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Critical Success Factors Business Heavy Equipment in Indonesia: Challenges, Opportunities and Sustainability

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The heavy equipment industry plays an important role in Indonesia's infrastructure development and mining sector. However, there are still various challenges faced by businesses in this sector, including high initial investment costs and increasing operational costs. This study aims to identify Critical Success Factors in the heavy equipment business and fill the knowledge gap regarding the influence of these variables. The research methodology uses a quantitative approach with the Partial Least Squares Structural Equation Modeling (PLS-SEM) method to test the hypotheses that have been formulated. The results show that initial investment, lifetime components, and physical availability have a significant influence on heavy equipment business success, while financial treatment, cost of ownership, and used unit prices do not show a significant influence. A good initial investment and the use of the latest technology in maintenance and materials can extend machine life and reduce downtime, which in turn improves operational efficiency. In addition, optimizing productive time and minimizing unproductive time also play an important role in operational success. The implication of this study is that heavy equipment companies need to focus on managing initial investment, optimizing component life, and physical availability of machines to improve their performance and competitiveness.

Keywords: heavy equipment; operational efficiency; critical success factors; PLS-SEM; Opportunities.

1. Introduction

The heavy equipment industry plays an important role in infrastructure development and the mining sector in Indonesia. Heavy equipment is used for various construction activities such as the construction of roads, bridges, buildings, as well as mineral exploration and extraction in the mining sector. Heavy equipment sales data shows significant fluctuations from 1990 to 2022, reflecting changing economic conditions and government policies that affect the industry. For example, heavy equipment sales peaked in 2011 with 17,360 units, reflecting the high investment in infrastructure projects during that period. However, the impact of the global

economic crisis and the COVID-19 pandemic saw a sharp decline in sales, as in 2009 and 2020.

Despite the importance of the heavy equipment industry in the economy, there are various challenges faced by businesses in this sector. One of the main issues is the high initial investment cost for purchasing new machines, which is affected by rising material prices and shipping costs. In addition, ownership costs such as maintenance and operational costs are also increasing. Economic fluctuations and government policy uncertainty further exacerbate this situation. Another issue is the increasing demand for new technologies such as electric and autonomous machines that require additional investment (Febrianto et al, 2022).

Strategic Management Theory states that in order to achieve competitive advantage, companies must be able to identify and utilize Critical Success Factors (CSFs) that are relevant to their industry. In the context of the heavy equipment business, CSFs include factors such as new technology adoption, cost management, and operational optimization. According to technological innovation theory, the adoption of technologies such as IoT and AI can improve efficiency and productivity, but require significant investment. Total cost of ownership theory is also relevant in criticizing high maintenance and operational costs, where companies should consider long-term costs rather than just initial costs.

This research is important to understand the key factors that determine the success of the heavy equipment business in Indonesia. By understanding the CSFs, companies can develop more effective strategies to improve competitiveness and business sustainability. In addition, this research can provide insights for policymakers in designing policies that support the growth of the heavy equipment industry. Given the importance of this industry in infrastructure development and mining, the research results are expected to make a real contribution to the Indonesian economy.

This research is also relevant in a global context, where technological changes and market dynamics are constantly evolving. A better understanding of CSFs can help heavy equipment companies in Indonesia to compete in the global market and benefit from the latest technology trends. In addition, this research can serve as a reference for other researchers interested in the study of the heavy equipment industry or related sectors in different countries.

The heavy equipment industry in Indonesia faces various challenges in achieving sustainable success. The main issue studied is how critical success factors (CSFs) affect the heavy equipment business in an evolving economic and technological context. Identifying and understanding these CSFs is critical for companies to survive and compete in a dynamic market. As such, this research aims to delve deeper into the critical success factors and how their application can improve heavy equipment business performance.

