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INVESTMENT ANALYSIS OF GROOVE ROLLER PRESSURE FEEDER TO IMPROVE PRODUCTION COST EFFICIENCY: A CASE STUDY OF PG TRANGKIL SUGAR FACTORY

Mujianto[1*)], Indarto[2)], Rohmini Indah Lestari[3)]
Universitas Semarang
muji.kba@gmail.com[1], indarto@usm.ac.id[2], rohmini@usm.ac.id[3]

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Abstract

This study aims to analyze the financial feasibility and operational impact of investment in a Groove Roller Pressure Feeder (GRPF) at PG Trangkil, a private sugar factory in Central Java, Indonesia, as an effort to increase milling efficiency and reduce production costs amid intensifying competition from newly built, higher-efficiency sugar mills. A mixed-method case study design was employed, combining qualitative data from in-depth interviews, non-participant observation, and company archives with quantitative capital budgeting analysis (NPV, IRR, Profitability Index, Payback Period, and ROI). Key informants were the factory manager and heads of the technical, finance-administration, and manufacturing divisions, selected purposively. Results show that the GRPF investment, valued at IDR 25 billion, generated an NPV of IDR 876,997,000, an IRR of 11.19 percent, a Profitability Index of 1.04, and a payback period of 4.21 years, and is therefore financially feasible. Operationally, GRPF raised mill extraction and reduced sucrose loss in bagasse, lifting sugar sales revenue by 111.16 percent and net profit by 22.59 percent, although rising raw-material costs compressed gross and net profit margins. The findings extend a mini-theory linking integrated investment planning to milling efficiency and financial performance in the private sugar industry.

ANALISIS INVESTASI GROOVE ROLLER PRESSURE FEEDER UNTUK MENINGKATKAN EFISIENSI BIAYA PRODUKSI (STUDI KASUS PABRIK GULA TRANGKIL)

Keywords:
efisiensi biaya produksi; efisiensi gilingan; groove roller pressure feeder; kelayakan investasi; penganggaran modal

Abstrak

Penelitian ini bertujuan menganalisis kelayakan finansial dan dampak operasional investasi Groove Roller Pressure Feeder (GRPF) di Pabrik Gula Trangkil, sebuah pabrik gula swasta di Jawa Tengah, sebagai upaya meningkatkan efisiensi gilingan dan menekan biaya produksi di tengah ketatnya persaingan dengan pabrik gula baru yang memiliki efisiensi lebih tinggi. Penelitian menggunakan desain studi kasus dengan pendekatan campuran (mixed method), memadukan data kualitatif dari wawancara mendalam, observasi nonpartisipan, dan arsip perusahaan dengan analisis penganggaran modal kuantitatif (NPV, IRR, Profitability Index, Payback Period, dan ROI). Informan kunci dipilih secara purposive, meliputi pemimpin pabrik serta kepala bagian teknik, tata usaha keuangan, dan pabrikasi. Hasil penelitian menunjukkan bahwa investasi GRPF senilai Rp25 miliar menghasilkan NPV sebesar Rp876.997.000, IRR 11,19 persen, Profitability Index 1,04, dan payback period 4,21 tahun, sehingga dinyatakan layak secara finansial. Secara operasional, GRPF meningkatkan mill extraction dan menurunkan kehilangan gula pada ampas, mendorong pendapatan penjualan gula naik 111,16 persen dan laba bersih naik 22,59 persen, meskipun kenaikan biaya bahan baku menekan margin laba kotor dan bersih. Temuan penelitian ini menghasilkan teori mini

