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Original Article

Strategic Investment Decision-Making for Modernizing PT XYZ's Production Facility: an AHP Approach

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Abstract: *PT XYZ faces significant challenges in modernizing its aging weapon production lines. This study aims to support strategic investment decision-making to ensure operational competitiveness. A structured Multi-Criteria Decision Analysis (MCDA) framework was developed by integrating the Kepner-Tregoe decision analysis and the Analytic Hierarchy Process (AHP). The study identified nine main criteria and 22 sub-criteria through thematic analysis and expert validation. Primary data were collected via in-depth interviews and internal documentation. The AHP model prioritized investment alternatives based on expert judgment. The analysis resulted in nine prioritized machine and equipment investments, including CNC machinery, automated inspection systems, collaborative robotics, and other technologies supporting productivity, precision, and automation. These investments reflect PT XYZ's strategic need for efficiency, flexibility, and long-term scalability. This study offers practical value in guiding capital allocation and contributes academically to structured decision-making models in strategic industrial environments.*

Keywords: *MCDA, AHP, Investment Decision, Production Modernization, Defense Industry.*

I. INTRODUCTION

The defense industry supports national sovereignty, economic growth, and technological advancement [1], [2]. As one of Indonesia's strategic state-owned enterprises, PT XYZ is responsible for manufacturing a wide range of defense equipment, including small arms, munitions, and military vehicles [3], [4]. However, to meet the growing domestic and international demand and to enhance competitiveness, modernization of its aging production facilities has become a strategic imperative [5]

PT XYZ faces significant challenges due to outdated machinery, with many units operating for over three decades. This condition limits production capacity, increases operational costs, and reduces flexibility in adopting Industry 4.0 technologies ([6], [7]. In response to these challenges, the Indonesian government has provided substantial support through the State Capital Participation (Penyertaan Modal Negara - PMN) fund, amounting to IDR 450 billion, aimed at modernizing and automating PT XYZ's production lines by 2029 [3], [8], [9]

Strategic investment decisions in such complex environments require a structured, objective, and multi-dimensional evaluation process. Conventional decision-making approaches often fall short of accommodating the complexity and interdependency of criteria involved in large-scale industrial investments [10], [11]. Hence, this study applies a Multi-Criteria Decision Analysis (MCDA) framework, integrating Kepner-Tregoe Decision Analysis [12]) and the Analytic Hierarchy Process (AHP) [13], to systematically assess and prioritize investment alternatives.

Previous studies highlight the importance of integrating qualitative and quantitative perspectives to enhance decision-making validity [14], [15]. In manufacturing contexts, AHP has proven effective for evaluating multiple investment criteria, such as cost, efficiency, technological readiness, and sustainability [16], [17].

This research contributes to the literature by applying a structured decision-making framework to the Indonesian defense sector, which remains relatively underexplored [18]. The findings provide valuable insights for PT XYZ and other strategic industries managing large-scale modernization initiatives [19], [20].

The objectives of this study are threefold: (1) to identify and prioritize investment criteria relevant to the modernization of production facilities, (2) to evaluate and rank alternative investments using MCDA methods, and (3) to propose strategic recommendations aligned with PT XYZ's long-term goals and Indonesia's defense industry development agenda.

II. LITERATURE REVIEW

Strategic investment decisions in manufacturing require structured methodologies to evaluate complex alternatives under multiple criteria. This research is grounded in two main decision-making frameworks: Kepner-Tregoe (KT) and the Analytic Hierarchy Process (AHP).

A) Kepner-Tregoe Decision Analysis

Kepner-Tregoe is a structured method used for problem-solving and decision-making. It includes Situation Appraisal (SA) and Decision Analysis (DA), allowing decision-makers to prioritize issues based on urgency, trend, and impact. The KT framework supports selecting optimal solutions among alternatives by evaluating each against pre-defined criteria [12].

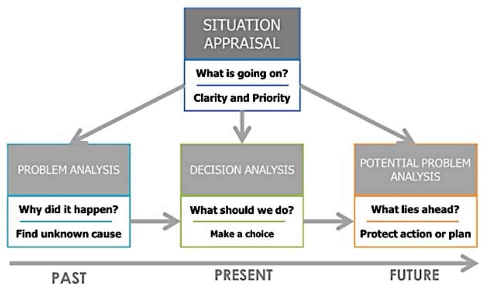

Fig.1 Kepner Tregoe Framework

B) Analytic Hierarchy Process (AHP)

AHP, developed by Saaty [13], is a Multi-Criteria Decision-Making (MCDM) technique that decomposes complex problems into a hierarchical structure, criteria, sub-criteria, and alternatives. It uses pairwise comparisons and Consistency Ratio (CR) validation to ensure logical coherence [21].AHP is widely applied in strategic investment decisions due to its ability to integrate qualitative and quantitative judgments [16]

C) Strategic Decision-Making in Industry

Strategic decisions in defense-related investments must align with long-term goals, market competitiveness, and operational sustainability. A combination of AHP and KT enables a systematic approach to balancing cost, risk, technology readiness, and strategic alignment [10], [22].

D) Conceptual Framework

The research framework integrates current production conditions, situational analysis, MCDA-based evaluation (AHP & KT), and expected outcomes such as improved efficiency, automation, and competitiveness. This framework guides the systematic selection of investment alternatives that align with PT XYZ's strategic goals and national defense priorities.