2. Literature Review

Research conducted by Laureani and Antony (2016) entitled Leadership - a critical success factor for the effective implementation of Lean Six Sigma. This study is a qualitative research published by Total Quality Management & Business Excellence. This study found that effective leadership is a key factor in successful Lean Six Sigma implementation. The similarity with this study is the focus on identifying key success factors that have a significant

impact on business performance. However, Laureani and Antony's research emphasizes more on the leadership aspect, while this research covers broader aspects including technology and operational costs.

Gunduz and Maki (2020) in their research entitled Critical Success Factors for Sustainable Construction Project Management examined the key factors that influence sustainable construction project management. This research was published by Sustainability and used a quantitative approach to identify these factors. The results showed that risk management, stakeholder engagement, and green technology are key success factors. This study has similarities with this study in terms of analyzing the key factors, but the difference lies in the focus of the study which is more specific to sustainable construction projects compared to the heavy equipment industry in general.

Simatupang, Piboonrungroj, and Williams (2017) in their research entitled A critical analysis of supply chain issues in construction heavy equipment examined supply chain issues in the heavy equipment industry. This research was published by the International Journal of Logistics Management and used the critical analysis method. The results showed that supply chain integration, information technology, and supplier relationship management are key factors that influence success in this industry. This research is similar to this study in that it focuses on the heavy equipment industry, but emphasizes supply chain issues rather than overall success factors.

Mohd Qadri (2013) in his research entitled Analysis of critical success factors of world-class manufacturing practices examines the key factors in world-class manufacturing practices. This study was published by the International Journal of Production Research and used a quantitative approach. The results showed that technological innovation, product quality, and human resource management are key success factors. This research is similar to this study in that it focuses on technological innovation and resource management, but is more specific to the manufacturing sector than the heavy equipment industry.

This study aims to identify and understand the key success factors (CSFs) that influence the heavy equipment business in Indonesia. Unlike previous studies that are more specific to certain sectors or aspects, this research takes a more holistic approach by covering various aspects such as technology, cost, operations, and customer satisfaction. Thus, this research is expected to provide more comprehensive and applicable insights for companies in developing effective strategies to achieve long-term success in the heavy equipment industry.

The researcher believes that the identification and understanding of Critical Success Factors (CSFs) is crucial in improving the competitiveness and sustainability of the heavy equipment business in Indonesia. This perception is based on the observation that the heavy equipment industry faces various challenges, including high investment costs, increasing operational costs, and the need for new technology adoption. The researcher believes that by identifying the right CSFs, companies can develop more effective strategies to face these challenges and achieve long-term success.

Strategic Management Theory is the main foundation in this study. This theory emphasizes the importance of internal and external environmental analysis to identify opportunities and threats facing the company. In the context of the heavy equipment business, this theory helps

researchers understand how companies can utilize their resources and capabilities to achieve competitive advantage. Researchers believe that through an in-depth analysis of CSFs, companies can develop strategies that are more adaptive and responsive to market and technological changes.

Total Cost of Ownership (TCO) theory is relevant in analyzing the cost of machine ownership, including purchase, operational and maintenance costs. We argue that understanding and managing TCO can help companies make smarter and more efficient investment decisions. By applying this theory, researchers can identify significant cost components and find ways to optimize these costs. Researchers believe that by reducing TCO, companies can increase their profitability and competitiveness (Febrianto et al, 2023).

Technological Innovation Theory is the focus in understanding how the adoption of new technologies can affect the performance of heavy equipment businesses. Researchers argue that technological innovations, such as the use of the Internet of Things (IoT) and artificial intelligence (AI), can improve operational efficiency and reduce downtime. This theory helps researchers evaluate the impact of technology on productivity and business sustainability. Researchers believe that companies that are able to adopt and integrate new technologies well will have a significant competitive advantage (Febrianto et al, 2023).

This research paradigm draws on the integration of these three theories to develop a comprehensive understanding of the key success factors in the heavy equipment business. Strategic Management Theory provides a framework for environmental analysis and strategy development, Total Cost of Ownership Theory assists in cost management, and Technology Innovation Theory provides insight into technology adoption. By combining these three theories, the researcher can produce a comprehensive and applicable guide for companies to improve performance and competitiveness in the heavy equipment industry.

