Development Study of Cost of Ownership Model in Heavy Equipment Business in Indonesia

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Abstract

In general, few people have comprehensively researched the cost of machine ownership. This research will present a new model to calculate the cost of machine ownership that is influenced by several critical factors such as Initial Cost, Maintenance Cost, and Operating Cost. The financial literacy gap in this sector causes many heavy equipment owners to be unaware of their business income potential. The methodology used is mathematical modeling that combines several methods to create a new model of heavy equipment ownership cost analysis. The main result of this research shows that the developed model provides a new perspective in calculating the cost of ownership. The model shows that the machine has the most optimal value if the cost is paid in installments. In addition, the model considers external factors such as changes in primary energy prices and fluctuations in backup power generation costs, thus providing a more accurate picture of costs. The implications of this research are that it makes it easier for machine owners to calculate ownership costs, improve operational efficiency, and support better investment decisions.

Keywords: Heavy Equipment, Ownership Cost, Initial Cost, Maintenance Cost, Operation Cost.

PT United Tractors, as one of the leaders in the heavy equipment industry in Indonesia, recorded significant sales in 2021 with 3,088 units sold, exceeding the set target of 1,700 units. The sector distribution of these sales included mining at 53%, construction at 25%, forestry at 12%, and agriculture at 10%. Meanwhile, the target for 2022 was set at 3,700 units (PT United Tractors, 2021). However, a preliminary survey shows that 24% of heavy equipment owners are unaware of the income potential of their business, indicating a financial literacy gap within the sector. Total sales of heavy equipment in Indonesia in 2021 reached 14,706 units, but

around 3,530 units (24%) were not optimized in use, indicating low operational efficiency. Previous research shows that few people have comprehensively examined the cost of ownership of heavy equipment, and the currently developed value is based on the life cycle (Bharati, 2019). This paper will introduce a new model for machine ownership cost that is influenced by several critical factors such as initial cost, maintenance cost, and operational cost (Chandra et al., 2023). The motivation of this research is to develop a machine ownership cost model that is more accurate and relevant to actual conditions in the field.

Overall Cost Modelling

The overall cost modeling developed using the microgrid model produces a quantification assessment by comparing the overall cost of penetration and microgrid reliability. Overall costs are obtained by adding initial costs plus operating costs.(Febrianto et al., 2023) The initial cost is obtained by multiplying the initial cost by one per total year during the equipment's life cycle and then the operational cost is obtained from the backup power generation which is added by 8760 and multiplied by the primary energy consumption price. From this model, the overall costs obtained only have a limited perspective, namely initial costs and operational costs so that other costs cannot be predicted comprehensively (Luo et al., 2022).

Total Cost Of Ownership Framework

The total cost of ownership above is the sum of capital, financial and operational costs plus air pollution costs.(Febrianto Anggi, 2023) Total cost of ownership also facilitates the possibility of an increase or change in book value from year to year caused by changes in costs that occur.(Febrianto, Dewi Sofianti, et al., 2022) However, the method above only focuses on the straight line method so that the results obtained do not represent costs that will arise in the future and the use of the formula cannot accommodate all forms of costs and additional cost factors that change over time (Onat et al., 2022).

There are several important issues that need to be highlighted in research related to machine ownership costs and overall cost assessment models. In general, there is a financial literacy gap among machine owners. Preliminary survey results show that 24% of machine owners are unaware of the revenue potential of their business. This ignorance can lead to poor business decisions and sub-optimal asset management.

In addition, low operational efficiency is a significant problem. Of the total heavy equipment sales in Indonesia in 2021, around 3,530 units or 24% were not optimized in use. This suggests that operational efficiency in the heavy equipment sector is still low, which could result in higher operating costs and lower return on investment.

On the other hand, research on machine ownership costs is still very limited. Few people have comprehensively researched the cost of machine ownership. Existing research is mostly based on the life cycle but has not considered all relevant cost factors thoroughly.

Existing overall cost models also have limited perspectives. The overall cost model developed using the microgrid model only provides a limited assessment of initial costs and operating costs and is unable to predict other costs comprehensively. This makes the model less able to provide a complete and accurate cost picture.

In addition, the overall cost model does not consider various external factors such as changes in primary energy prices or fluctuations in backup power generation costs. This lack of influence of external factors makes the model less adaptive to dynamic changes in economic and environmental conditions.