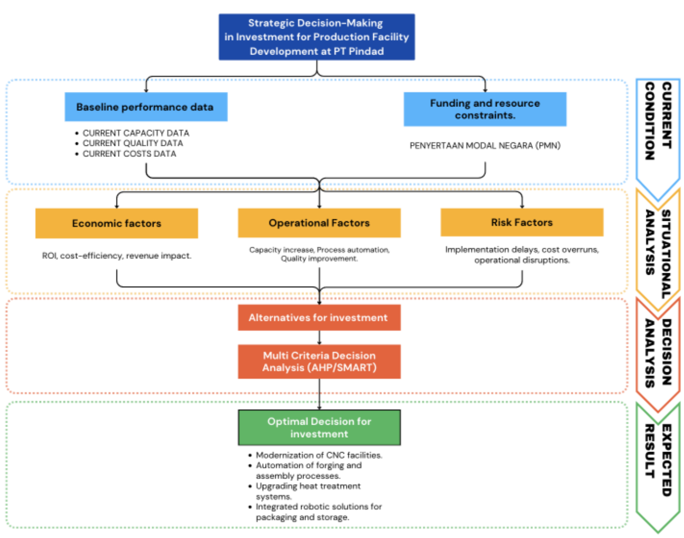

Fig. 2 Conceptual Framework of The Research

III. RESULTS AND DISCUSSION

This section presents the findings derived from the thematic analysis and the AHP-based prioritization of investment alternatives for PT XYZ's production facility modernization. The results are then critically discussed in relation to the existing literature and managerial implications.

A) Situational Analysis Results

This section summarizes the situational analysis conducted to provide a strong foundation for investment decision-making at PT XYZ using the Kepner-Tregoe approach.

a. Findings from Situational Analysis

Based on primary and secondary data from PT XYZ's weapons production unit, the following key points were identified:

1. **Machine Condition**: Most machines are over 20 years old, leading to reduced precision, higher downtime, and increased maintenance costs.
2. **Strategic Target**: PT XYZ aims to increase production from 54,000 to 75,000 units per year by 2029, which requires modernization.
3. **Technology Integration Pressure**: To remain competitive, the company must integrate automation, IoT, and Industry 4.0 readiness.
4. **Government Support**: A government capital injection of IDR 450 billion is allocated for manufacturing transformation.
5. **Decision-Making Risk**: Delays in investment could lead to missed contracts and reduced competitiveness.

b. Implications for Decision-Making Models

These findings form the basis for the AHP evaluation dimensions, critical to PT XYZ's strategic objectives and modernization efforts. The following dimensions are evaluated:

1. Performance & Efficiency
2. Automation & Technology
3. Reliability & Maintenance
4. Flexibility & Scalability
5. Costs & Investments
6. Compliance & Security
7. Ergonomics & Health
8. Supply Chain & Availability
9. Environment & Sustainability

Pairwise comparisons are used to determine the priority weights for each dimension, guiding the investment decision and machine selection process for modernization. The results of the situational analysis strengthen the need for multi-criteria decision-making to identify the optimal machine alternatives based on strategic objectives and modernization requirements [23]

This analysis highlights the importance of multi-criteria decision-making when selecting the optimal machine alternatives to meet PT XYZ's modernization goals.

B) Internal Document Review: Overview of Production Facility

PT XYZ's weapons production facilities are essential for meeting the national defense system's (Alutsista) needs. Currently, the production line has a maximum capacity of 54,000 units annually, producing firearms for the Indonesian National Army (TNI), the National Police (Polri), and the export market. However, the production facilities face key challenges, including capacity limitations, outdated machine technology, and inefficiencies in material flow.

The existing facility layout includes various production lines, such as:

1. Integrated Barrel Production Line
2. CNC Milling Machining Line
3. CNC Turning Machining Line
4. Weapon Assembly Line

Each line requires modernization to improve efficiency, reduce downtime, and integrate modern manufacturing systems.

C) Analysis of Current Production Layout

The current production layout poses several risks due to limitations in technology and capacity. To address these, PT XYZ needs to modernize its production lines. The table below outlines the urgent needs for the weapons division production lines:

Table 1: Required Machines and Suitable Options

Machine Category	Suitable Machine Options
CNC 5-Axis Multitasking	DMG Mori NTX 2000, Mazak Integrex i-200, Okuma Multus U3000
Deep Hole Drilling Machine	Tibo T-Series, BTA Systems BDH-800, Gundrill SIG L55
CNC Lathe for Barrel Profiling	Okuma LB3000 EX II, Doosan Puma GT2600, Mazak Quick Turn 250MY
Automated Inspection System	Hexagon Absolute Arm 7-Axis, Zeiss O-Inspect 322, Mitutoyo Quick Vision Apex
Collaborative Robot (Cobot)	Universal Robots UR10e, KUKA LBR iiwa 14 R820, Fanuc CRX-10iA
Automated Screw Assembly System	Weber Vibratory Screw Feeder, Janome JR3000 Series, Bosch Rexroth Smart Screwdriver
AGV for Material Handling	MiR 250, Omron LD-250, KUKA KMP 600-S
Automated Warehouse System	Kardex Remstar Shuttle XP 500, SSI Schaefer LogiMat, Daifuku Smart Storage System

These machines were selected based on their technical capabilities, precision, and integration with modern manufacturing systems such as IoT and CAD/CAM [24], [25]. This analysis reinforces the urgency of investment in modern machinery to ensure PT XYZ can meet its production targets and remain competitive in the defense manufacturing industry.