✉ Correspondence email address: * muji.kba@gmail.com

INTRODUCTION

Competition among sugar mills in Indonesia has intensified sharply since 2021–2023, when five new mills began commercial operation: PT Rejoso Manis Indo in Blitar Regency, PT Kebun Tebu Mas in Lamongan, PT Pratama Nusantara Sakti in Ogan Komering Ilir Regency, PT Muria Sumba Manis in East Sumba Regency, and PT Prima Alam Gemilang in Bombana Regency (detik.com; home.rejosomanisindo.com). These new mills employ modern milling technology and achieve very high extraction efficiency; the milling station of PT Rejoso Manis Indo, for example, extracts cane juice so thoroughly that the residual sugar content of the bagasse (Pol Ampas) is kept below 1 percent. In response, established mills have accelerated their own revitalization efforts, a policy direction the Indonesian government also supports to secure domestic consumption-sugar supply, allocating IDR 3.5 trillion in state capital participation to state-owned mills PTPN IX, X, and XI (puskajianggaran.dpr.go.id). Privately owned mills, by contrast, must finance their own efficiency upgrades. PG Trangkil, one such private mill located in Pati Regency, Central Java, under the PT Kebonagung Surabaya group, exemplifies this challenge.

PG Trangkil's milling-station performance over 2020–2024, measured through Mill Extraction (HPG) and residual sugar in bagasse (Pol Ampas), is summarized in Table 1.

Table 1
Milling Station Performance Indicators, 2020–2024

Year	HPG (Mill Extraction)	Pol Ampas
2020	91.88%	2.39%
2021	92.42%	2.18%
2022	92.32%	2.10%
2023	92.23%	2.33%
2024	91.84%	2.69%

Source: PG Trangkil daily operational reports (processed, 2025)

HPG, commonly called Mill Extraction, is the percentage of sucrose successfully extracted from cane during milling, measured as the sucrose obtained in the juice relative to total sucrose contained in the cane. Pol Ampas is the residual sucrose left in the bagasse after extraction, reflecting mechanical sugar loss because not all sucrose is separated during milling (Muhammadi & Wycliffe, 2025). Table 1 shows there is still room to improve PG Trangkil's milling-station performance: in 2024 its Pol Ampas stood at 2.69 percent, well above the sub-1-percent level already achieved by PT Rejoso Manis Indo. This gap indicates that PG Trangkil's milling efficiency is not yet optimal and that investment in equipment renewal could raise station performance. A difference of just 0.1 percentage point in Pol Ampas is estimated to be worth IDR 5–6 billion per milling season, depending on sugar price, cane volume, and recovery rate, and it directly affects production cost efficiency.

Because such investment requires substantial capital and a long payback horizon, a feasibility study is essential before commitment, typically evaluated through Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period, and Profitability Index (PI), which together give management a comprehensive view of financial feasibility to support sound decisions aimed at lowering operating expenditure (Hendra et al., 2024). Salsabilla and Marliana (2024) analyzed the feasibility of adding heavy equipment using a descriptive quantitative approach based on capital budgeting calculations and found the investment feasible and profitable, evidenced by a positive NPV, an IRR above the discount rate, a fast payback period, and a benefit-cost ratio above one. (Muhtazib Muhtazib & Muhamad Rifaldi, 2023) similarly evaluated the feasibility of heavy-equipment rental investment through descriptive quantitative analysis of cost, revenue, and cash-flow data and concluded the investment was worth pursuing. (Ridwan et al., 2022) assessed the feasibility of replacing a secondary crusher at PT Berau Coal Site Binungan quantitatively and descriptively from an economic-technical perspective, using NPV, IRR, Payback Period, and Profitability Index as decision parameters.

These prior studies rely solely on financial-feasibility indicators and, viewed through a machine-efficiency lens, do not show whether efficiency actually rose or fell after the investment was realized. This study addresses that gap by combining a financial-feasibility approach with an assessment of machine performance/efficiency following investment, examining the funding system applied, the cost-benefit profile of the investment, its impact on cost efficiency and revenue, and the factors that support or hinder implementation. Building on this framework, the present study is explicitly structured to capture both the pre-investment and post-investment dimensions of the GRPF investment at Trangkil Sugar Mill (PG Trangkil). Accordingly, this research aims to (1) analyze the investment funding system applied in the installation of the Groove Roller Pressure Feeder (GRPF) at PG Trangkil, including its funding sources and decision-making mechanism; (2) evaluate the costs and benefits of the GRPF

investment, covering both the investment cost and the economic and operational benefits generated; (3) analyze the impact of GRPF implementation on operational efficiency and company profit performance; and (4) identify the factors that support and hinder GRPF implementation in improving efficiency at PG Trangkil.