We argue that the combination of these theories will enable this research to produce relevant and practical recommendations for heavy equipment companies in Indonesia. Through this approach, the researcher hopes to make a real contribution to the development of this industry and increase understanding of how companies can optimize the use of CSFs to achieve long-term success.

2.1 Hypothesis development

Recent trends show that the initial investment cost of purchasing new machines continues to rise, driven by rising material prices and high shipping costs. In addition, the demand for more efficient and environmentally friendly machines is also affecting prices (Febrianto et al, 2022). Many companies are starting to consider alternatives such as purchasing used machines through online auctions, which offer significant cost savings and faster delivery times.

H1: Increased initial investment costs for new machine purchases, including price and shipping costs, significantly affect the success of the machine business.

In terms of financing, the current trend reflects rising interest rates that affect installment costs and payment tenures. Nevertheless, investment in heavy equipment remains high due to the need to improve efficiency and meet the increasing demand for construction projects. Many companies use leasing or fixed-rate financing to cope with economic uncertainty and take advantage of financing incentives.

H2: Financing conditions such as installment tenure, interest costs, and payment amounts have a significant impact on the success of the heavy equipment business.

The cost of machine ownership, including maintenance and operational costs, continues to rise. The use of technologies such as telematics and data analytics helps companies predict maintenance needs and optimize fuel usage, thereby lowering operating costs and improving efficiency (EquipmentTrader.com). In addition, there is a trend towards the use of electric and hybrid equipment that is more energy efficient and requires less maintenance compared to fossil-fueled equipment.

H3: Cost of ownership, including maintenance and operating costs, significantly affects the success of a heavy equipment business.

The physical availability of machines, including productive and non-productive time, is affected by the adoption of automation and autonomous technologies. These technologies enable machine operations without human intervention, thereby reducing non-productive time and improving jobsite safety. Detection and geofencing systems also help in monitoring and optimizing machine usage.

H4: The physical availability of machines, which includes productive and unproductive time, has a significant impact on the success of a heavy equipment business.

The price of used units of heavy equipment increases along with the high demand due to the high price of new equipment. Purchasing used machines through online auctions is becoming a popular option as it offers more affordable prices and reduced delivery time. Used machine certification programs also provide quality assurance to buyers.

H5: The unit price of used machines significantly affects the success of the heavy equipment business, especially in the context of cost savings and efficient delivery times.

Machine life components are continuously extended through the latest technologies in materials and predictive maintenance. The use of data analytics helps in planning maintenance and replacement of components before major failures occur, thereby increasing machine life and reducing downtime.

H6: The use of new technologies in materials and predictive maintenance, which extends machine life and reduces downtime, has a significant impact on the success of the machine business.

3. Methodology

3.1 Framework CSF-BHE

This research uses a quantitative approach with the Partial Least Squares Structural Equation Modeling (PLS-SEM) method to test the hypotheses that have been formulated. PLS-SEM was chosen because of its ability to handle complex models with many latent variables and indicators, as well as its ability to work with relatively small sample data. This method allows researchers to identify the relationship between independent and dependent variables and test the validity and reliability of the proposed model, as shown in Figure 1.