D) Pairwise Comparison Matrix and Normalization of Each Sub-Criterion

A pairwise comparison matrix determines the relative weight of each sub-criterion within each dimension. This process follows the Saaty scale, ensuring the assessment is structured, consistent, and reflective of PT XYZ's actual conditions. The weight for each sub-criterion is calculated, helping to quantify its relative importance in the decision-making process. Below is a summary of the pairwise comparison and the local priority for each sub-criterion:

1. **Performance & Production Efficiency**

Pairwise Matrix:						
Sub-Criteria	**Capacity**	**Cycle Time**	**Precision**	**λ**	**CI**	**CR**
Production Capacity	1.00	3.00	0.50	3.06	0.03	0.05
Cycle Time	0.33	1.00	0.33	3.02		
Precision & Consistency	2.00	3.00	1.00	3.08		
Total	**3.33**	**7.00**	**1.83**	**3.05**		
				Average λ		
Normalized Matrix:						
Sub-Criteria	**Capacity**	**Cycle Time**	**Precision**	**Row Avg (Priority)**		
Production Capacity	0.30	0.43	0.27	**33%**		
Cycle Time	0.10	0.14	0.18	**14%**		
Precision	0.60	0.43	0.55	**52%**		

2. **Automation & Technological Integration**

Pairwise Matrix:						
Sub-Criteria	**Level of Automation**	**IoT & AI Compatibility**	**Industry 4.0 Adaptability**	**λ**	**CI**	**CR**
Level of Automation	1.00	3.00	3.00	3.00	0	0
IoT & AI Compatibility	0.33	1.00	1.00	3.00		
Industry 4.0 Adaptability	0.33	1.00	1.00	3.00		
Total	**1.67**	**5.00**	**5.00**	**3.00**		
				Average λ		
Normalized Matrix:						
Sub-Criteria	**Level of Automation**	**IoT & AI Compatibility**	**Industry 4.0 Adaptability**	**Row Avg (Priority)**		
Level of Automation	0.60	0.60	0.60	**60%**		
IoT & AI Compatibility	0.20	0.20	0.20	**20%**		
Industry 4.0 Adaptability	0.20	0.20	0.20	**20%**		

3. **Flexibility & Scalability**

Pairwise Matrix:			
Sub-Criteria	**Multi-Functionality**	**Scalability**	
Multi-Functionality	1.00	2.00	
Scalability	0.50	1.00	
Total	**1.50**	**3.00**	
Normalized Matrix:			
Sub-Criteria	**Multi-Functionality**	**Scalability**	**Row Avg (Priority)**
Multi-Functionality	0.67	0.67	**67%**
Scalability	0.33	0.33	**33%**

4. **Reliability & Maintenance**

Pairwise Matrix:			
Sub-Criteria	**Downtime & Reliability**	**Predictive Maintenance**	
Downtime & Reliability	1.00	3.00	
Predictive Maintenance	0.33	1.00	
Total	**1.33**	**4.00**	
Normalized Matrix:			
Sub-Criteria	**Downtime & Reliability**	**Predictive Maintenance**	**Row Avg (Priority)**
Downtime & Reliability	0.75	0.75	**75%**
Predictive Maintenance	0.25	0.25	**25%**

5. **Cost & Investment Considerations**

Pairwise Matrix:						
Sub-Criteria	Initial Purchase	Operational Cost	ROI	λ	CI	CR
Initial Purchase	1.00	0.33	0.33	3.05	0.07	0.12
Operational Cost	3.00	1.00	0.33	3.13		
ROI	3.00	3.00	1.00	3.23		
Total	**7.00**	**4.33**	**1.67**	**3.14**		
				Average λ		
Normalized Matrix:						
Sub-Criteria	Initial Purchase	Operational Cost	ROI	**Row Avg (Priority)**		
Initial Purchase	0.14	0.08	0.20	**14%**		
Operational Cost	0.43	0.23	0.20	**29%**		
ROI	0.43	0.69	0.60	**57%**		

6. **Regulatory Compliance & Safety Standards**

Pairwise Matrix:			
Sub-Criteria	Compliance	Safety	
Compliance	1.00	0.50	
Safety	2.00	1.00	
Total	**3.00**	**1.50**	
Normalized Matrix:			
Sub-Criteria	Compliance	Safety	**Row Avg (Priority)**
Compliance	0.33	0.33	**33%**
Safety	0.67	0.67	**67%**

7. **Ergonomics & Operator Health**

Pairwise Matrix:			
Sub-Criteria	Ergonomic Design	Health Impact	
Ergonomic Design	1.00	0.50	
Health Impact	2.00	1.00	

Total	**3.00**	**1.50**	
Normalized Matrix:			
Sub-Criteria	Ergonomic Design	Health Impact	**Row Avg (Priority)**
Ergonomic Design	0.33	0.33	**33%**
Health Impact	0.67	0.67	**67%**

8. **Supply Chain & Availability**

Pairwise Matrix:			
Sub-Criteria	Lead Time	Supply Chain Risk	
Lead Time	1.00	2.00	
Supply Chain Risk	0.50	1.00	
Total	**1.50**	**3.00**	
Normalized Matrix:			
Sub-Criteria	Lead Time	Supply Chain Risk	**Row Avg (Priority)**
Lead Time	0.67	0.67	**67%**
Supply Chain Risk	0.33	0.33	**33%**

9. **Environmental Impact & Sustainability**

Pairwise Matrix:			
Sub-Criteria	Energy Efficiency	Sustainable Production	
Energy Efficiency	1.00	0.50	
Sustainable Production	2.00	1.00	
Total	**3.00**	**1.50**	
Normalized Matrix:			
Sub-Criteria	Energy Efficiency	Sustainable Production	**Row Avg (Priority)**
Energy Efficiency	0.33	0.33	**33%**
Sustainable Production	0.67	0.67	**67%**

E) Weight of Criteria

The 22 evaluation attributes are grouped into 9 main criteria:

Table 2: Final Weight Calculation of Criteria

Dimensi	Weight	Sub-Criteria	Weight	Final Weight
1. Kinerja & Efisiensi	**28%**	Production Capacity	**33%**	**9.23%**
		Cycle Time	**14%**	**3.91%**
		Precision & Consistency	**52%**	**14.52%**
2. Otomasi & Teknologi	**26%**	Level of Automation	**60%**	**15.58%**
		IoT & AI Compatibility	**20%**	**5.19%**
		Industry 4.0 Adaptability	**20%**	**5.19%**
3. Fleksibilitas & Skalabilitas	**15%**	Multi-Functionality	**67%**	**10.05%**
		Scalability	**33%**	**5.03%**
4. Keandalan & Pemeliharaan	**10%**	Downtime & Reliability	**75%**	**7.24%**
		Predictive Maintenance	**25%**	**2.41%**
5. Biaya & Investasi	**8%**	Initial Purchase Cost	**14%**	**1.11%**
		Operational Cost	**29%**	**2.27%**
		Return on Investment (ROI)	**57%**	**4.55%**
6. Kepatuhan & Keamanan	**5%**	Standards Compliance	**33%**	**1.72%**
		Operator Safety	**67%**	**3.44%**
7. Ergonomi & Kesehatan	**4%**	Ergonomic Design	**33%**	**1.30%**
		Health Impact	**67%**	**2.60%**
8. Rantai Pasokan & Ketersediaan	**3%**	Lead Time / Delivery	**67%**	**1.88%**
		Supply Chain Risk	**33%**	**0.94%**
9. Lingkungan & Keberlanjutan	**2%**	Energy Efficiency	**33%**	**0.61%**
		Sustainable Production	**67%**	**1.22%**

TOTAL	100%	100%

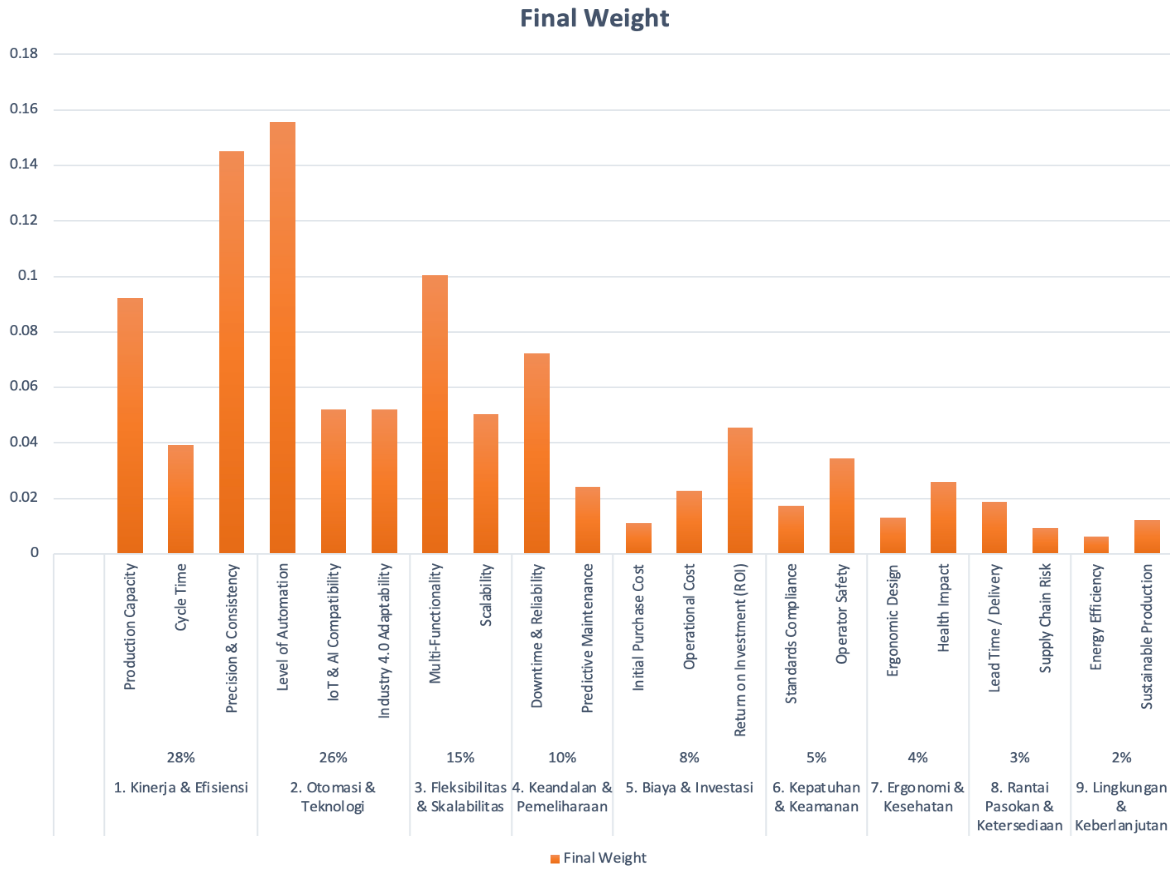

Fig. 2 Final Weight Chart

F) Ranking of Investment Alternatives

After obtaining the global weights of each sub-criterion based on the AHP method, the next step is to evaluate the proposed engine alternatives. Each alternative is scored against each sub-criterion on a scale of 1–10 based on technical assessments and vendor data.

Table 3: Final Scoring Calculation for CNC 5-Axis Multitasking

Dimensi	Sub-Criteria	Weight (%)	DMG Mori NTX 2000		Mazak Integrex i-200		Okuma Multus U3000	
			Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
1. Kinerja & Efisiensi	Production Capacity	9.23%	9	0.831	8	0.738	8	0.738
	Cycle Time	3.91%	8	0.313	9	0.352	8	0.313
	Precision & Consistency	14.52%	9	1.306	8	1.161	9	1.306
2. Otomasi & Teknologi	Level of Automation	15.58%	8	1.246	8	1.246	8	1.246
	IoT & AI Compatibility	5.19%	8	0.415	8	0.415	9	0.467
	Industry 4.0 Adaptability	5.19%	8	0.415	8	0.415	9	0.467
3. Fleksibilitas & Skalabilitas	Multi-Functionality	10.05%	10	1.005	9	0.905	9	0.905
	Scalability	5.03%	8	0.402	7	0.352	8	0.402
4. Keandalan & Pemeliharaan	Downtime & Reliability	7.24%	9	0.652	9	0.652	9	0.652
	Predictive Maintenance	2.41%	8	0.193	7	0.169	9	0.217
5. Biaya & Investasi	Initial Purchase Cost	1.11%	6	0.067	7	0.078	7	0.078
	Operational Cost	2.27%	8	0.182	7	0.159	8	0.182
	Return on Investment (ROI)	4.55%	8	0.364	8	0.364	8	0.364