The current total cost of ownership framework also has limitations in its methodology. The framework only focuses on the straight-line method, which makes the cost assessment results unrepresentative of the costs that will arise in the future. It is also unable to

accommodate all forms of costs and additional factors that change over time.

In addition, the current total cost of ownership framework does not fully account for costs related to air pollution, which is an important factor in the environmental impact assessment of heavy equipment use. This inability to accommodate air pollution costs leads to incomplete cost evaluations and insufficient attention to sustainability aspects.

The use of the straight-line depreciation method in calculating book value also has limitations. This method causes the valuation results to be less flexible and cannot accommodate changes in asset value that may occur during the equipment's life cycle. This method also does not consider other factors that can affect the depreciation of asset values.

These issues emphasize the importance of developing a more comprehensive and adaptive cost of ownership model and framework. The new model developed should be able to cover all cost factors and changes that may occur over time. This research aims to address this gap by presenting a new model that is completer and more accurate in assessing the cost of ownership of heavy equipment.

This research is important and urgent as it identifies and resolves key issues in the heavy equipment ownership sector in Indonesia, namely low financial literacy, suboptimal operational efficiency, and limitations in existing cost assessment models. The survey results show that most machine owners are unaware of the revenue potential of their business, which negatively impacts decision-making and asset management. In addition, the overall cost models used today only consider initial costs and operating costs, without considering external factors and additional costs that may arise over time. Therefore, the findings of this research provide a solution to the problem by providing a more comprehensive and adaptive cost of ownership model, capable of providing a more accurate and complete picture of costs. This will not only improve operational efficiency, but also assist machine owners in planning and managing costs more effectively, which will ultimately improve their profitability and business sustainability.

Therefore, this research aims to explore and develop a new model for machine ownership costs that is more comprehensive and accurate. The model will consider various critical factors such as initial cost, maintenance cost, operational cost, as well as external factors that may affect the overall cost. By using a more holistic approach, this research is expected to provide a more effective solution to the existing problems, as well as improve financial literacy and operational efficiency in the heavy equipment sector. In addition, this research also aims to develop a framework that is adaptive to changing economic and environmental conditions, so that it can provide a more realistic picture of costs and support better decision-making for machine owners.

Method And Data

Heavy Equipment In This Research

In the process of preparing the methodology, one of which is the use of heavy equipment in this paper, a screening was carried out such as sectors that use heavy equipment against the types of heavy equipment that are most widely used as in table 1 below.

Table 1: Kind of heavy equipment in Indonesia.

Kind of heavy equipment	Used Sector					This Research
	Plantation	Mining	Construction	Transportation	Logging	
Backhoe Loader	*Used*	X	*Used*	*Used*	X	X
Bulldozer	*Used*	*Used*	X	X	*Used*	X
Big Hydraulic Excavator	X	*Used*	X	X	*Used*	X
Small Hydraulic Excavator	*Used*	*Used*	*Used*	X	*Used*	*Used*

Motor Grader	X	*Used*	*Used*	X	*Used*	X
Heavy Duty Dump Truck	X	*Used*	X	X	X	X
Small Dump Truck	*Used*	X	*Used*	*Used*	X	X
Wheel Dozer	*Used*	X	X	X	X	X
Wheel Loader	X	*Used*	X	*Used*	*Used*	X

Source: Prepared by the author (2024)

In Table 1, the most popular heavy equipment used in various sectors in Indonesia is the small excavator.(Gurcanli et al., 2017) So, the focus of the object in this study is the small excavator (Elia et al., 2020). Komatsu brand has the largest sales of heavy equipment each year in Indonesia.(Febrianto, Pratama, et al., 2022) So, the focus of the brand object in this study is the Komatsu brand. In Table 2 are the types of small excavators from the Komatsu brand that are currently popular.