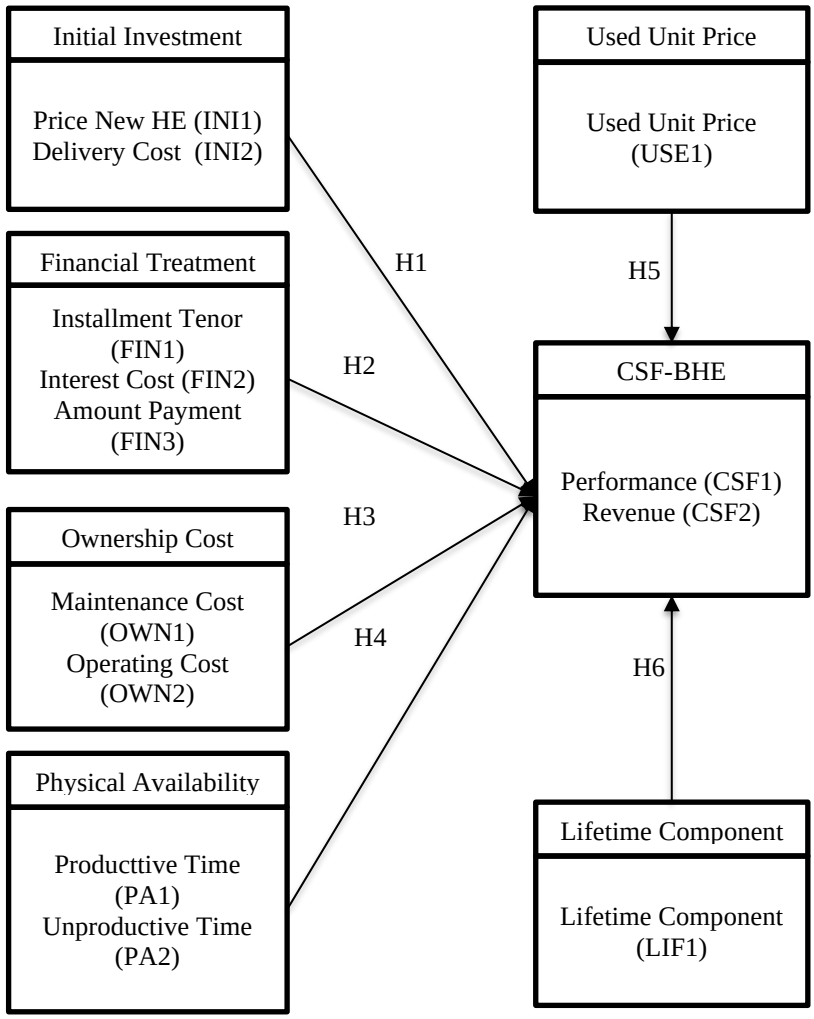

Figure 1. Conceptual Framework

This study measures six main variables that influence the key success factors in the heavy equipment business (CSF-BHE). Initial Investment (INI) evaluates initial costs including the price of the new machine and shipping costs. Financial Treatment (FIN) assesses financing conditions including installment tenure, interest cost, and payment amount. Ownership Cost (OWN) assesses the cost of ownership which includes machine maintenance and operational costs. Physical Availability (PA) measures the physical availability of the machine, including productive and unproductive time. Used Unit Price (USE) evaluates the used unit price of the machine, which is often an economic alternative for companies. Lifetime Component (LIF) measures machine life, including material quality and predictive maintenance technology to extend machine life and reduce downtime. This approach provides a comprehensive view of operational costs and efficiencies, as well as management strategies that can improve the success of the machine business.

3.2 Data Collection

Data was collected through a survey distributed to heavy equipment practitioners. The research sample consisted of 62 practitioners who have experience and knowledge in the heavy equipment industry. The questionnaire was designed to measure variables related to key success factors (CSFs) in the heavy equipment business, including initial investment, financial treatment, cost of ownership, physical availability, used unit price, and service life components, as shown in Figure 2. Each variable was measured using a 5-point Likert scale, ranging from strongly disagree to strongly agree.