6. Kepatuhan & Keamanan	Standards Compliance	1.72%	10	0.172	10	0.172	10	0.172
	Operator Safety	3.44%	9	0.310	9	0.310	9	0.310
7. Ergonomi & Kesehatan	Ergonomic Design	1.30%	8	0.104	8	0.104	9	0.117
	Health Impact	2.60%	8	0.208	8	0.208	9	0.234
8. Rantai Pasokan & Ketersediaan	Lead Time / Delivery	1.88%	6	0.113	6	0.113	6	0.113
	Supply Chain Risk	0.94%	8	0.075	8	0.075	7	0.066
9. Lingkungan & Keberlanjutan	Energy Efficiency	0.61%	8	0.049	7	0.043	8	0.049
	Sustainable Production	1.22%		0.000		0.000		0.000
		1.0		8.4223		8.0314		8.3982

Table 4: Final Scoring Calculation for Deep Hole Drilling Machine (Weapon Barrels)

Dimensi	Sub-Criteria	Weight (%)	Tibo T-Series		BTA Systems BDH-800		Gundrill SIG L55	
			Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
1. Kinerja & Efisiensi	Production Capacity	9.23%	9	0.831	9	0.831	8	0.738
	Cycle Time	3.91%	8	0.313	8	0.313	7	0.274
	Precision & Consistency	14.52%	9	1.306	8	1.161	9	1.306
2. Otomasi & Teknologi	Level of Automation	15.58%	8	1.246	7	1.091	7	1.091
	IoT & AI Compatibility	5.19%	7	0.364	6	0.312	6	0.312
	Industry 4.0 Adaptability	5.19%	7	0.364	6	0.312	6	0.312
3. Fleksibilitas & Skalabilitas	Multi-Functionality	10.05%	8	0.804	7	0.704	7	0.704
	Scalability	5.03%	8	0.402	7	0.352	6	0.302
4. Keandalan & Pemeliharaan	Downtime & Reliability	7.24%	9	0.652	8	0.579	8	0.579
	Predictive Maintenance	2.41%	7	0.169	6	0.145	6	0.145
5. Biaya & Investasi	Initial Purchase Cost	1.11%	7	0.078	7	0.078	7	0.078
	Operational Cost	2.27%	8	0.182	7	0.159	8	0.182
	Return on Investment (ROI)	4.55%	8	0.364	7	0.319	8	0.364
6. Kepatuhan & Keamanan	Standards Compliance	1.72%	10	0.172	9	0.155	9	0.155
	Operator Safety	3.44%	9	0.310	8	0.275	8	0.275
7. Ergonomi & Kesehatan	Ergonomic Design	1.30%	8	0.104	7	0.091	7	0.091
	Health Impact	2.60%	8	0.208	7	0.182	7	0.182
8. Rantai Pasokan & Ketersediaan	Lead Time / Delivery	1.88%	7	0.131	6	0.113	7	0.131
	Supply Chain Risk	0.94%	8	0.075	7	0.066	7	0.066
9. Lingkungan & Keberlanjutan	Energy Efficiency	0.61%	8	0.049	7	0.043	8	0.049
	Sustainable Production	1.22%	8	0.098	7	0.085	7	0.085
		1.0		8.2208		7.3634		7.4199

Table 5: Final Scoring Calculation for CNC Lathe for Barrel Profiling

Dimensi	Sub-Criteria	Weight (%)	OKUMA LB3000 EX II		DOOSAN PUMA GT2600		MAZAK QUICK TURN 250MY	
			Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
1. Kinerja & Efisiensi	Production Capacity	9.23%	9	0.831	8	0.738	8	0.738
	Cycle Time	3.91%	8	0.313	8	0.313	9	0.352
	Precision & Consistency	14.52%	9	1.306	8	1.161	9	1.306
2. Otomasi & Teknologi	Level of Automation	15.58%	8	1.246	7	1.091	9	1.402
	IoT & AI Compatibility	5.19%	7	0.364	6	0.312	9	0.467
	Industry 4.0 Adaptability	5.19%	8	0.415	6	0.312	9	0.467
3. Fleksibilitas & Skalabilitas	Multi-Functionality	10.05%	8	0.804	7	0.704	9	0.905
	Scalability	5.03%	8	0.402	7	0.352	9	0.452
4. Keandalan & Pemeliharaan	Downtime & Reliability	7.24%	9	0.652	8	0.579	9	0.652
	Predictive Maintenance	2.41%	8	0.193	6	0.145	9	0.217

5. Biaya & Investasi	Initial Purchase Cost	1.11%	7	0.078	9	0.100	6	0.067
	Operational Cost	2.27%	8	0.182	8	0.182	7	0.159
	Return on Investment (ROI)	4.55%	8	0.364	8	0.364	8	0.364
6. Kepatuhan & Keamanan	Standards Compliance	1.72%	9	0.155	8	0.138	9	0.155
	Operator Safety	3.44%	9	0.310	8	0.275	9	0.310
7. Ergonomi & Kesehatan	Ergonomic Design	1.30%	8	0.104	7	0.091	9	0.117
	Health Impact	2.60%	9	0.234	8	0.208	9	0.234
8. Rantai Pasokan & Ketersediaan	Lead Time / Delivery	1.88%	7	0.131	8	0.150	7	0.131
	Supply Chain Risk	0.94%	8	0.075	8	0.075	7	0.066
9. Lingkungan & Keberlanjutan	Energy Efficiency	0.61%	8	0.049	7	0.043	8	0.049
	Sustainable Production	1.22%	7	0.085	7	0.085	8	0.098
		1.0		8.2935		7.4172		8.7088