Table 2 Model small excavator in brand komatsu

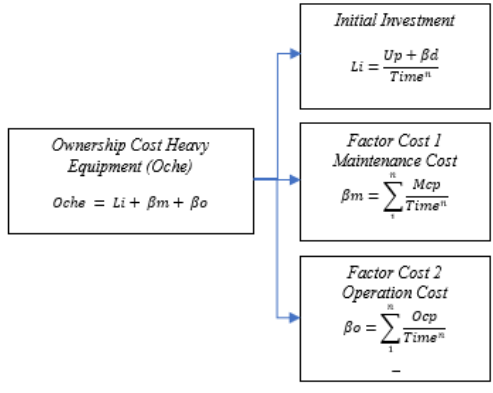
Model Small Excavator	Plantation	Mining	Construction	Transportation	Logging	This Reseach
PC45MR-3	*Used*	*X*	*Used*	*X*	*X*	*X*
PC70-8	*Used*	*X*	*X*	*X*	*X*	*X*
PC137F-10M0	*Used*	*X*	*X*	*X*	*X*	*X*
PC195LC-8	*Used*	*X*	*Used*	*X*	*X*	*X*
PC200-10M0CE	*Used*	*Used*	*Used*	*X*	*Used*	*X*
PC210-10M0	*Used*	*Used*	*Used*	*X*	*Used*	*Used*
PC300SE-8M0	*Used*	*Used*	*Used*	*X*	*Used*	*X*
HB365-1	*X*	*X*	*Used*	*X*	*X*	*X*

Source: Prepared by the author (2024)

In Table 2, the most popular small excavator used in various sectors is the PC210-10M0 model. So, the focus of the object in this study is the small excavator with the PC210-10M0 model.

Heavy Equipment Ownership Costs Framework

In ownership costs there are many cost factors that will be considered, one of which is initial costs, then maintenance costs and operating costs. The costs contained in ownership costs will of course continue to change according to the age of the unit and according to the situation and conditions over time.



Ownership Cost Heavy Equipment (Oche)

Oche=Cost/Time (lifetime Value) …….. (6)

Oche = Li+Factor 1 + Factor 2 + ...+ 〖Factor〗 ^n ……..……..... (7)

Initial Cost Investment

Li=(Up+βd)/〖Time〗^n
…… (8)
Factor 1 Maintenance Cost
β m=∑_1^n▒(Maintenance Cost Planning (Mcp))/〖Time〗^n
…… (9)
Mcp=Costschedulemaintenance(Csm)+CostUnschedulemaintenance(Cum)
…… (10)
Cum=∑_1^n▒〖(Csm*Coefficient maintenance (fm))*Coefficient time of maintenance(fΔt)〗
…… (11)
Factor 2 Operating Cost
β o=∑_1^n▒(Operation Cost Planning (Ocp))/〖Time〗^n
…… (12)
Ocp=((cost operator(co)+cost consumable(cc))/Time)*Plan production in hour (Pph) …….. (13)

Oche =Li+βm+βo
……. (14)

Legend
Ii : Initial investment
Up : Unit price
β d : Budget delivery
β m : Budget maintenance
β o : Budget operation
Time : in years
Mcp : Maintenance cost planning
Csm : Cost schedule maintenance
Cum : Cost unschedule maintenance
Ocp : Operating cost planning
fm : Coefficient maintenance
fΔt : Coefficient time of maint
Co : Cost operator
Cc : Consumable cost
Pph : Plan production in hours
Oche : Ownership cost heavy equip

Table 3: Reference of ownership cost

No	Deskripsi	*Authors*
1	*Ownership cost*	(Cichy et al., 2018)(lo Storto, 2018)(Brenner et al., 2018)(Palmer et al., 2018)(Wouters & Sandholzer, 2018)(Simon Mariono & Andrian Saputra, 2020)(Febrianti & Zakia, 2019)(Tatas et al., 2018)(Rödger et al., 2017)(Susanti et al., 2021)
2	*Initial Cost*	(Gurcanli et al., 2017)
3	*Maintenance Cost*	(Kirchherr et al., 2023)(Acerbi, 2020)(Kyi Swe et al., 2019)(Auda, 2019)(Škerlič & Sokolovskij, 2020)(Wibowo & Santosa, 2021)(Ernest Monday & Ugbomhe, 2021)
4	*Operation Cost*	(Kjaer et al., 2019)(Bharati, 2019)(Sassanelli et al., 2019)(Nikolaou et al., 2021)

Source: Prepared by the author (2024)

Result And Discussion

Validation Factors

From the research results, all factors are accepted into the latent variable cluster which influences the endogenous variable Ownership Cost (OC). The latent variables consist of Initial Cost (IC), Maintenance Cost (MC) and Operation Cost (OC) which are tested using SMART PLS shown as figure 1.

