

**ANALYZING SUSTAINABLE PRODUCTIVITY AND EFFICIENCY AT  
THE TJOEKIR SUGAR FACTORY OF PT SINERGI GULA NUSANTARA  
USING DATA ENVELOPMENT ANALYSIS AND THE  
MALMQUIST PRODUCTIVITY INDEX**

**UNDERGRADUATE THESIS**



**Submitted by:**

**ALYA NUR AZIZAH**

**21012010221/FEB/EM**

**FACULTY OF ECONOMIC AND BUSINESS  
UNIVERSITAS PEMBANGUNAN NASIONAL "VETERAN"  
JAWA TIMUR**

**2026**

**ANALYZING SUSTAINABLE PRODUCTIVITY AND EFFICIENCY AT  
THE TJOEKIR SUGAR FACTORY OF PT SINERGI GULA NUSANTARA  
USING DATA ENVELOPMENT ANALYSIS AND THE  
MALMQUIST PRODUCTIVITY INDEX**

**UNDERGRADUATE THESIS**

**Submitted in Partial Fulfill Part of the Requirements  
For the Degree of Bachelor of Management  
Study Program in Management**



**Submitted by:**

**ALYA NUR AZIZAH**

**21012010221/FEB/EM**

**FACULTY OF ECONOMIC AND BUSINESS  
UNIVERSITAS PEMBANGUNAN NASIONAL "VETERAN"  
JAWA TIMUR**

**2026**

**UNDERGRADUATE THESIS**

**ANALYZING SUSTAINABLE PRODUCTIVITY AND EFFICIENCY AT THE  
TJOEKIR SUGAR FACTORY OF PT SINERGI GULA NUSANTARA  
USING DATA ENVELOPMENT ANALYSIS AND THE  
MALMQUIST PRODUCTIVITY INDEX**

**Submitted by:**

**ALYA NUR AZIZAH**  
**21012010221/FEB/EM**

**Has Been Defended and Accepted  
by The Board of Examiners of The Management Study Program  
Faculty of Economics and Business  
Universitas Pembangunan Nasional "Veteran" Jawa Timur  
on: May 25, 2026**

**Thesis Supervisor**

**Examination Committee  
Chair**

  
**Prof. Dr. Wiwik Handayani, S.E., M.Si**  
**NIP. 196901132021212003**

  
**Dra. Ec. Kustini, M.Si, CHRA**  
**NIP. 196304291991032001**

**Member**

  
**Drs. Ec. Hery Pudjoprastvono, M.M.**  
**NIP. 196203181988031002**

**Acknowledged by:**

**Dean of the Faculty of Economics and Business  
Universitas Pembangunan Nasional Veteran Jawa Timur**

  
**Dr. Dra. Tri Kartika Pertiwi, M.M., CRP.**  
**NIP. 196304201991032001**

## STATEMENT OF ORIGINALITY

The undersigned individual hereby provides the following declaration:

Name : ALYA NUR AZIZAH  
NPM : 21012010221  
Program : Bachelor Degree (S1)  
Study Program : Management  
Faculty : Economics and Business

I hereby declare that there is no part of this Thesis academic document that has been submitted previously to obtain an academic degree at any institution of higher education. Furthermore, there is no work or opinion that has been written or published by another person or institution, except where it is explicitly cited in writing within this document and properly listed in the references.

I also declare that this academic document is free from any elements of plagiarism. Should there be any indication of plagiarism found in this Thesis in the future, I am willing to accept any sanctions in accordance with the prevailing laws and regulations.

I make this statement truthfully, without any coercion from any party, and for it to be used as necessary.

