



Application of Analytical Hierarchy Process (AHP) Method in Determining Commercial Vehicle Type of Supply Considering Owning and Operating Cost

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Abstract Customer vehicle is a type of vehicle used to transport goods for commercial purposes. In Indonesia commercial vehicle distributor is the center of sales distribution, thus the marketing and sales team must be able to offer their product according to each customer needs. In the common practice, the offering is only based on customer budget of the vehicle price (owning cost) for the required specifications, without providing an understanding of the total cost of ownership which includes operating costs. The team's lack of knowledge about vehicle specifications and operating costs is the main cause, for this reason it is necessary to analyze the calculation of owning & operating costs and determine the offer for the type of commercial vehicle. The purpose of this study is to determine the type of commercial vehicle that must be selected in order to earn more profit for the customer, as well as to provide an investment feasibility analysis of the type of commercial vehicle selected based on the calculation of the vehicle's owning & operating cost. Vehicle selection analysis is carried out using the Analytical Hierarchy Process (AHP) by comparing alternative vehicle options by considering the specification criteria, purchase price, and maintenance costs. In addition, an investment feasibility analysis is carried out using NPV and IRR analysis to find out whether the investment made is profitable or not.

Keywords Investment analysis, Owning & Operating Cost, AHP, NPV, IRR

Introduction

Commercial vehicles are types of vehicles used to transport goods or passengers for the use of commercial. Even though the increments does not giving a good impact to the environment [1-10], especially from the exhaust emission [10-12]. Along with the increasing number of production mass will meet domestic needs as well as fill foreign market demands. In the other hand, the production increase will bring an impact to the commercial vehicle market in Indonesia, which also brings the opportunity to develop logistics business industry.

According to Indonesia Central Bureau of Statistics (BPS) data[13], the need for commercial vehicle ranks third highest compared to other types of motorized vehicles every year[14, 15], which increased in 2019 about 4.68% compared to 2018.



Table 1: The Growth of Number of Vehicles by Type

Vehicles by Type	The Growth of Number of Vehicles by Type (Unit)		
	2017	2018	2019
Total	118,992,708	126,508,776	133,617,012
Motorbike	100,200,245	106,657,952	112,771,136
Passenger Car	13,968,202	14,830,698	15,592,419
Freight Car	4,540,902	4,797,254	5,021,888
Bus	213,359	222,872	231,569

Sourced: Republic of Indonesia Police (Revision data on 2015-2018)

Indonesia has 3 top brands of commercial vehicle manufacturers who always vying to increase the sales of their vehicle units. Brand B are the second largest commercial vehicle that is in great demand by logistics entrepreneurs because of considerations, which is economic value and aesthetics, as shown in Table 2. The sales of these commercial vehicles are carried out by each distributor, thus they can focusing their commercial vehicle marketing activities as their core business.

Table 2: Commercial Vehicle Sales Data

Commercial Vehicle Brand	Percentage Sales of Year 2019
Brand A	21.2%
Brand B	56.3%
Brand C	20.4%
TOTAL	100.0%

(Sourced: *Gaikindo Retail Sales*, 2020)

In making offers for the sales of these commercial vehicles, distributors generally have several references, which are generally in the form of prices, vehicle specifications, and after sales service or maintenance and spare parts. The current obstacle is that the marketing team does not yet have an understanding of the value of ownership of goods (Total Cost of Ownership) so that the offer only focuses on the purchase price of a vehicle which is lower than other brands. Another factor of these obstacles is the lack of knowledge of each marketing team regarding vehicle specifications and after sales service needs. In line with this, for buyers who lack information, the only consideration used is on the vehicle with the lowest price without calculating the post-purchase costs, namely for maintenance and replacement of spare parts, as the overall value of the ownership of the goods or vehicle.

Taking this into account, the determination of the type of commercial vehicle should be determined in order to obtain long-term benefits for customers. The Analytical Hierarchy Process (AHP) is a model that is often used to solve complex problems into a hierarchy, by breaking down problems into groups so that problems can be more structured and systematic in the form of alternative choices [16, 17]. One of the criteria used to make a decision to purchase a commercial vehicle is by using the calculation of owning & operating cost so that customers can calculate the estimated total cost of ownership of the vehicle to be purchased. In addition, the previous research shown that the lack of inventory will likewise fetches an impact on the rose frequency of ordering raw materials as well as the raise of total cost of other components [18].