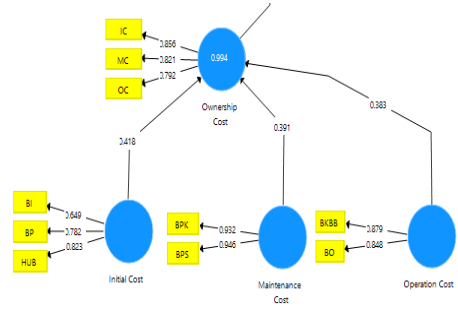


Figure 1: Validation factors using SMART PLS

From the research results on figure 4, it was found that the relationship (correlation) between the independent variable and the dependent variable was strong and moderate, the explanation is as follows:

1. Initial Cost (IC) to Ownership Cost is 0.660 (Strong)
2. Maintenance Cost (MC) to Ownership Cost is 0.651 (Strong)
3. Operation Cost (OC) to Ownership Cost is 0.651 (Strong)

Table 4: Loading Factors

No	Code	Description Variabel	Loading Factor
3		**Initial Cost**	
	HUB	Price New unit	0.823
	BP	Delivery Cost	0.782
	BI	Cost of Interest	0.649
4		**Maintenance Cost**	
	BPS	Periodic Service Cost	0.946
	BPK	Comp. Replacement Cost	0.932
5		**Operation Cost**	
	BO	Operator Cost	0.848
	BKBB	Fuel Consumption	0.879

Source: Prepared by the author (2024)

Initial Cost (IC) significantly influences Ownership Cost (OC) with a significance level of 0.002 and a total effects coefficient of 0.241, indicating that the more effective the Initial Cost, the higher the value impact on the heavy equipment feasibility analysis. Maintenance Cost (MC) has a positive and significant impact on Ownership Cost (OC), with a significance of 0.021 and a path coefficient of 0.219, indicating that the more effective the Maintenance Cost, the higher the value impact on the heavy equipment feasibility analysis. Operation Cost (OC) has a positive and significant impact on Ownership Cost (OC), with a significance of 0.007 and a total effect coefficient of 0.209. shows that the more effective the Operation Cost, the higher the value impact on the heavy equipment feasibility analysis(Bressanelli et al., 2019) .

The cost of owning heavy equipment or what is often called ownership cost of heavy equipment is a calculation of the total costs that will be incurred while the equipment is being used. In this research, the ownership costs that will be considered are initial costs, maintenance costs, and operational costs (Castro et al., 2022).

Initial Cost

These initial costs are the costs of purchasing heavy equipment to start a heavy equipment rental/rental business. This initial cost consists of several costs that are needed, including heavy equipment purchase costs, delivery costs and installment (Chiappetta et al., 2020). The initial costs for heavy equipment in table 5 are then converted to initial costs every year and converted to initial costs for each hour of operation. This method will make it easier to analyse the ownership costs of heavy equipment. The initial costs in table 5 are divided into every 1000 hours up to 10000 hours or the equivalent of a payment tenor of 5 years.

Table 5: Initial Cost Per Years

Time	Conversion to hour meter	Initial Cost Per Years
0,5 Year	1000 Hours	193.750.000
1 Year	2000 Hours	193.750.000
1,5 Year	3000 Hours	193.750.000
2 Year	4000 Hours	193.750.000
2,5 Year	5000 Hours	193.750.000

3 Year	6000 Hours	193.750.000
3,5 Year	7000 Hours	193.750.000
4 Year	8000 Hours	193.750.000
4,5 Year	9000 Hours	193.750.000
5 Year	10000 Hours	193.750.000

Source: Prepared by the author (2024)

So the initial costs can be written as follows:

$$Initial\ investment\ (Li) = \frac{Unit\ price\ (Up) + Budget\ delivery\ (\beta d)}{Time\ (Installment)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(15)$$

The discussion of initial costs above provides a general calculation model for determining initial costs. making it easier for heavy equipment owners to calculate heavy equipment maintenance needs in the investment process.

Maintenance Cost

Maintenance cost in installments plotted with a linear approach line so that it gives an idea that maintenance costs are linear to the age of the unit (Daman et al., 2020). The costs incurred for heavy equipment maintenance are the same as the age of the unit so this can be used as a reference by owners in making heavy equipment investment analyzes from purchase to 14,000 working hours.