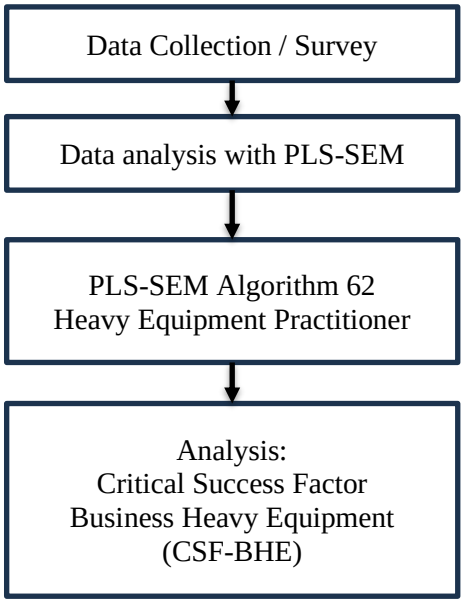

Figure 2. Methodology Outline

The collected data was analyzed using PLS-SEM. The data analysis process begins with an evaluation of the measurement model to ensure construct validity and reliability. Construct validity was tested using convergent validity and discriminant validity, while reliability was tested using composite reliability and Cronbach's alpha. After the measurement model is validated, the next step is the evaluation of the structural model to test the relationship between latent variables and test the research hypotheses.

3.3 PLS-SEM

The data that has been collected is analyzed using PLS-SEM. The data analysis process begins with the evaluation of the measurement model to ensure construct validity and reliability. Construct validity was tested using convergent validity and discriminant validity, while reliability was tested using composite reliability and Cronbach's alpha. Hair et al. (2017) state that a composite reliability value greater than 0.70 indicates a good level of reliability. After the measurement model is validated, the next step is to evaluate the structural model to test the relationship between latent variables and test the research hypothesis. Model validation is carried out through several stages, including measurement model evaluation by looking at the Average Variance Extracted (AVE) value which must be greater than 0.50, as well as

composite reliability and Cronbach's alpha which are expected to be greater than 0.70 (Hair et al., 2017). Structural model evaluation includes measuring Path Coefficients, R-Square (R^2), Effect Size (f^2), and Predictive Relevance (Q^2). Hypothesis testing is done by looking at the t-statistics and p-values of the bootstrapping results, with the hypothesis accepted if the t-statistics value is greater than 1.96 and the p-values are smaller than 0.05 (Hair et al., 2017).

4. Result

4.1 Demographics of respondents

This study involved 62 practitioners from the heavy equipment industry as respondents. Based on work experience, 5 respondents have less than 10 years of experience. Respondents with work experience between 10 to 15 years totaled 25 people, while 14 respondents had work experience between 16 to 20 years. A total of 18 respondents have more than 21 years of work experience, as shown in Table 1.

Table 1. Respondents demograpic characteristics

Experience	N
Below 10 year	5
10 - 15 year	25
16 - 20 year	14
Above 21 year	18
Position	
Director	7
Manager	23
Staff	14
Supervisor	18
Company	
Heavy Equipment Company	18

In terms of position, respondents consisted of 7 directors, 23 managers, 14 staff, and 18 supervisors. All respondents were from heavy equipment companies, with a total of 18 companies participating in the survey. These respondent demographics show a diverse range of experience levels and positions within the company, providing a comprehensive view of the key success factors in the heavy equipment business.

4.2 Descriptive statistics

The SRMR (Standardized Root Mean Square Residual) value for the saturation model and the estimation model is 0.143. SRMR is a measure of model fit that indicates how well the model can reproduce the observed covariance matrix. SRMR values below 0.08 are considered to indicate a good model fit (Hu & Bentler, 1999), so the value of 0.143 indicates an acceptable model fit, albeit slightly higher than the recommended threshold. In addition, the d_ULS (Unweighted Least Squares Discrepancy) value for both models was 1.869, which measures

the model fit using the unweighted least squares method, as shown in Table 2.

Table 2. Model of Fit

Fit Model	Saturated Model	Estimated Model
SRMR	0,143	0,143
d_ULS	1,869	1,869
d_G	0,772	0,772
Chi-Square	274,918	274,918
NFI	0,502	0,502

The d_G (Geodesic Distance) value for the saturation model and the estimation model was 0.772. d_G measures the geodesic distance between the observed covariance matrix and that predicted by the model, where a lower value indicates a better model fit. The Chi-Square value for both models was 274.918, which was used to test the null hypothesis that the proposed model fits the observed data. However, Chi-Square is very sensitive to sample size, and models with large sample sizes often have high Chi-Square values.