According to Dania's research [19], total cost ownership is the total cost incurred by the customer on the vehicle that can be calculated with a reliable estimate, the total cost of the vehicle consists of the cost of ownership (owning cost) and operating cost (operating cost). The cost of ownership itself consists of the cost of purchasing a vehicle, interest, insurance, depreciation, and application development costs (rear body). While operating costs consist of maintenance costs, spare parts purchase costs, fuel costs, tire replacement costs. This total cost of ownership and operating costs can be calculated in a simulation for 1 year to 10 years.

In addition to calculating the cost of owning & operating costs, as a consideration for decision making, an investment analysis of the purchase of commercial vehicles is also needed to determine whether the decision to purchase the selected vehicle will be profitable or not. Ardianti & Prabowo are explained that to analyze the investment it is necessary to know the Net Present Value (NPV) and Internal Rate Return (IRR) to determine the



feasibility of the investment to be made by taking into account the income and expenses of owning & operating costs of the commercial vehicle [20].

Methods

Owning Cost

Owning costs or ownership costs are costs that must be incurred by vehicle owners to purchase vehicles, even though the actual condition of the vehicle does not always operate, but still costs must be paid. The cost of ownership consists of several major components, namely product price, biofuel cost, and resale value.

Operating Cost

Operation costs or operating costs are costs that must be incurred by the user of the vehicle when the vehicle is working. Operating costs are influenced by several factors including fuel, maintenance including spare parts such as the use of oil, and repair costs [19]. In general, vehicle operating costs are divided into three, namely fuel costs, maintenance costs, and tire costs.

▪ Fuel costs

Calculation of fuel costs can be calculated by the equation:

$$\text{Fuel Cost} = \frac{\text{Milage} \times \text{Duration}}{\text{Fuel consumption rate}} \times \text{Price per liter}$$

▪ Periodic maintenance and periodic maintenance labor

This maintenance and labor costs can be calculated by the calculation below:

$$\text{Maintenance \& Labour} = \text{sparepart price} + \text{Labour cost}$$

▪ Tire Cost

Calculation of the cost of tires can be calculated by the equation:

$$\text{Quantity of Tire} = \frac{\text{Vehicle Usage Time (Month)}}{\text{Replacement Interval (Month)}} \times \text{Tire Quantity} \times \text{Tire Price}$$

Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Process (AHP) is a decision support model developed by scientist Thomas L. AHP is a method for solving a complex problem, by describing the problem in a hierarchical form [16, 21-23]. Hierarchy is a representation of a complex problem in a multi-level structure, where the first level is the goal, then the level of factors, criteria, sub-criteria and so on until the last level is the alternative choice. The use of AHP is to build a hierarchy of criteria, then determine alternative options by comparing both qualitative and quantitative criteria so that the priority weights are obtained so that the best alternative ranking results can be obtained. With AHP, problems will be broken down into a more structured and systematic way, by applying a complex mathematical approach combined with a qualitative approach, making it easier to make decisions.

Research Methods

This type of research based on data collection methods are qualitative research and quantitative research. Qualitative research was conducted by interviewing the sales team. Quantitative research is carried out by observing the vehicle offering process carried out by Sales. The first step is to calculate the vehicle total cost of ownership in the form of owning costs and operating costs based on similar specifications. Owning cost is the initial purchase cost, such as the purchase price, costs for transfer fees or license fees and the resale value of the vehicle [20, 24]. Operating costs are vehicle maintenance costs which include the cost of spare parts, fuel costs



and tire replacement costs [25-30]. The purpose of this step is to determine the best type of commercial vehicle. The analysis is performed to analyze the investment by calculating Net Present Value and IRR to check the feasibility of the investment of buying the commercial vehicle.

Results and Discussion

Criteria Score Weighting

Step 1

Counting cell values and adding them up, the calculation results can be seen in Table 2.

Table 2: Weighting Matrix Between Criteria

Criteria	Specification	Owning Cost	Operating Cost
Specification	1.00	0.33	0.15
Owning cost	3.00	1.00	0.21
Operating Cost	6.77	4.80	1.00
Total	10.77	6.14	1.36

Step 2

Normalize the matrix by dividing the cell value by the number in each column.

Table 3: Matrix of Normalized Criteria

Criteria	Specification	Owning Cost	Operating Cost
Specification	0.09	0.05	0.11
Owning cost	0.28	0.16	0.15
Operating Cost	0.63	0.78	0.74

Step 3

Calculates the average to find the priority vector of the normalized matrix.