Surabaya, May 22 2026

Statement made by



**Alya Nur Azizah**  
NPM.21012010221

## ACKNOWLEDGEMENTS

All praise and gratitude are due to Allah SWT, whose boundless mercy and guidance have enabled the author to complete this undergraduate thesis entitled *"Analyzing Sustainable Productivity and Efficiency at the Tjoekir Sugar Factory of PT Sinergi Gula Nusantara using Data Envelopment Analysis and the Malmquist Productivity Index,"* submitted in partial fulfillment of the requirements for a Bachelor's degree in Management, Faculty of Economics and Business, Universitas Pembangunan Nasional "Veteran" Jawa Timur. Throughout this journey, the author faced various challenges and moments of doubt, yet through Allah's grace and the support of many wonderful individuals, this work was brought to completion. The author would therefore like to sincerely express the deepest gratitude to the following parties:

1. Prof. Dr. Ir. Akhmad Fauzi, MMT., IPU as Rector of the Universitas Pembangunan Nasional "Veteran" Jawa Timur
2. Dr. Dra. Ec. Tri Kartika Pertiwi, M.Si., CRP as Dean of the Faculty of Economics and Business Universitas Pembangunan Nasional "Veteran" Jawa Timur.
3. Dr. Drs. Ec. Muhadjir Anwar, M.M., Head of the Management Study Program, for his guidance and commitment to academic excellence
4. Prof. Dr. Wiwik Handayani, S.E., M.Si. as Coordinator of the Management Study Program Universitas Pembangunan Nasional

“Veteran” Jawa Timur and as my thesis advisor in completing this undergraduate thesis research.

5. Herry Pudjoprastyono, S.E., M.M., as the author's academic advisor, who has consistently provided guidance, assistance, and support in navigating all academic matters throughout the author's studies.
6. Muhammad Ahmi Husein, S.Si., M.Sc. and Wilma Cordelia Izaak, S.E., M.M., as lecturers and mentors who have generously shared their invaluable knowledge, advice, and insights, and whose support has greatly contributed to the author's academic and personal achievements.
7. The lecturers who served as examiners and provided constructive criticism and suggestions for the improvement of this research.
8. The author's beloved mother, father, sisters and extended family whose endless prayers, sacrifices, and unconditional love have been the greatest source of strength throughout this journey. In every moment of doubt, you were there — believing when the author could not. No words could ever fully repay what you have given, but know that every step taken was made possible because of you.
9. The author's dearest friends, Asih Saputri, Zumrotul Rosyidah, Lailatul Munawaroh, Elisa Salsabilah, Indri Oktafia, and Amalia Eka — who have been a constant and genuine presence throughout the struggles of completing this thesis. Your companionship, solidarity, and support meant more than you know.

10. The author's boarding house companions, Arek Kos Belajar (Neza, Diva, Elina, Sabrina, and others) who have shared the same roof and the same struggles throughout these college years. Thank you for the laughter, the togetherness, and the prayers that kept this journey warm and meaningful.
11. The author's cherished friends, Bro is Speaking (Ary and Dandung), whose presence and support have been felt across every chapter of this journey, be it in academics, competitions, or personal growth. May we each find our own success, and may our paths continue to cross in the years to come.

The author also extends sincere gratitude to all those who cannot be named individually, yet have offered their prayers, encouragement, and kindness throughout this journey your support is deeply felt and appreciated. The author acknowledges that this thesis is far from perfect and undoubtedly carries certain limitations. As such, any constructive criticism and suggestions toward the betterment of this research are warmly welcomed. It is the author's sincerest hope that this work may prove useful and meaningful, particularly for fellow students at UPN "Veteran" Jawa Timur.

