

## CHAPTER 5

### CONCLUSIONS AND RECOMMENDATIONS

#### 5.1 Conclusion

Based on the results of the technical efficiency analysis using DEA-CCR, productivity change assessment through the Malmquist Productivity Index, and integration with the ESG framework, the following conclusions can be drawn:

1. The technical efficiency of Tjoekir Sugar Mill is high and relatively stable throughout the observation period. The DEA scores indicate that the mill consistently operates in close proximity to the efficient frontier, attaining full efficiency in several periods. This demonstrates that the combination of inputs sugarcane crushed and outputs refined crystal sugar, molasses, and bagasse has been managed optimally within the Constant Returns to Scale framework.
2. The company's productivity growth is technology-driven, with productivity change more substantially influenced by the technological change component than by efficiency change. This improvement did not originate from the acquisition of new machinery, but rather from the effectiveness of maintenance and overhaul of existing equipment reflecting the optimization of current assets rather than capital expansion.

3. Operational efficiency bears a directional relationship with environmental performance. Reductions in production losses move in tandem with improvements in technical efficiency scores, indicating that production process optimization not only enhances output but simultaneously reduces waste and improves resource utilization.
4. The company's operational sustainability is underpinned by human resource competence and data-driven governance. The stability of efficiency change reflects management's capacity to sustain operational performance despite fluctuations in production volume. Nevertheless, slack analysis reveals that room for improvement remains, achievable through more systematic data-based evaluation.
5. Overall, the efficiency achievements and productivity growth of Tjoekir Sugar Mill demonstrate that performance improvement does not rest solely on new asset expansion, but on operational resilience built through disciplined maintenance, technical workforce competence, and the implementation of accountable and measurable governance practices.

## **5.2 Recommendations**

Based on the findings of this study, the following recommendations are proposed:

1. The results of the DEA and Malmquist Productivity Index analyses should be institutionalized as routine post-milling season evaluation instruments to enable the continuous monitoring of efficiency and productivity change on a systematic basis.

2. Preventive and predictive maintenance systems should be strengthened to sustain the stability of technological performance and minimize the risk of productivity deterioration across milling seasons.
3. Loss indicators and by-product utilization metrics should be integrated as part of ESG-based Key Performance Indicators (KPIs) within the company's annual performance reporting framework.
4. The standardization of overhaul procedures and operational best practices across sugar mills within the same holding company should be actively pursued as a form of internal benchmarking, enabling the transfer of efficiency gains across units.
5. Given that the research findings indicate productivity improvement is predominantly driven by the optimization of existing technology, large-scale revitalization through comprehensive asset replacement does not constitute an immediate necessity. Nevertheless, phased revitalization of specific process units that continue to exhibit slack potential warrants consideration as a means of enhancing long-term efficiency.
6. Future research should explore complementary methodological approaches — such as the DEA-BCC model or Stochastic Frontier Analysis (SFA) — to allow efficiency analysis to account for Variable Returns to Scale assumptions and to disentangle the effects of genuine inefficiency from random disturbances. Additionally, the incorporation of more quantitatively rigorous ESG indicators is recommended, so as to provide a more

comprehensive picture of the relationship between operational performance, production efficiency, and corporate sustainability.

This study makes a practical contribution to the management of the sugar industry by providing a foundation for formulating productivity improvement strategies that are aligned with sustainability principles and grounded in the optimization of existing assets.