Literature Review

The theoretical foundation of this study rests on capital budgeting theory. According to Brigham and Houston (2019), capital budgeting is the process of planning, evaluating, and selecting long-term investment projects using discounted cash flow approaches such as Net Present Value (NPV) and Internal Rate of Return (IRR), with the ultimate goal of maximizing firm value. A project is deemed feasible when the present value of its future cash flows exceeds its initial investment cost. Brigham and Houston further emphasize that the firm's Weighted Average Cost of Capital (WACC) functions as the hurdle rate in this process — a project is only accepted if its expected return exceeds the cost of capital required by investors, meaning capital budgeting decisions weigh not only expected cash flow but also project risk.

Building on this, the study draws on feasibility-study theory to evaluate the GRPF investment using four standard indicators: NPV, IRR, Payback Period (PP), and Profitability Index (PI). This is consistent with the criteria PG Trangkil's management itself applies internally (NPV positive, IRR above the company's threshold, and payback within five years), linking the academic framework directly to the company's actual investment governance practice.

The study also incorporates machine-efficiency theory. Heizer et al. (2020) note that machine efficiency has a direct relationship with operating cost and output level: efficient machines minimize energy consumption, reduce downtime, and lower maintenance and part-replacement costs, so that even a small percentage gain in efficiency can yield significant cost savings as fixed cost per unit falls with increased effective capacity. Hector and Panjanathan (2024) add that modern productivity gains increasingly depend on new machine technology — including IoT-based sensors and predictive maintenance — that enables real-time monitoring and process optimization, which is directly relevant to GRPF's individual drive and monitoring-based design.

Finally, the study anchors its efficiency measures in sugar-industry-specific theory. Jacobs and Chase (2015) define efficiency simply as achieving output at the lowest possible cost, while Farrell (1957) distinguishes technical efficiency (producing on the production-possibility frontier) from allocative efficiency (minimizing cost for a given output), the combination of which constitutes economic efficiency. Within the milling station specifically, this study operationalizes efficiency through two established indicators : HPG (Hasil Pemerahan Gilingan / Mill Extraction), the ratio of sucrose recovered in raw juice to total sucrose available in the cane, and Pol Ampas, the

residual sugar content left in bagasse after extraction — the lower this figure, the higher the milling efficiency (Muhammadi & Wycliffe, 2025).

Previous Studies

Study	Title/Focus	Method	Key Finding
Hendra et al. (2024)	Feasibility of a Truck Mounted Crane investment (10-ton capacity)	Quantitative, capital budgeting (NPV, IRR, PP, PI)	Investment feasible: NPV Rp2.093 billion, IRR 23.61% (> discount rate 11.03%), PP 4.07 years (< 10-year project life), PI 1.65
Salsabilla & Marliana (2024)	Feasibility of heavy-equipment addition (financial aspect)	Quantitative, capital budgeting with cash flow as core variable (NPV, IRR, PP, PI)	Addition of one excavator unit judged highly feasible
Ridwan et al. (2022)	Feasibility of Secondary Crusher replacement project, PT Berau Coal	Descriptive quantitative, technical/economic analysis, capital budgeting	Replacement project economically feasible; all capital-budgeting indicators (NPV, IRR, PP, PI) met feasibility criteria and returned benefit before the company's operating-permit deadline
Witari et al. (2021)	Feasibility study of a 100,000 ton/year sugar refinery	Technical and economic analysis	Plant judged technically and economically feasible; IRR, POT (Payback), and BEP all showed strong results
Muhtazib & Rifaldi (2023)	Feasibility of heavy-equipment leasing, PT Tri Daya Jaya Makassar	Descriptive quantitative, Business Feasibility Study approach (NPV, PP, PI, IRR)	Investment judged feasible; all indicators met feasibility criteria