Table 6: Final Scoring Calculation for Automated Inspection System

Dimensi	Sub-Criteria	Weight (%)	HEXAGON ABSOLUTE ARM 7-Axis		Zeiss O-Inspect 322 (CNC Optical + Tactile CMM)		Mitutoyo Quick Vision Apex (Optical Measuring System)	
			Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
1. Kinerja & Efisiensi	Production Capacity	9.23%	8	0.738	7	0.646	7	0.646
	Cycle Time	3.91%	8	0.313	9	0.352	8	0.313
	Precision & Consistency	14.52%	9	1.306	10	1.452	9	1.306
2. Otomasi & Teknologi	Level of Automation	15.58%	6	0.935	9	1.402	9	1.402
	IoT & AI Compatibility	5.19%	7	0.364	7	0.364	7	0.364
	Industry 4.0 Adaptability	5.19%	7	0.364	8	0.415	7	0.364
3. Fleksibilitas & Skalabilitas	Multi-Functionality	10.05%	9	0.905	8	0.804	8	0.804
	Scalability	5.03%	8	0.402	7	0.352	6	0.302
4. Keandalan & Pemeliharaan	Downtime & Reliability	7.24%	9	0.652	9	0.652	8	0.579
	Predictive Maintenance	2.41%	6	0.145	6	0.145	6	0.145
5. Biaya & Investasi	Initial Purchase Cost	1.11%	6	0.067	5	0.056	6	0.067
	Operational Cost	2.27%	8	0.182	8	0.182	8	0.182
	Return on Investment (ROI)	4.55%	8	0.364	8	0.364	8	0.364
6. Kepatuhan & Keamanan	Standards Compliance	1.72%	9	0.155	10	0.172	9	0.155
	Operator Safety	3.44%	9	0.310	9	0.310	9	0.310
7. Ergonomi & Kesehatan	Ergonomic Design	1.30%	9	0.117	8	0.104	8	0.104
	Health Impact	2.60%	9	0.234	9	0.234	9	0.234
8. Rantai Pasokan & Ketersediaan	Lead Time / Delivery	1.88%	7	0.131	7	0.131	7	0.131
	Supply Chain Risk	0.94%	8	0.075	8	0.075	8	0.075
9. Lingkungan & Keberlanjutan	Energy Efficiency	0.61%	9	0.055	8	0.049	8	0.049
	Sustainable Production	1.22%	8	0.098	7	0.085	8	0.098
		1.0		7.9100		8.3454		7.9926

Table 7: Final Scoring Calculation for Collaborative Robot (Cobot) for Assembly

Dimensi	Sub-Criteria	Weight (%)	Universal Robots UR10e		FANUC CRX-10iA		Doosan H-Series H2017	
			Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
1. Kinerja & Efisiensi	Production Capacity	9.23%	8	0.738	9	0.831	10	0.923
	Cycle Time	3.91%	8	0.313	8	0.313	8	0.313
	Precision & Consistency	14.52%	9	1.306	10	1.452	9	1.306

2. Otomasi & Teknologi	Level of Automation	15.58%	9	1.402	9	1.402	9	1.402
	IoT & AI Compatibility	5.19%	8	0.415	8	0.415	9	0.467
	Industry 4.0 Adaptability	5.19%	9	0.467	9	0.467	9	0.467
3. Fleksibilitas & Skalabilitas	Multi-Functionality	10.05%	10	1.005	9	0.905	9	0.905
	Scalability	5.03%	8	0.402	7	0.352	8	0.402
4. Keandalan & Pemeliharaan	Downtime & Reliability	7.24%	9	0.652	10	0.724	9	0.652
	Predictive Maintenance	2.41%	7	0.169	8	0.193	7	0.169
5. Biaya & Investasi	Initial Purchase Cost	1.11%	7	0.078	6	0.067	5	0.056
	Operational Cost	2.27%	9	0.205	8	0.182	8	0.182
	Return on Investment (ROI)	4.55%	9	0.410	8	0.364	7	0.319
6. Kepatuhan & Keamanan	Standards Compliance	1.72%	10	0.172	10	0.172	10	0.172
	Operator Safety	3.44%	10	0.344	9	0.310	10	0.344
7. Ergonomi & Kesehatan	Ergonomic Design	1.30%	9	0.117	8	0.104	9	0.117
	Health Impact	2.60%	10	0.260	9	0.234	10	0.260
8. Rantai Pasokan & Ketersediaan	Lead Time / Delivery	1.88%	9	0.169	7	0.131	6	0.113
	Supply Chain Risk	0.94%	9	0.084	8	0.075	7	0.066
9. Lingkungan & Keberlanjutan	Energy Efficiency	0.61%	9	0.055	8	0.049	9	0.055
	Sustainable Production	1.22%	8	0.098	8	0.098	8	0.098
		1.0		8.8618		8.8393		8.7868