Table 6: Coefficient approach of unit prices

Hour meter (i)	Actual	Approach	Coefficient (η)
1000	20,00	20	0,014
2000	28,00	25	0,017
3000	20,00	30	0,021
4000	50,00	40	0,028
5000	20,00	50	0,034
6000	68,72	70	0,048
7000	86,54	90	0,062
8000	166,43	115	0,079
9000	136,43	140	0,097
10000	162,31	165	0,114
11000	184,50	190	0,131
12000	268,79	215	0,148
13000	227,37	240	0,166
14000	211,30	270	0,186

Source: Prepared by the author (2024)

The linear model approach can be seen in detail in table 6 with details of the increase in maintenance costs from the first 1000 working hours to the next 14000 hours. A generalization of this approach can be taken as a maintenance cost coefficient point on the price of a new unit. The coefficient value of the unit price of 1,450,000,000 divided by the cost of the heavy equipment maintenance approach produces detailed maintenance costs for 1000 hours of 0.014. The coefficient of 0.014 from the price of this new unit can be used as a reference for calculating total maintenance costs and so on. So, maintenance costs can be written as follows:

Maintenance Cost (βm)=Price new unit (Hub)* Coefficient (η) ……..(16)

So the formula will be used,

〖βm〗_i=Hub* η_i (Tabel 22) where (i) is hour meter (i) …… (17)

To find total maintenance costs, you can use the formula,

∑_1^i▒〖βm〗_i =∑_1^i▒〖Hub* η_i (Tabel 22)〗 where (i) is hour meter ke-(i) ……..(18)

Where η_i is coefficient value, see table 22.

The discussion of total maintenance above provides a general calculation model for determining maintenance costs from working hour (i) to working hour (i). making it easier for heavy equipment owners to calculate heavy equipment maintenance needs in the investment process.

Operation costs

Operational costs are the costs needed to run heavy equipment operations. Heavy equipment operational costs include fuel costs and operator costs. In this study, other operational costs were not a factor in the calculation.

Fuel costs

The cost of fuel for heavy equipment is determined by the fuel consumption of the heavy equipment and the cost of fuel purchased from the fuel manufacturer. Fuel consumption on heavy equipment is divided into 3 perspectives, namely low fuel consumption, the second is medium fuel consumption and the third is high fuel consumption. From a low fuel consumption perspective, it is in the range of 17 liters per hour to 20 liters per hour. Then the second perspective is medium fuel consumption with a consumption range of 20 liters per hour to 22 liters per hour or the normal category. Meanwhile, the third perspective has high fuel consumption with a consumption range of 22 liters per hour to 24 liters per hour.

Fuel prices in Indonesia can be seen in databooks published in 2023. Industrial diesel fuel or you can use the Pertamax Dex price at Pertamina. The price of Pertamax Dex in June and July has increased from 13250 to 13550, so the price increase needs to be predicted so that when making fuel cost calculations it can be adjusted to the length of work to be carried out. So fuel costs can be written as follows:

Fuel cost=Fuel Consumption (L/hour)*Price Fuel ……..(19)

The discussion of fuel costs above provides a general calculation model for determining fuel costs per hour by determining the amount of fuel consumed and the cost of the fuel used. making it easier for heavy equipment owners to calculate heavy equipment fuel needs in the investment process.

Operator Costs

Operator costs labor costs in operating heavy equipment. In this research, we use a reference from Law number 6 of 2023 in article 77 relating to the number of working hours as well as a reference for the district minimum wage to obtain the amount of rupiah per hour. The provisions of article 77 read as follows, working time as intended in paragraph 1. Every entrepreneur is obliged to implement the working time provisions including 7 working hours in 1 day and 40 working hours in 1 week for 6 working days in 1 week, or 8 working hours in 1 day and 40 working hours for 1 week for 5 working days in 1 week. The working hours provisions in article 77 can be interpreted as the worker's obligation to fulfill 40 working hours per week or 160 working hours per month (Bharti, 2018).

Average wages in various sectors in Indonesia according to book data. The national average wage data is 2,940,000 with working hours of 160 hours per month. So, the operator costs with the national average hourly wage are 18,375 / hour. So, the operator costs can be written as follows:

Operator cost= (wages operator)/160*(i) where (i) is hour meter. ……..(20)

The discussion of operator costs above provides a general calculation model for determining operator costs per hour by determining the amount of the operator's wages and the number of hours worked according to the regulations used. making it easier for heavy equipment owners to calculate heavy equipment operator costs in the investment process.