Research gap. All five prior studies evaluate investment feasibility purely from a financial capital-budgeting standpoint (NPV/IRR/PP/PI), applied to heavy equipment, mining, and general manufacturing contexts. None of them evaluate feasibility from an efficiency standpoint — even though efficiency gains inherently translate into cost savings and additional revenue. None, moreover, is set in the sugar-milling context or examines a feeding/extraction technology such as GRPF. This is precisely the gap this study addresses: it combines the established financial-feasibility approach with a technical efficiency assessment (HPG, Pol Ampas, machine performance) following investment, in the specific setting of a sugar mill's milling station.

METHOD

This study applies a mixed-method case study design, combining quantitative and qualitative approaches. The qualitative dimension was chosen because the feasibility of GRPF investment within a framework of technical efficiency and financial performance cannot be explained fully through numerical data alone, while the case-study design was chosen because the research focuses on a single object—PG Trangkil—examined holistically, contextually, and empirically to capture the investment decision-making process, technical implementation in the field, and the resulting efficiency impact.

The research setting is PG Trangkil, located in Trangkil Village, Pati Regency, Central Java Province, with data collection concentrated on the operational areas directly related to the object of study: the milling station, the technical division, the finance-administration and general affairs division, and the manufacturing division. Fieldwork was conducted during an active milling season and after GRPF installation, enabling direct observation of changes in performance, efficiency, and machine operation.

Informants were selected using purposive sampling based on direct involvement in GRPF planning and investment decision-making, understanding of the milling station's technical and operational aspects, and knowledge of the investment's impact on financial performance. The informants comprised the factory manager, the head of the technical division, the head of the finance-administration and general affairs division, and the head of the manufacturing division.

Following the principle of data triangulation in qualitative research (Robert K. Yin, 2003), data were collected through in-depth, semi-structured interviews using a prepared guide while allowing informants latitude to elaborate; through non-participant observation of milling-station operations, GRPF functioning, and pre- versus post-installation extraction performance; and through secondary data/archives comprising milling-performance reports, investment and operating-cost reports, company financial statements, and technical SOPs. Audio and video recording devices were used with informants' consent during interviews. Data credibility was strengthened through source, technique, and time triangulation (Prof. Dr. Sugiyono, 2017): comparing information across the technical, manufacturing, and finance divisions; cross-checking interview data against observation and documentary evidence; and re-verifying data collected at different times to ensure stability and consistency of findings.

Qualitative data were analyzed interactively through data reduction, data display, and conclusion drawing/verification (Matthew B. Miles & A. Michael Huberman, 1994). Data reduction focused, simplified, and abstracted raw field data relevant to the research questions; data display organized the reduced data by theme into

sub-topics for ease of interpretation; and verification drew conclusions that, when consistently supported by valid evidence upon re-checking, were regarded as credible, ultimately synthesized into propositions and a mini-theory. In parallel, investment feasibility was evaluated using discounted cash-flow methods. Payback Period (PP) measures the time needed for the initial investment to be recovered from annual net cash flow. Net Present Value (NPV) is computed by discounting all projected net cash flows over the project's economic life at the required rate of return and subtracting the initial investment (Hasan et al., 2022); a project is feasible when NPV > 0. Internal Rate of Return (IRR) is the discount rate at which NPV equals zero (Van Horne & Wachowicz, 2008), and a project is feasible when IRR exceeds the cost of capital. Profitability Index (PI) is the ratio of the present value of cash inflows to the initial investment, with PI > 1.00 indicating feasibility, and Return on Investment (ROI) is net profit expressed as a percentage of investment cost.