Surabaya, 22 May 2026

Author

## TABLE OF CONTENT

<b>ACKNOWLEDGEMENTS</b> .....	i
<b>TABLE OF CONTENT</b> .....	iv
<b>LIST OF FIGURES</b> .....	vi
<b>LIST OF TABLES</b> .....	vii
<b>LIST OF APPENDIX</b> .....	viii
<b>ABSTRACT</b> .....	ix
<b>CHAPTER 1 INTRODUCTION</b> .....	1
1.1 Research Background.....	1
1.2 Problem Statement .....	7
1.3 Research Objective.....	8
1.4 Benefits of the Study .....	8
<b>CHAPTER 2 LITERATURE REVIEW</b> .....	10
2.1 Prior Research .....	10
2.2 Theoretical Framework .....	13
2.2.1 The Concept and Cycle of Productivity.....	13
2.2.2 The Concept of Efficiency .....	16
2.2.3 Operational Management of the Sugar Industry.....	19
2.2.4 <i>Data Envelopment Analysis (DEA) – CCR Model</i> .....	21
2.2.5 <i>Malmquist Productivity Index (MPI)</i> .....	23
2.2.6 Sustainability and ESG in the Manufacturing Industry .....	25
2.3 Conceptual Framework .....	28
<b>CHAPTER 3 RESEARCH METHOD</b> .....	29
3.1 Operational Definitions and Variable Measurement.....	29
3.2 Research Subject .....	33
3.3 Research Object.....	34
3.4 Data Collection Techniques .....	34
3.5 Data Analysis Techniques .....	36
<b>CHAPTER 4 RESULT AND DISCUSSION</b> .....	44
4.1 Research Object Description .....	44
4.1.2 Vision and Mission .....	46

4.2 Data Collection.....	48
4.2.1 Identification of Research Variables.....	48
4.2.2 Descriptive Statistics and Data Pre-processing .....	52
4.3 Technical Efficiency Analysis (Data Envelopment Analysis – CCR) .....	56
4.3.1 Annual Efficiency Scores Based on the Output-Oriented DEA-CCR Model.....	56
4.3.2 Efficiency Target Analysis and Slack Variables .....	59
4.3.3 Decision-Making Unit (DMU) Grouping Based on Efficiency Level .	62
4.4 Productivity Change Analysis (Malmquist Productivity Index) .....	65
4.4.1 Total Factor Productivity Index (TFPCH).....	65
4.4.2 Index Decomposition (Efficiency Change vs Technological Change).	69
4.5 Integration of the ESG Framework in Sustainable Productivity .....	73
4.5.1 Environmental Pillar (E) — Resource Efficiency and Waste Management .....	73
4.5.2 Social Pillar (S) — Quality of the Work Environment and Human Resources.....	75
4.5.3 Governance Pillar (G) — Transparency and Target Achievement.....	78
4.6 Discussion .....	80
<b>CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS .....</b>	<b>85</b>
5.1 Conclusion.....	85
5.2 Recommendations .....	86
<b>REFERENCES .....</b>	<b>89</b>
<b>APPENDIX .....</b>	<b>95</b>

## LIST OF FIGURES

Figure 1. 1 Sugar Import History 2015–2024 .....	1
Figure 1. 2 Comparison of Indonesia’s Sugar Production and Consumption.....	2
Figure 4. 1 Organizational Structure of PG Tjoekir.....	48
Figure 4. 2 Graph of Technical Efficiency Trend of Tjoekir Sugar Factory .....	58
Figure 4. 3 Conceptual Visualization of Frontier Line .....	65
Figure 4. 4 Malmquist Index Trend Graph (TFPCH, EFFCH, TECHCH) PG Tjoekir 2021–2025 .....	68
Figure 4. 5 Comparison of Efficiency Change and Technological Change PG Tjoekir 2021–2025 .....	72
Figure 4. 6 Trend Graph of the Relationship between DEA Efficiency Score and Residual Sugar (Losses) in 2021–2025 .....	73
Figure 4. 7 Relationship between Operational Expenses (Milled Sugar Cane) and Efficiency Change (EFFCH) 2021–2025 .....	76
Figure 4. 8 Alignment of DEA Efficiency Score with Realization of RKAP Targets for 2021–2025 .....	79