Table 4: Matrix Priority Vector Criteria

Criteria	Specification	Owning Cost	Operating Cost	Total	Priorities
Specification	0.09	0.05	0.11	0.26	0.08
Owning cost	0.28	0.16	0.15	0.60	0.20
Operating Cost	0.63	0.78	0.74	2.15	0.72

Step 4

Consistency Test Comparison of Questionnaire Results

Due to the large number of weighting criteria, there may be inconsistency in giving weights due to the lack of focus between one criterion and another. Therefore it is necessary to test the consistency of the weights that have been given.

Criteria Consistency Test

Based on the above equation, it can be obtained the value of the consistency of the criteria which can be seen in Table 5.

Table 5: Criteria Consistency Test

Criteria	Specification	Owning Cost	Operating Cost	Priorities
Specification	1.00	0.33	0,15	0,09
Owning cost	3.00	1,00	0,21	0,20
Operating Cost	6.77	4,80	1,00	0,72
Total	10.77	6,14	1,36	1,00
	Max λ			3.10
	n			3
	CI			0.053
	CR			0.1>0.093



The CR value is less than 0.1 or 10% so that the data can be said to be consistent. Processing data on sub-criteria and range are using the same steps in Steps 1 to 4. So that the weighting of each criterion is clear, as shown in Table 6.

Table 6: Research Results Sub-criteria Weight

Alternatives	Criteria	Weight
Specification	Tub Area	0.162
	Turning Radius	0.085
	Payload	0.245
	Power	0.064
	Fuel Cons	0.444
Owning Cost	<i>Off The Road</i>	0.655
	Administration Fee	0.169
	Selling Price	0.175
Operating Cost	Petrol	0.627
	Maintenance	0.298
	Tires	0.076

Weighting Based on Criteria Data Value

The next step is to translate the value of the criteria data into the weights of each criterion, so that the results are shown in Table 7.

Table 7: Results of Weighting Values

Criteria	Sub Criteria	Brand A	Brand B	Brand C
Specification	0.08 Tub Area	0.162 4.55	0.558 3.88	0.122 3.72
	Turning Radius	0.085 4.5	0.515 4.6	0.282 4.7
	Payload	0.245 1480	0.558 1335	0.263 1075
	Power	0.064 80	0.159 73	0.077 97
	Fuel Cons	0.444 11.7	0.669 10	0.243 9.3
Owning Cost	0.20 <i>Off The Road</i>	0.655 Rp187,035,000	0.106 Rp171,500,000	0.106 Rp101,900,000
	Administration Fee	0.169 Rp14,535,000	0.260 Rp16,405,000	0.106 Rp14,105,000
	Selling Price	0.175 Rp60,480,000	0.558 Rp56,400,000	0.263 Rp34,830,000
Operating Cost	0.72 Petrol	0.627 Rp220,085,470	0.633 Rp257,500,000	0.260 Rp411,290,323
	Maintenance	0.298 Rp112,784,400	0.633 Rp145,356,300	0.106 Rp129,185,274
	Tires	0.076 Rp19,306,667	0.106 Rp17,680,000	0.260 Rp13,066,667

Determination of the Best Alternative

The final step in the AHP method is determining the best alternative by adding up the total of the alternative assessments, namely the result of multiplying each weight of the criteria. The calculation results can be seen in Table 8.

Table 8: Alternative Ranking Results

Alternative	Specification	Owning Cost	Operating Cost	Score Total	Rank
Brand A	0.049	0.042	0.425	0.516	1
Brand B	0.019	0.027	0.154	0.199	3
Brand C	0.008	0.106	0.138	0.251	2

So that the 1st, 2nd, and 3rd alternative rankings were obtained, where Brand A was ranked as the first, Brand C as the second, and Brand B as the third.



Investment Feasibility Analysis Calculation

NPV

Based on the equation for calculating the NPV value, the results of the NPV calculation are as follows:

Table 9: Calculation of NPV (in Rupiah Indonesia)