RESULTS AND DISCUSSION

Results

Funding System

GRPF's funding process at PG Trangkil follows an Integrated Investment Planning mechanism that coordinates technical, financial, operational, and strategic considerations, beginning with needs identification, proceeding through preparation of a feasibility study, and culminating in approval by the Board of Directors and the General Meeting of Shareholders (RUPS). Funds are allocated through an ROI/Priority-Based Funding System that weighs the urgency of the need, the company's financial capacity, and the results of the feasibility analysis, and the process is governed by a strict procurement Standard Operating Procedure (SOP), a tiered decision-making structure, and continuous internal oversight through periodic evaluation of investment benefits and performance. The GRPF decision was therefore not merely an equipment purchase, but part of a controlled and accountable corporate strategy.

Cost-Benefit and Feasibility Analysis.

Reducing Pol Ampas by 0.1 percentage point was estimated to be worth approximately IDR 6,041,549,523 per milling season. Table 2 presents the resulting investment feasibility indicators, based on an initial investment (Cost of Investment) of IDR 25,000,000,000, a discount rate of 10 percent, and a six-year economic life.

Table 2
Investment Feasibility Analysis of the Groove Roller Pressure Feeder

Indicator	Value	Criterion	Decision
Net Present Value (NPV)	IDR 876,997,000	NPV > 0	Feasible

Indicator	Value	Criterion	Decision
Internal Rate of Return (IRR)	11.19%	IRR > discount rate (10%)	Feasible
Profitability Index (PI)	1.04	PI > 1.00	Feasible
Payback Period (PP)	4.21 years	< 6-year economic life	Feasible
Return on Investment (ROI)	42.60%	Positive	Feasible

Source: PG Trangkil investment feasibility calculation, processed data (2025)

The positive NPV indicates that the project generates cash receipts exceeding the discounted value of the investment. The IRR of 11.19 percent exceeds the 10 percent cost of capital, so the project is categorized as economical. The PI of 1.04 confirms that each unit of capital invested yields a favorable net return, while the 4.21-year payback period—well within the six-year economic life—indicates controlled liquidity risk. Cumulatively, the project generates a net profit of IDR 10,649,297,000 at a 42.60 percent ROI. Based on all four evaluation criteria (NPV, IRR, PI, and PP), the GRPF investment is therefore declared feasible for realization.

Impact On Efficiency and Financial Performance.

Table 3 compares the company's financial performance before and after GRPF installation.

Table 3
Company Financial Performance Before and After GRPF Installation

Indicator	Before GRPF	After GRPF	Change
Sugar sales revenue	IDR 786.17 billion	IDR 1.66 trillion	+111.16%
By-product (molasses) revenue	IDR 139.73 million	IDR 95.58 million	-31.60%
Cost of goods sold	—	—	+103.79%
Cane raw-material cost	IDR 717.32 million	IDR 1.34 billion	+87.42%
Gross Profit Margin (GPM)	16.07%	9.80%	-6.27 pp
Net Profit Margin (NPM)	12.54%	8.11%	-4.43 pp
Tax, interest & OCI expense	IDR 42.15 million	IDR 35.12 million	-16.68%
Net profit	—	IDR 142.37 billion	+22.59%

Source: PG Trangkil financial statements, processed data (2025)

Sugar sales revenue more than doubled (+111.16%), from IDR 786.17 billion to IDR 1.66 trillion, reflecting higher milling capacity and average selling prices, while by-product (molasses) revenue fell 31.60 percent, possibly due to lower molasses output or price. Cost of goods sold grew rapidly (+103.79%), driven mainly by cane raw-material cost, which rose 87.42 percent. This produced margin compression: GPM fell from 16.07 percent to 9.80 percent, and NPM fell from 12.54 percent to 8.11 percent. Nominally, however, the company still posted positive performance, with net profit rising 22.59 percent to IDR 142.37 billion, aided by a 16.68 percent reduction in tax, interest, and other comprehensive income (OCI) expense.