4.4 Analysis Ownership cost heavy equipment

Analysis of each cost results in more appropriate cost planning so that Ownership Cost Heavy Equipment (Oche) is the sum of Initial investment, Maintenance Cost and Operation

Cost. Shown by combining the formulas and equations below. The ownership cost heavy equipment equation is an equation formed from an age perspective based on working hours. So, the unit of total cost of this heavy equipment becomes cost per hour or cost per hour. Table 7 contains a combination of initial costs, maintenance costs and operational costs for each working hour. Then the results of ownership cost of heavy equipment are obtained as in table 7.

Table 7: Ownership cost heavy equipment.

Time	Hour meter	Initial Cost	Maintenance Cost	Operation Cost	Ownership Cost
0,5 Year	1000	193	20	18	231
1 Year	2000	193	25	18	236
1,5 Year	3000	193	30	18	241
2 Year	4000	193	40	18	251
2,5 Year	5000	193	50	18	261
3 Year	6000	193	70	18	281
3,5 Year	7000	193	90	18	301
4 Year	8000	193	115	18	326
4,5 Year	9000	193	140	18	351
5 Year	10000	193	165	18	376
5,5 Year	11000	0	190	18	208
6 Year	12000	0	215	18	233
6,5 Year	13000	0	240	18	258
7 Year	14000	0	270	18	288

Source: Prepared by the author (2024)

In Figure 7 the initial cost is flat and constant from 1000 working hours to 10,000 working hours. Meanwhile, maintenance costs appear linear with the age of the unit from 1000 working hours to 14,000 working hours. Meanwhile, operation costs are flat or constant from 1000 working hours to 14,000 working hours. This indicates that initial costs and operational costs are constant, while maintenance costs are linear with the age of the unit.

Then for ownership costs, the results of adding up the total costs of heavy equipment can be seen in Figure 2. There is a trend of increasing costs from 1000 working hours to 10,000 working hours, then decreasing at 11,000 working hours and a linear increase again up to 14,000 working hours. This is because the range from 1,000 working hours to 10,000 working hours occurs due to quite large initial costs, while at 11,000 working hours there is a decrease due to the absence of initial costs. So, it can be seen in the graph in Figure 2 that there is a drastic increase and decrease at 10,000 and 11,000 working hours.

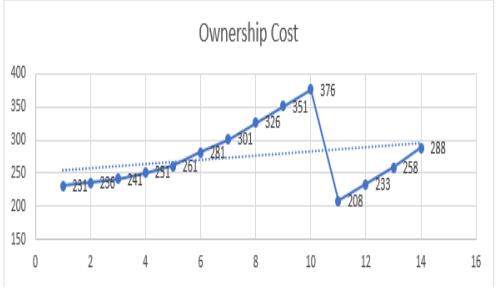


Figure 2: Ownership Cost Heavy Equipment

The data figure 2 above shows that the total cost required from 1000 working hours to 14,000 working hours is 3,842,000,000. In detail, the total initial cost is 1,930,000,000. Maintenance costs amount to 1,660,000,000. Then the operating costs are 252,000,000. By knowing the total costs, it can be used as a reference for calculating heavy equipment investment. So, cost calculations can be used to calculate the profitability that will be obtained for the PC200 type heavy equipment business.

Conclusion

This research shows that the cost of ownership of heavy equipment is the result of a combination of existing studies and research developed in the field of heavy equipment to obtain a new mathematical model in calculating the cost of ownership from an economic and investment perspective. This research aims to facilitate stakeholders or heavy equipment owners in assessing heavy equipment investments to be made from an economic point of view, especially the cost of ownership. The key to success in assessing the cost of ownership is how all costs are defined. The cost of ownership paid in installments will give a broad view to heavy equipment owners or investors that the business being run has predictable costs. Proper improvement will result in appropriate business planning for the heavy equipment rental business.The benefits of these findings, both theoretical and practical in the field of Industrial Engineering, are significant. Theoretically, the findings enrich the literature and provide a new mathematical model that can be used in further research related to machine ownership costs. Practically, this model offers a solution for stakeholders in making better and well-informed investment decisions, thus improving efficiency and business planning in the heavy equipment rental industry. However, this research has limitations and is far from perfect, so further research is needed so that the developed model can be easily implemented. Combining cost of ownership with revenue will strengthen investment decision-making methods and generate better perspectives. The development of digital-based benefits can also be an option for future research, making these tools easier to use by stakeholders.

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