The NFI (Normed Fit Index) value for the saturation model and the estimated model was 0.502. The NFI measures the improvement in fit of the proposed model compared to the base model (null model), with values ranging between 0 and 1. The NFI value of 0.502 indicates a moderate model fit and can be further improved. From this descriptive analysis, it can be concluded that the proposed model has a moderate fit with the observed data. This analysis provides a basis for further evaluation and adjustment of the model to improve the overall fit and validity of the model.

4.3 Measurement model

The results of the reliability and validity analysis showed variations in the internal consistency and validity of the measured constructs. The Cronbach's Alpha values for some constructs, such as CSF (0.612), INI (0.636), and OWN (0.471), are below the threshold generally considered adequate (0.7). This suggests that the items in these constructs may not be consistent in measuring the same concept. In contrast, the Cronbach's Alpha values for FIN (0.759), PA (0.901), LIF (1.000), and USE (1.000) indicate good reliability, as shown in Figure 3.

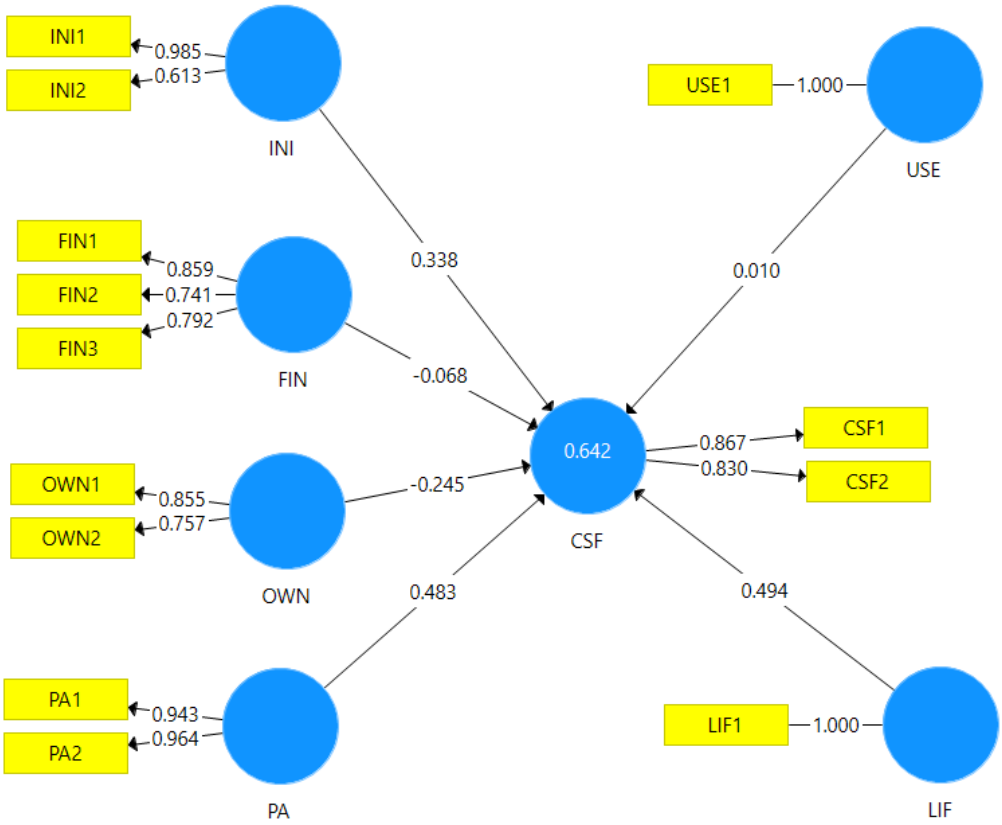

Figure 3. Path diagram framework

In terms of rho_A, most constructs show adequate values, except OWN (0.487) and CSF (0.617) which are still below the 0.7 threshold. This indicates that the reliability of some constructs still needs to be improved. However, the composite reliability (CR) for all constructs is above 0.7, indicating good internal consistency. The high CR values indicate that although some constructs have low internal reliability based on Cronbach's Alpha and rho_A, overall, the constructs are still consistent, as shown in Table 3.