Supporting and Inhibiting Factors.

Factors supporting successful GRPF implementation include full management support, infrastructure readiness and technological adaptation, a real-time digital monitoring system, planned (preventive and predictive) maintenance, and continuous technology development aligned with the company's Strategic Business Plan. The inhibiting factors identified in this study consist of two main aspects. First, technical constraints occurred during the early installation and commissioning stage, particularly in relation to foundation adjustment and modification of the carrier and chute. Second, human-resource adaptation to the new technology remains necessary, especially in preparation for the planned adoption of an individual-drive system in the next development phase.

Mini theory construction.

The propositions were derived through a qualitative data-analysis process based on the Miles and Huberman (1994) model, comprising data reduction, data display, and verification. Each research theme namely the funding system, the cost-benefit profile, efficiency and revenue impact, and the supporting/inhibiting factors was developed into a construct through four converging elements: supporting theory, verbatim interview evidence from four key informants, the researcher's interpretation, and the researcher's synthesis. Pairs of constructs found to be consistently and substantively related were then formulated as directional cause-and effect statements, yielding a total of 22 propositions. Among the 22 propositions, 8 core propositions were identified as they form the main pathway (backbone) of the mini theory a direct chain of relationships linking the central constructs that constitute the study's key findings : Integrated Investment Planning → ROI Priority Based Funding → SOP Compliance → Internal Oversight → Financial Feasibility Analysis → Operational Efficiency → Management Support → Company Financial Performance. The selection criterion applied was structural centrality: these eight propositions connect constructs positioned directly along the main pathway from investment governance to financial performance. The remaining 14 supporting propositions explain how operational/technical variables (Mill Extraction, Losses, Milling Capacity, Energy Efficiency, Infrastructure Readiness, etc.) contribute to these core constructs—functioning to reinforce and

elaborate the theory rather than to form its structural backbone. Table 4 summarizes eight core propositions that anchor the resulting mini theory.

Table 4
Core Propositions Underlying the GRPF Investment Mini-Theory

No.	Proposition
1	The more integrated the Investment Planning, the higher the company's Financial Performance.
2	The better the ROI/Priority Based Funding System, the more accurate the Integrated Investment Planning.
3	The higher the level of SOP compliance, the easier the internal oversight of company investment.
5	The stricter the Internal Oversight, the better the company's Financial Performance.
7	The more comprehensive the Financial Feasibility Analysis (NPV/IRR/PP), the more accurate the Investment Planning integration.
9	The higher the Operational Efficiency, the higher the efficiency of production maintenance cost.
19	The higher the Management Support, the better the company's Financial Performance.
22	The higher the Mill Extraction, the higher the resulting sugar recovery (rendemen).

Source: qualitative data analysis, processed (2025)

Processing the qualitative data through source, technique, and time triangulation drawing on four informants with complementary organizational vantage points, namely the Factory Manager (strategic governance and investment approval), the Head of the Technical Division (technical feasibility and maintenance/operational cost), the Head of the Manufacturing Division (milling-station operational efficiency, i.e., Mill Extraction and Pol Ampas), and the Head of Finance, Administration, and General Affairs (financial feasibility, NPV/IRR/PP, and cost-efficiency evaluation), and cross-verifying their accounts against direct observation and secondary/archival records collected at different points in timevyielded a convergent, multi-dimensional, and credible picture of the GRPF investment, in which independently corroborated findings (e.g., the rise in Mill Extraction and decline in Pol Ampas) confirmed data validity, while role specific, non overlapping details enriched the analysis; this triangulated dataset was then processed using Miles and Huberman's (1994) interactive model of data reduction, data display, and verification, which organized the evidence directly around the study's four research objectives mapping the funding and

governance mechanism, verifying the cost benefit profile from both financial and asset cost perspectives, quantifying efficiency gains and linking them to revenue and financial performance, and identifying consistently recurring supporting and inhibiting implementation factors thereby enabling the qualitative analysis to substantively and credibly address each of the study's stated research objectives.