Year	Invest	Total Revenue	Cost	Depreciation	Brutto	Maintenance and Tax	Net Revenue	i=8.6%
		a	b	c	d=(a-b-c)	e	f=(d-e)	PV
0	201,570,000	. 0	201,570,000	. 0	- 201,570,000	. 0	- 201,570,000	- 201,570,000
1	-	150,000,000	35,217,654	18,141,300	96,641,046	4,375,000	92,266,046	84,959,527
2	-	150,000,000	35,217,654	18,141,300	96,641,046	4,375,000	92,266,046	78,231,609
3	-	150,000,000	35,217,654	18,141,300	96,641,046	4,375,000	92,266,046	72,036,472
4	-	150,000,000	35,217,654	18,141,300	96,641,046	4,375,000	92,266,046	66,331,926
5	-	150,000,000	35,217,654	18,141,300	96,641,046	4,375,000	92,266,046	61,079,122
6	-	150,000,000	35,217,654	18,141,300	96,641,046	4,375,000	92,266,046	56,242,285
7	-	150,000,000	35,217,654	18,141,300	96,641,046	4,375,000	92,266,046	51,788,476
8	-	150,000,000	35,217,654	18,141,300	96,641,046	4,375,000	92,266,046	47,687,363
9	-	150,000,000	35,217,654	18,141,300	96,641,046	4,375,000	92,266,046	43,911,016
10	-	150,000,000	35,217,654	18,141,300	96,641,046	4,375,000	92,266,046	40,433,716
TOTAL							922,660,463	401,131,513

The calculation data obtained a positive NPV value (NPV>) which is Rp. 401,131,513. Meanwhile, that the investment of Brand A is feasible and profitable in the future.

IRR

IRR compares the NPV value at the first interest rate and the second interest rate. To determine the interest rate, it is obtained from the annual value and the A/P factor of 45.8%, where the value is between the interest rate of 40% and 50%.

Table 10: Calculation of IRR

Year	Net Revenue	Interest rate	
		PV (40%)	PV (50%)
0	-Rp201,570,000	-Rp201,570,000	-Rp201.570.000
1	Rp92,266,046	Rp65,904,319	Rp61.510.698
2	Rp92,266,046	Rp47,074,513	Rp41.007.132
3	Rp92,266,046	Rp33,624,652	Rp27.338.088
4	Rp92,266,046	Rp24,017,609	Rp18.225.392
5	Rp92,266,046	Rp17,155,435	Rp12.150.261
6	Rp92,266,046	Rp12,253,882	Rp8.100.174
7	Rp92,266,046	Rp8,752,773	Rp5.400.116
8	Rp92,266,046	Rp6,251,981	Rp3.600.077
9	Rp92,266,046	Rp4,465,700	Rp2.400.052
10	Rp92,266,046	Rp3,189,786	Rp1.600.034
	NPV	Rp21,120,651	-Rp20,237,976
	IRR		0.45=45%

From the IRR calculation, the IRR value of 45% is obtained, where the value is above the initial interest rate of 8.6%. So that the investment in purchasing a Brand A vehicle is feasible and profitable in the future.

Discussion

Based on the research that has been done to be able to analyze the best types of commercial vehicles that can be offered by distributors to their customers, the following conclusions can be drawn:

1. Distributors as the spearhead of sales need to think of strategies to be able to increase sales and make their Commercial Vehicle Products Selling Brand a product that is of interest to customers. In terms of selling price,



Brand A has a disadvantage, namely because the price is relatively higher than its competitors, so to be able to compete with its competitors, it is necessary to take into account the aspects of owning & operating costs as a unit of the total cost of ownership of the ownership of an item.

2. Determination of the type of Commercial Vehicle which is more profitable for the customer is analyzed using the AHP method, where from the calculation results, the results of the alternative ranking of commercial vehicles are obtained which are influenced by several criteria, namely vehicle specifications, owning costs and operating costs. From the results of the analysis, it was found that the best type of CV vehicle was Brand A, which was ranked first with a score of 0.516, Brand B was ranked second with a score of 0.199, and Brand C was ranked third with a score of 0.251.

3. Based on the investment feasibility analysis of the best type of commercial vehicle, namely Vehicle Brand A, the result is that the investment in purchasing brand A commercial vehicles is feasible, based on the results of the calculation of the Net Present Value (NPV) and Internal Rate of Return (IRR) analysis.

- NPV has a positive value ($NPV > 0$), which is the result of the projected profit and loss for 10 years with a positive value of Rp. 401,131,513, thus showing that the investment is feasible to continue
- IRR is 45%, where the value is above the interest at the time of initial investment ($IRR > \text{initial interest rate}$), thus indicating that the investment is feasible to continue.

Table 11: Specification of Models in stage

Nf	Rt	Aw	Cd*1000	V/(Cd*10)	Cv*100
1	1944	11.16	3.484	59.99	2.38
1.15	1820	11.79	3.087	73.20	2.11

Conclusion

Suggestion

Based on the research conducted, the suggestions that can be given are as follows:

1. Create a web-based specification and owning & operating comparison system or application that Sales can use in offering commercial vehicles to customers.
2. Develop research by considering factors

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