Table 3. Reability and validity of model

Reliability and Validity	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
CSF	0,612	0,617	0,837	0,720
FIN	0,759	0,896	0,841	0,638
INI	0,636	1,856	0,796	0,673
LIF	1,000	1,000	1,000	1,000
OWN	0,471	0,487	0,789	0,652
PA	0,901	0,933	0,952	0,909
USE	1,000	1,000	1,000	1,000

Convergent validity was measured using Average Variance Extracted (AVE), and all AVE values were above 0.5, indicating good convergent validity. This means that the constructs managed to capture most of the variance attributable to their indicators compared to the error variance. Overall, these results indicate that most constructs have adequate validity and reliability, although there are some areas, especially the OWN construct, that require further attention to improve measurement consistency and reliability.

4.4 Hypotheses testing

The analysis shows that not all variables have a significant influence on the key success factors (CSFs) in the heavy equipment business. The Financial Treatment (FIN) variable has a coefficient of -0.0682 with a T-value of 0.5420 and a P-value of 0.5880, so this hypothesis is rejected. This indicates that financing conditions such as installment tenure, interest cost, and payment amount do not have a significant impact on the success of the heavy equipment business. Similarly, the Ownership Cost (OWN) and Used Unit Price (USE) variables are also insignificant, with a P-Value of 0.2128 and 0.9406 respectively, as shown in Table 4. This indicates that maintenance and operational costs, as well as used unit prices, do not have a major influence on the success of the heavy equipment business.

Table 4. Hipotheses analysis of critical success factors through PLS-SEM

Variable	Coef	Mean	STDEV	T	P	Hypotheses
FIN -> CSF	-0,0682	-0,0442	0,1258	0,5420	0,5880	Rejected
INI -> CSF	0,3380	0,3002	0,1956	1,7278	0,0846	Accepted
LIF -> CSF	0,4944	0,4690	0,1689	2,9271	0,0036	Accepted
OWN -> CSF	-0,2451	-0,1842	0,1965	1,2476	0,2128	Rejected
PA -> CSF	0,4835	0,4296	0,1441	3,3550	0,0009	Accepted
USE -> CSF	0,0097	0,0399	0,1307	0,0746	0,9406	Rejected

On the other hand, the Initial Investment (INI) variable shows a positive coefficient of 0.3380 with a T-value of 1.7278 and a P-value of 0.0846. Although the P-Value is slightly higher than 0.05, this hypothesis is accepted as it shows a positive trend that initial costs, including the price of new machines and shipping costs, have an effect on business success. The Lifetime Component (LIF) and Physical Availability (PA) variables show a highly significant influence on CSFs, with coefficients of 0.4944 and 0.4835 and P-values of 0.0036 and 0.0009, respectively. The use of the latest technology in materials and predictive maintenance that extends machine life as well as machine physical availability that includes productive and unproductive time have a positive and significant impact on machine business success.

In conclusion, this study found that initial investment, service life components, and physical availability are key variables that contribute significantly to machine business success. In contrast, financial treatment, cost of ownership, and used unit price did not show a significant effect. These results provide important insights for heavy equipment companies to focus on managing initial investment, optimizing lifetime components, and ensuring physical availability of heavy equipment to improve their business performance and success.

5. Findings and discussion

This study found that the variables of initial investment, component life and physical availability have a significant influence on Critical Success Factors in the heavy equipment business. The initial investment variable shows a positive effect, indicating that high initial costs, including the price of new machines and shipping costs, contribute positively to business success. This suggests that companies that are able to manage their initial investment well tend to perform better in the long run.