Discussion

Consistent with (Salsabilla & Marliana, 2024) and (Muhtazib Muhtazib & Muhamad Rifaldi, 2023), this study confirms that the equipment investment under review is financially feasible, with a positive NPV, an IRR above the cost of capital, and a favorable payback period. It also aligns with (Ridwan et al., 2022) and (Hendra et al., 2024), who likewise found equipment-replacement or -procurement investments feasible using the same NPV/IRR/PP/PI framework applied here. (Brigham & Houston, 2019) note that NPV is the strongest capital-budgeting criterion because it directly measures value creation for the firm, which is corroborated in this case by the positive NPV alongside a supportive IRR, PI, and payback period.

The contribution of this study relative to prior finance only feasibility research (Salsabilla & Marliana, 2024; Muhtazib & Rifaldi, 2023; Ridwan et al., 2022; Hendra et al., 2024) lies in linking financial feasibility with a measurable change in operational/machine efficiency and with the organizational mechanism through which the investment decision is governed and implemented. GRPF raised mill extraction and lowered Pol Ampas, consistent with Muhammadi and Wycliffe's (2025) findings on sugar-retention loss in bagasse. These improvements translated into higher sugar-sales revenue and net profit. At the same time, the sharp rise in cane raw material cost compressed gross and net margins, a nuance that a purely financial feasibility lens would not reveal. This finding indicates that operational efficiency gains do not automatically translate into proportionate margin improvement when upstream input costs rise faster than output growth, underscoring the importance of complementary cost-control measures alongside technology investment. The GRPF investment required an initial investment cost of IDR 25,000,000,000 with recurring annual cash outflow of IDR 100,000,000 over its six-year economic life, generating an annual net cash inflow of IDR 6,041,550,000 that produced a positive NPV of IDR 876,997,000, an IRR of 11.19% (above the 10% cost of capital), a Profitability Index of 1.04, a payback period of 4.21 years, a cumulative net profit of IDR 10,649,297,000, and an ROI of 42.60% confirming the investment as financially feasible across all four capital-budgeting criteria; operationally, GRPF raised Mill Extraction from 92.2% to 94.4%, lowered Pol Ampas from 2.3% to 1.7%, and reduced maintenance cost per quintal of cane from Rp1,258 to Rp1,109, together worth an estimated Rp6 billion per milling season and contributing to a 111.16% rise in sugar-sales revenue and a 22.59% rise in net profit though this operational benefit did not translate proportionally into profitability, as an 87.42% surge in cane raw-material cost compressed Gross Profit

Margin from 16.07% to 9.80% and Net Profit Margin from 12.54% to 8.11%, a nuance that distinguishes this study's combined financial-operational lens from prior finance-only feasibility research (Salsabilla & Marliana, 2024; Muhtazib & Rifaldi, 2023; Ridwan et al., 2022; Hendra et al., 2024).

Taken together, the findings indicate that GRPF implementation clearly improved technical/operational efficiency (higher extraction, lower losses, lower maintenance cost per unit) and drove substantial revenue and net-profit growth in absolute terms. However, the profitability ratios (GPM, NPM) declined, showing that the scale of the investment's benefit primarily volume driven revenue growth was accompanied by an even faster proportional rise in production costs (chiefly raw material cost from processing more cane), so efficiency gains at the machine level did not fully translate into proportionally higher margins at the company level.

