richer dataset with more degrees of freedom and reduced collinearity, improving estimation efficiency. Moreover, the fixed effects framework allows for controlling omitted variables that are constant over time but vary across mills—an essential requirement when dealing with socio-economic institutions like cooperatives.

4. Results

4.1 Regression Analysis Overview

To identify the key determinants of profitability among cooperative sugar mills in Maharashtra, a Panel Least Squares regression was conducted on a balanced panel dataset comprising 71 mills observed over 10 years (2006–07 to 2015–16), resulting in 710 observations. The analysis focused on evaluating the effect of four independent variables—Cane Cost, Conversion Cost, Capacity Utilisation, and Age of the Mill—on the dependent variable, Profitability, measured by Profit Before Interest and Tax (PBIT).

The Hausman test was employed to determine the appropriate model specification between Fixed Effects and Random Effects. The test indicated that the Fixed Effects Model (FEM) was more appropriate for this study, as it accounts for individual mill-specific characteristics that are constant over time but vary between units. This choice enhances the internal validity of the estimates by addressing unobserved heterogeneity across mills.

4.2 Regression Output

Table 1: Panel Least Squares Regression Results – Profitability Determinants

Variable	Coefficient	t-Statistic	Probability (p-value)
Cane Cost	-0.472	-5.12	0.0000
Conversion Cost	-0.238	-3.45	0.0010
Capacity Utilisation	0.315	4.28	0.0002
Age of Mill	-0.192	-2.87	0.0046
Constant (Intercept)	1.156	6.05	0.0000

(Dependent Variable: Profitability; Number of Observations: 710; $R^2 = 0.61$)

4.2 Interpretation of Results

The regression results reveal that all four independent variables have statistically significant effects on profitability at the 1% significance level. The model explains approximately 61% of the variation in profitability, as indicated by the R-squared value.

- Cane Cost shows a strong negative relationship with profitability. The coefficient of -0.472 suggests that for every unit increase in cane cost, profitability declines by 47.2%, holding other factors constant. The associated t-statistic (-5.12) and p-value (0.0000) confirm the statistical significance of this relationship.
- Conversion Cost also has a negative effect on profitability, with a coefficient of -0.238. This implies that higher operational costs in the sugar conversion process are associated with a 23.8% reduction in profitability. The t-statistic (-3.45) and p-value (0.0010) confirm the robustness of this effect.
- Capacity Utilisation is positively associated with profitability, as indicated by its coefficient of 0.315. The relatively high t-statistic (4.28) and low p-value (0.0002) suggest a strong and significant contribution of improved capacity use to better financial outcomes.
- Age of the Mill displays a negative relationship with profitability. The coefficient of -0.192 implies that older mills, potentially due to outdated machinery or inefficiencies, experience lower profitability. This result is statistically significant with a t-statistic of -2.87 and a p-value of 0.0046.
- The constant/intercept value of 1.156 reflects the expected baseline profitability when all independent variables are held at zero, and it is highly significant ($p = 0.0000$).

Overall, the regression model demonstrates that operational cost control, capacity optimisation, and infrastructure modernisation are empirically linked to profitability outcomes in Maharashtra’s cooperative sugar sector.

5. Discussion

This study identifies several key operational and structural factors that significantly affect the profitability of cooperative sugar mills in Maharashtra. The regression analysis revealed that cane cost, conversion cost, capacity utilisation, and the age of the mill are statistically significant determinants of financial performance. These findings hold important implications for operational policy, cooperative governance, and long-term sustainability of the sugar industry.

The negative association between cane cost and profitability reinforces the well-documented sensitivity of sugar mills to fluctuations in raw material pricing. As cane procurement constitutes a major portion of total production costs, any increase directly reduces margins. This finding aligns with prior studies (e.g., Ganeshgouda et al., 2016) that highlight procurement inefficiency as a key financial stressor. The result points to the urgent need for improved pricing mechanisms, supply chain coordination, and exploration of alternative or blended feedstocks to mitigate the risks associated with volatile cane prices.

The conversion cost, reflecting operational expenses excluding cane procurement, also exhibits a strong negative relationship with profitability. This result is consistent with existing literature that links high conversion costs to inefficiencies in energy use, outdated technology, and labour-intensive processes (Macedo et al., 2008). Many cooperative mills still operate under traditional process structures that lack automation or process integration. Investing in energy-efficient equipment, process control technologies, and workforce upskilling can help reduce operational costs and improve financial outcomes in the long term.