Component life has the most significant influence. The use of the latest technology in materials and predictive maintenance that extends the life of the machine proved to contribute greatly to business success. This is in line with the literature which states that investment in maintenance technology can reduce downtime and improve operational efficiency. Physical availability also showed a significant effect, indicating that optimal productive time and minimal unproductive time are critical to operational success.

Although the financial treatment variable did not show a significant effect on business success, these results provide insight that financing conditions such as installment tenure and interest costs may not be the main factors determining success in the heavy equipment industry. Instead, a focus on managing initial investment and operating costs seems to be more critical. This may be due to the fact that companies in this industry tend to have varied and optimized financing strategies that have little impact on overall performance.

Ownership costs also did not show a significant effect. While maintenance and operational costs are an important part of the total cost of ownership, this result indicates that firms may already have good practices in managing these costs so that they are not a determining factor in business success. Companies that have invested in maintenance technology and operational management are likely to have the ability to better control ownership costs, reducing their negative impact on business performance.

In contrast, the price of used units also had no significant effect on business success. This suggests that while purchasing used machines can be a more economical alternative, this factor does not have a significant impact on company success. This may be because the quality and reliability of used machines may vary, and the decision to purchase used machines should be tailored to the specific needs and operating conditions of the company.

The findings of this study have practical implications for managers and company leaders in the heavy equipment industry. The main focus should be on managing the initial investment, optimizing the component life, and ensuring the physical availability of the machine. Investments in the latest technologies for predictive maintenance and the use of high-quality materials can help extend machine life and reduce downtime. In addition, strategies to efficiently manage productive and unproductive time are critical to improving operational performance.

Overall, this study provides important insights into the key factors that contribute to machine business success. Initial investment, lifetime components, and physical availability proved to be the key variables affecting business performance. On the other hand, financial treatment, cost of ownership, and used unit price showed no significant influence, emphasizing the importance of focusing on operational management and technology investment. These results

can be used by companies to develop more effective strategies to improve efficiency and competitiveness in a competitive market.

6. Conclusions

This study aims to identify and understand the critical success factors (CSFs) in the heavy equipment business in Indonesia. Based on the results of the analysis, it was found that the variables of initial investment, lifetime components, and physical availability have a significant influence on the success of the heavy equipment business. Initial investment, which includes the cost of purchasing and delivering new machines, has been shown to contribute positively to company performance. This shows the importance of good management of initial investment costs to achieve long-term success.

The service life component, which includes the use of the latest technologies in materials and predictive maintenance, has the most significant influence. Companies that invest in these technologies are able to extend machine life and reduce downtime, thereby improving operational efficiency and business performance. In addition, the physical availability of machines, which includes productive and unproductive time, also plays an important role in determining a company's operational success. Optimizing physical availability can reduce unproductive time and increase productivity.

In contrast, the variables of financial treatment, cost of ownership, and used unit price did not show a significant influence on the success of the heavy equipment business. This suggests that while these aspects are important, they are not the main determinants of heavy equipment business performance. Companies that have optimized their financing strategies and cost of ownership management seem to have been able to control the negative impact of these variables. Therefore, the main focus of companies should be on managing initial investment, optimizing component life, and physical availability of machines to improve competitiveness and success in a competitive market. The results of this study provide strategic guidance for companies in developing best practices to achieve long-term success.

Future research could explore additional variables such as government policies and macroeconomic conditions, use a longitudinal approach to observe changes over a longer period of time, and combine a qualitative approach with in-depth interviews to gain direct perspectives from practitioners. In addition, comparative studies across countries can identify best practices from different geographical contexts, while a focus on the influence of digitization and automation can evaluate the impact of new technologies such as IoT and AI on operational efficiency. Evaluating risk management strategies is also important to understand how heavy equipment companies manage market uncertainty and volatility to ensure long-term success.

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of the heavy equipment industry and make a positive contribution to the wider community.

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