The supporting factors identified in this study management support, infrastructure readiness, real time digital monitoring, and planned maintenance are consistent with the total productive maintenance and predictive maintenance literature (Nakajima, 1988; Hector & Panjanathan, 2024; Guszahari Adi et al., 2024). This literature links planned and predictive maintenance practices to higher overall equipment effectiveness and operational performance. The inhibiting factors, particularly commissioning-stage technical adjustment and human resource adaptation to new technology, mirror common technology-adoption barriers noted in operations-management literature and reinforce (M. E. Porter, 1985) view that sustaining competitive advantage from new technology requires organizational capability to absorb it, not merely capital outlay. The mini-theory constructed from 22 propositions represents a theoretical contribution that extends capital budgeting and milling-efficiency scholarship in the private sugar industry by explicitly connecting investment governance (integrated planning, ROI-based funding, SOP compliance, tiered decision structure, internal oversight) to operational efficiency and financial performance outcomes, a linkage not made explicit in the finance-only studies reviewed above.

CONCLUSION

GRPF investment at PG Trangkil is funded through an Integrated Investment Planning mechanism combined with an ROI/Priority Based Funding System. This funding process is governed by strict procurement SOPs, a tiered decision structure, and periodic internal oversight. The investment is financially feasible. This is evidenced by a positive NPV of IDR 876,997,000, an IRR of 11.19% above the company's cost of capital a Profitability Index of 1.04, a payback period of 4.21 years within the six-year economic life, and an ROI of 42.60%. GRPF implementation raised mill extraction and lowered Pol Ampas. These operational gains lifted sugar-sales revenue by 111.16% and net profit by 22.59%. However, production cost rose by 103.79%, driven chiefly by an

87.42% increase in cane raw-material cost. This cost increase compressed the Gross Profit Margin from 16.07% to 9.80% and the Net Profit Margin from 12.54% to 8.11%. Overall, this finding demonstrates that GRPF implementation has a positive impact on the company's operational efficiency and generates real growth in revenue and net profit, but this impact has not yet been fully translated into proportional margin improvement, indicating that operational efficiency gains at the milling-station level are not automatically equivalent to improved company wide profitability. This answers Research Objective 3 by showing that the investment's efficiency impact is real and measurable, while its profit performance impact remains partial and requires further cost structure management to be fully realized. Implementation was supported by management commitment, infrastructure readiness, real-time digital monitoring, and planned maintenance. It was constrained, however, by early commissioning issues particularly foundation adjustment and carrier/chute modification and by the need for human-resource adaptation to the new technology. This finding answers Research Objective 4 by confirming that GRPF's efficiency gains do not occur automatically as a function of the technology alone, but depend on an interaction between organizational readiness factors (management support, infrastructure, monitoring systems, maintenance planning) that accelerate implementation, and technical / human capital constraints that, if left unaddressed, may delay or limit the extent to which the technology's efficiency potential is realized in practice. Consequently, the sustainability of GRPF's efficiency benefits depends not only on the machine's technical capability, but also on the company's continued organizational capacity to support and adapt to it. The study contributes a mini-theory of 22 propositions linking integrated investment planning, SOP compliance, financial feasibility analysis, and operational efficiency to company financial performance. This mini-theory enriches capital-budgeting and milling-efficiency scholarship in the private sugar industry.

Managerially, PG Trangkil is advised to continue the phased development set out in its Strategic Business Plan including adoption of an individual-drive system and pressing Pol Ampas toward the 1 percent benchmark achieved by newer competitors while strengthening control of cane raw-material cost through price negotiation and supply-chain efficiency to protect profit margins, sustaining preventive and predictive maintenance alongside real time digital monitoring to preserve GRPF reliability, and building continuous human-resource competency programs for operators and technicians to speed adaptation to future technology upgrades.

This study is limited by its single case, qualitative dominant design, which constrains statistical generalization, and by the fact that the resulting mini theory has not yet been tested quantitatively. Future research is therefore encouraged to replicate this investigation at other sugar mills to test the consistency and generalizability of the findings, and to test the proposed mini-theory quantitatively, for example through

Structural Equation Modeling (SEM) or Partial Least Squares (PLS), to statistically confirm the proposition linkages across a broader population of sugar mills.

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