In contrast, capacity utilisation shows a positive and significant impact on profitability. This finding underscores the importance of operational discipline and production planning. Mills operating at or near optimal capacity are better able to spread fixed costs and achieve economies of scale. The result is in line with earlier observations by Patil and Naik (2018),

who stressed that underutilisation often stems from inconsistent cane supply or poor logistical planning. Strategic focus on maintenance scheduling, supply assurance contracts, and regional coordination of cane harvesting can help stabilise throughput and enhance capacity use.

The negative correlation between mill age and profitability highlights the structural challenges posed by ageing infrastructure. Older mills typically incur higher maintenance costs, face frequent breakdowns, and suffer from lower energy efficiency. This result corroborates findings from Bhavani and Reddy (2017), who advocated for phased modernisation supported by financial and technical assistance. Technology upgrading, supported through government-backed capital schemes or cooperative reinvestment plans, could address this persistent issue and enable mills to remain viable in a competitive environment.

Beyond operational aspects, the study points to a broader institutional challenge—the need to strengthen governance frameworks within cooperative sugar mills. Many cooperatives struggle with managerial inefficiencies, politicisation, and lack of transparency, all of which indirectly affect performance. The introduction of professionalised management, periodic audits, and cooperative member training can help ensure more effective decision-making. Balancing corporate best practices with cooperative values will be essential to fostering financial accountability and long-term success.

Furthermore, the study affirms the potential of strategic diversification to enhance profitability and resilience. Cooperative mills that expand into ethanol production, bagasse-based cogeneration, or biogas from press mud can generate additional revenue streams while contributing to national goals on clean energy and carbon reduction. The Indian government's aggressive ethanol blending targets (20% by 2025) open up opportunities for sugar mills to participate in the energy transition. Access to these alternative markets can also buffer cooperatives from price volatility in sugar and reduce overreliance on a single product line.

Limitations

This study, while comprehensive in scope and methodologically robust, has certain limitations. First, the analysis relies on secondary data, which may not capture nuanced operational practices or governance variables affecting mill performance. Second, although the panel covers ten years, it does not include the post-2016 period, during which several policy shifts—such as GST implementation and increased ethanol focus—have occurred. Finally, external market conditions, climate variability, and political influences were not included in the model but may have indirect effects on profitability.

Future Research Directions

Future studies could extend the dataset to more recent years and include private sugar mills to allow a comparative analysis of cooperative and corporate performance. Additionally, qualitative assessments involving interviews with cooperative leaders, farmers, and operational managers could offer deeper insights into internal decision-making and governance dynamics. Inclusion of environmental and policy variables may also improve the explanatory power of future models.

Broader Implications

The findings of this study have direct relevance for policymakers, cooperative leaders, and development agencies. Improving profitability in Maharashtra's cooperative sugar sector is not only a financial imperative but also a rural development priority, given the large number of farmers and workers dependent on the sector. A coordinated approach involving financial restructuring, capacity building, infrastructure investment, and policy support is essential to revitalise this historically significant industry.

6. Conclusion

This study examined the determinants of profitability in cooperative sugar mills in Maharashtra, drawing on a panel dataset covering a ten-year period. The analysis revealed that

both cane cost and conversion cost have significant negative effects on profitability, indicating that input and operational expenditures remain critical challenges for the sector. In contrast, capacity utilisation showed a strong positive association with profitability, while the age of mills negatively affected financial performance, suggesting the importance of infrastructure modernisation.

These findings underscore the need for cooperative mills to prioritise cost management and operational efficiency. Improvements in cane procurement processes, conversion cost control, and better use of installed capacity could substantially enhance financial resilience. The inverse relationship between mill age and profitability further highlights the pressing need for technological upgrades and asset renewal to improve performance and competitiveness.

From a policy standpoint, the results support the case for targeted assistance in the form of modernisation grants, energy-efficiency incentives, and financial management training. Strengthening governance frameworks through professionalisation and transparency can also play a key role in ensuring better outcomes.

Future research could expand on this analysis by comparing cooperative and private sugar mills, exploring policy impacts, or investigating the role of diversification into ethanol and other allied sectors. Ultimately, a focus on strategic cost control, asset modernisation, and enhanced capacity utilisation is essential for securing the long-term sustainability of Maharashtra's cooperative sugar industry.

Conflict of Interest: The corresponding author, on behalf of second author, confirms that there are no conflicts of interest to disclose.

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