## LIST OF TABLES

Table 1. 1 Output and Milling Period of PG Tjoekir over the Last 5 Years .....	4
Table 3. 1 Productivity Measurement Indicators for Tjoekir Sugar Mill .....	30
Table 3. 2 Input and Output Variables for Technical Efficiency Analysis at Tjoekir Sugar Mill .....	32
Table 3. 3 Sustainability and ESG Indicators for Tjoekir Sugar Mill.....	33
Table 4. 1 Summary of ESG-Based DEA-MPI Research Variables .....	52
Table 4. 2 Descriptive Statistics of Research Variables (2021–2025).....	53
Table 4. 3 Summary of Technical Efficiency Scores for Tjoekir Sugar Mill Based on the Output-Oriented DEA-CCR Model (2021–2025) .....	57
Table 4. 4 Efficiency Target Projections and Slack Values for Inefficient DMUs Based on the Output-Oriented DEA-CCR Model .....	60
Table 4. 5 DMU Performance Classification for Tjoekir Sugar Mill Based on DEA-CCR Technical Efficiency Scores (2021–2025).....	63
Table 4. 6 Malmquist Productivity Index for Tjoekir Sugar Mill, Period 2021– 2025 .....	66
Table 4. 7 Malmquist Component Decomposition for Tjoekir Sugar Mill, Period 2021–2025 .....	69

## **LIST OF APPENDIX**

Appendix 1 Annual Data Summary for the Period 2021–2025 .....	95
Appendix 2 Data Processing Program Code .....	97
Appendix 3 Interview Transcript .....	108
Appendix 4 Research Permission Letter .....	113
Appendix 5 Documentation .....	114

**ANALYZING SUSTAINABLE PRODUCTIVITY AND EFFICIENCY AT  
THE TJOEKIR SUGAR FACTORY OF PT SINERGI GULA NUSANTARA  
USING DATA ENVELOPMENT ANALYSIS AND THE  
MALMQUIST PRODUCTIVITY INDEX**

**By:**

**ALYA NUR AZIZAH**  
**21012010221/EM/FEB**

**ABSTRACT**

Indonesia's sugar industry confronts a persistently widening gap between domestic production and consumption. The operational management of sugar mills, which continues to rely heavily on aging capital assets, has been widely identified as a primary contributor to chronically low levels of technical efficiency and productivity. This study aims to analyze the technical efficiency and sustainable productivity dynamics of PT Sinergi Gula Nusantara's Tjoekir Sugar Mill for the period 2021–2025, while simultaneously examining the relationship between operational performance and the implementation of Environmental, Social, and Governance (ESG) principles within the company's operations.

To achieve these objectives, the study employs a quantitative descriptive approach, integrating two complementary methodologies: the output-oriented CCR model of Data Envelopment Analysis (DEA) and the Malmquist Productivity Index (MPI). Data were obtained from the historical operational records of Tjoekir Sugar Mill and supplemented by structured interviews conducted with the Quality Assurance Department. All data processing and computational analyses were performed using the Python programming language within the Google Colab environment.

The findings demonstrate that Tjoekir Sugar Mill achieved full technical efficiency ( $\theta = 1.000$ ) in both 2023 and 2025, whereas 2024 recorded the lowest efficiency score ( $\theta = 0.942$ ), indicating an output improvement potential of 5.8%. Aggregate productivity growth of 2.2% over the study period was predominantly attributable to Technological Change rather than Efficiency Change, providing empirical evidence that asset optimization through systematic maintenance and overhaul constitutes a more decisive driver of productivity enhancement than the acquisition of new machinery per se. Furthermore, these findings indicate that operational efficiency is closely aligned with ESG principles, as reflected in minimized production losses, the utilization of bagasse and molasses as manifestations of a circular economy framework, and the adoption of data-driven governance characterized by transparency and accountability.

**Keywords:** Data Envelopment Analysis; Technical Efficiency; Malmquist Productivity Index; Sustainable Productivity; Environmental, Social, and Governance (ESG)