Table 8: Final Scoring Calculation for Automated Screw Assembly System

Dimensi	Sub-Criteria	Weight (%)	Weber Automatic Screwdriving System (SEV-L Series)		eprag Screwdriving System (Minimat-EC Servo)		Kilews SKD-R Screwdriving Robot System	
			Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
1. Kinerja & Efisiensi	Production Capacity	9.23%	9	0.831	8	0.738	7	0.646
	Cycle Time	3.91%	9	0.352	8	0.313	7	0.274
	Precision & Consistency	14.52%	10	1.452	10	1.452	8	1.161
2. Otomasi & Teknologi	Level of Automation	15.58%	9	1.402	9	1.402	8	1.246
	IoT & AI Compatibility	5.19%	8	0.415	9	0.467	6	0.312
	Industry 4.0 Adaptability	5.19%	9	0.467	9	0.467	6	0.312
3. Fleksibilitas & Skalabilitas	Multi-Functionality	10.05%	7	0.704	8	0.804	7	0.704
	Scalability	5.03%	9	0.452	9	0.452	8	0.402
4. Keandalan & Pemeliharaan	Downtime & Reliability	7.24%	10	0.724	9	0.652	8	0.579
	Predictive Maintenance	2.41%	7	0.169	8	0.193	6	0.145
5. Biaya & Investasi	Initial Purchase Cost	1.11%	6	0.067	6	0.067	9	0.100
	Operational Cost	2.27%	9	0.205	9	0.205	8	0.182
	Return on Investment (ROI)	4.55%	8	0.364	8	0.364	9	0.410
6. Kepatuhan & Keamanan	Standards Compliance	1.72%	10	0.172	10	0.172	8	0.138
	Operator Safety	3.44%	10	0.344	9	0.310	9	0.310
7. Ergonomi & Kesehatan	Ergonomic Design	1.30%	9	0.117	9	0.117	8	0.104
	Health Impact	2.60%	10	0.260	10	0.260	9	0.234
8. Rantai Pasokan & Ketersediaan	Lead Time / Delivery	1.88%	8	0.150	7	0.131	9	0.169
	Supply Chain Risk	0.94%	8	0.075	7	0.066	9	0.084
9. Lingkungan & Keberlanjutan	Energy Efficiency	0.61%	9	0.055	9	0.055	8	0.049
	Sustainable Production	1.22%	8	0.098	8	0.098	7	0.085
		1.0		8.8748		8.7849		7.6450

Table 9: Final Scoring Calculation for AGV for Material Handling

Dimensi	Sub-Criteria	Weight (%)	MiR250 (Mobile Industrial Robots		Omron LD-250		Hikrobot Forklift AGV (FMR-FA)	
			Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
1. Kinerja & Efisiensi	Production Capacity	9.23%	8	0.738	9	0.831	10	0.923
	Cycle Time	3.91%	9	0.352	8	0.313	7	0.274
	Precision & Consistency	14.52%	8	1.161	8	1.161	7	1.016
2. Otomasi & Teknologi	Level of Automation	15.58%	9	1.402	8	1.246	9	1.402
	IoT & AI Compatibility	5.19%	10	0.519	9	0.467	9	0.467
	Industry 4.0 Adaptability	5.19%	9	0.467	8	0.415	7	0.364
3. Fleksibilitas & Skalabilitas	Multi-Functionality	10.05%	9	0.905	8	0.804	7	0.704
	Scalability	5.03%	9	0.452	8	0.402	7	0.352
4. Keandalan & Pemeliharaan	Downtime & Reliability	7.24%	10	0.724	9	0.652	9	0.652
	Predictive Maintenance	2.41%	9	0.217	8	0.193	7	0.169
5. Biaya & Investasi	Initial Purchase Cost	1.11%	6	0.067	7	0.078	7	0.078
	Operational Cost	2.27%	8	0.182	8	0.182	7	0.159
	Return on Investment (ROI)	4.55%	8	0.364	8	0.364	7	0.319
6. Kepatuhan & Keamanan	Standards Compliance	1.72%	10	0.172	10	0.172	9	0.155
	Operator Safety	3.44%	10	0.344	9	0.310	9	0.310
7. Ergonomi & Kesehatan	Ergonomic Design	1.30%	9	0.117	8	0.104	7	0.091
	Health Impact	2.60%	10	0.260	9	0.234	10	0.260
8. Rantai Pasokan & Ketersediaan	Lead Time / Delivery	1.88%	7	0.131	6	0.113	6	0.113
	Supply Chain Risk	0.94%	8	0.075	8	0.075	7	0.066
9. Lingkungan & Keberlanjutan	Energy Efficiency	0.61%	9	0.055	9	0.055	8	0.049
	Sustainable Production	1.22%	8	0.098	8	0.098	8	0.098
		1.0		8.8038		8.2689		8.0180

Table 10: Final Scoring Calculation for Automated Warehouse System (AS/RS)

Dimensi	Sub-Criteria	Weight (%)	SSI Schäfer Cuby Shuttle System (Germany)		Daifuku Unit Load AS/RS (Japan)		Geek+ RoboShuttle RS8 (China)	
			Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
1. Kinerja & Efisiensi	Production Capacity	9.23%	8	0.738	9	0.831	10	0.923
	Cycle Time	3.91%	9	0.352	8	0.313	7	0.274
	Precision & Consistency	14.52%	8	1.161	8	1.161	7	1.016
2. Otomasi & Teknologi	Level of Automation	15.58%	9	1.402	8	1.246	9	1.402
	IoT & AI Compatibility	5.19%	10	0.519	9	0.467	9	0.467
	Industry 4.0 Adaptability	5.19%	9	0.467	8	0.415	7	0.364
3. Fleksibilitas & Skalabilitas	Multi-Functionality	10.05%	9	0.905	8	0.804	7	0.704
	Scalability	5.03%	9	0.452	8	0.402	7	0.352
4. Keandalan & Pemeliharaan	Downtime & Reliability	7.24%	10	0.724	9	0.652	9	0.652
	Predictive Maintenance	2.41%	9	0.217	8	0.193	7	0.169
5. Biaya & Investasi	Initial Purchase Cost	1.11%	6	0.067	7	0.078	7	0.078
	Operational Cost	2.27%	8	0.182	8	0.182	7	0.159
	Return on Investment (ROI)	4.55%	8	0.364	8	0.364	7	0.319
6. Kepatuhan & Keamanan	Standards Compliance	1.72%	10	0.172	10	0.172	9	0.155
	Operator Safety	3.44%	10	0.344	9	0.310	9	0.310
7. Ergonomi & Kesehatan	Ergonomic Design	1.30%	9	0.117	8	0.104	7	0.091

	Health Impact	2.60%	10	0.260	9	0.234	10	0.260
8. Rantai Pasokan & Ketersediaan	Lead Time / Delivery	1.88%	7	0.131	6	0.113	6	0.113
	Supply Chain Risk	0.94%	8	0.075	8	0.075	7	0.066
9. Lingkungan & Keberlanjutan	Energy Efficiency	0.61%	9	0.055	9	0.055	8	0.049
	Sustainable Production	1.22%	8	0.098	8	0.098	8	0.098
		1.0		8.8038		8.2689		8.0180

G) Ranking Results

After adding up the weighted score of each alternative, the following results were obtained:

Table 11: Ranking results of AHP Calculation

Kategori Mesin	Rank	Machine
CNC 5 Axis Multi-Tasking	1	DMG Mori NTX 2000
	2	Okuma Multus U3000
	3	Mazak Integrex i-200
Deep Hole Drilling	1	Tibo T-Series
	2	Gundrill SIG L55
	3	BTA Systems BDH-800
CNC Turning Center	1	MAZAK QUICK TURN 250MY
	2	OKUMA LB3000 EX II
	3	DOOSAN PUMA GT2600
CMM (Coordinate Measuring Machines)	1	Zeiss O-Inspect 322 (CNC Optical + Tactile CMM)
	2	Mitutoyo Quick Vision Apex (Optical Measuring System)
	3	HEXAGON ABSOLUTE ARM 7-Axis
Collaborative Robot (Cobot)	1	Universal Robots UR10e
	2	FANUC CRX-10iA
	3	Doosan H-Series H2017
Screwdriving Automation	1	Weber Automatic Screwdriving System (SEV-L Series)
	2	eprag Screwdriving System (Minimat-EC Servo)
	3	Kilews SKD-R Screwdriving Robot System
Autonomous Mobile Robot (AMR)	1	MiR250 (Mobile Industrial Robots)
	2	Omron LD-250
	3	Hikrobot Forklift AGV (FMR-FA)
Warehouse Automation / Shuttle System	1	SSI Schäfer Cuby Shuttle System (Germany)
	2	Geek+ RoboShuttle RS8 (China)
	3	Daifuku Unit Load AS/RS (Japan)

H) Discussion

The results emphasize the primacy of **technological advancement** and **operational efficiency** in modernization decision-making. These findings align with [18], who underscored the growing significance of technological sophistication in capital investment decisions within strategic industries. Investment in **CNC machinery** is justified by its technological relevance and strong contribution to operational efficiency and product quality, key factors in global defense competitiveness [14], [26]. The relatively lower ranking of **collaborative robotics** reflects its longer-term payback horizon and higher initial complexity despite its strategic relevance in advanced manufacturing paradigms [15]. From a managerial perspective, PT XYZ should prioritize investments that deliver immediate operational improvements while gradually building capabilities for future technological shifts.

I) Managerial and Scientific Implications

Managerial Implications:

- Prioritize CNC machinery modernization projects in budget allocation.
- Establish KPI-driven monitoring for the impact of new technology adoption.
- Align investment execution with PT XYZ's strategic roadmaps and national defense capability targets.

Scientific Implications:

- This study validates the effectiveness of hybrid MCDA-AHP frameworks in strategic investment contexts.

- It offers empirical support for extending decision-analytic models to industries with high complexity and uncertainty, such as defense manufacturing.

IV. CONCLUSION

This research was initiated in response to the strategic need of PT Pindad (Persero) to modernize its Light Weapons Division by acquiring more advanced and reliable production machinery. The study applied the **Analytic Hierarchy Process (AHP)** to support a multi-criteria decision-making model in the procurement process.

Based on a thematic analysis of expert interviews and a literature review, nine primary dimensions were identified:

- Performance & Production Efficiency
- Automation & Technological Integration
- Flexibility & Scalability
- Reliability & Maintainability
- Cost & Investment
- Compliance & Safety
- Ergonomics & Health
- Supply Chain & Availability
- Environmental & Sustainability Factors

The AHP method was used to determine the relative importance of each criterion. **Performance & Efficiency (27.66%)**, **Automation & Technology (25.81%)**, and **Cost & Investment (17.92%)** emerged as the top three priorities. Sub-criteria such as **Precision & Consistency (14.52%)** and **Level of Automation (15.58%)** played dominant roles in influencing the decision model.

The most appropriate machine alternatives were selected based on the evaluation criteria developed through AHP and expert judgment. Using the **Weighted Sum Model (WSM)**, all machine alternatives across various categories were scored and ranked according to their overall performance against the weighted sub-criteria.

The following table summarizes the best-performing alternatives across the eight evaluated machine categories:

Machine Category	**Best Alternatives**
CNC 5 Axis Multi-Tasking	DMG Mori NTX 2000
Deep Hole Drilling	Tibo T-Series
CNC Turning Center	MAZAK QUICK TURN 250MY
CMM (Coordinate Measuring Machines)	Zeiss O-Inspect 322 (CNC Optical + Tactile CMM)
Collaborative Robot (Cobot)	Universal Robots UR10e
Screwdriving Automation	Weber Automatic Screwdriving System (SEV-L Series)
Autonomous Mobile Robot (AMR)	MiR250 (Mobile Industrial Robots)
Warehouse Automation / Shuttle System	SSI Schäfer Cuby Shuttle System (Germany)

Each alternative achieved the highest composite score in its respective category, aligning with prioritized dimensions such as precision, automation compatibility, and investment return.

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