

Total Cost of Ownership Evaluation and Investment Feasibility Analysis for Operational Fleet Strategy in the Manufacturing Industry

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Abstract

Operational vehicle lease-or-own decisions cannot be based solely on contract rates or acquisition prices because each alternative reallocates costs and risks differently. This study evaluates vehicle operating costs, total cost of ownership (TCO), and investment feasibility for a four-wheeled operational fleet at a consumer-goods manufacturer. The quantitative case study covered all active vehicles through a census and used operational records and structured interviews. Costs were classified as fixed, variable, and overhead costs over a five-year horizon. Purchase feasibility was assessed using the simple payback period, an NPV implication for non-negative discount rates, and $\pm 20\%$ savings sensitivity. Aggregate annual operating costs were IDR 848,534,400 for leased vehicles and IDR 411,825,600 for owned vehicles, yielding savings of IDR 436,708,800 or 51.46%. Five-year cumulative costs were IDR 4,242,672,000 and IDR 2,059,128,000, respectively. Nevertheless, the per-alternative investment scenario IDR 150,000,000 initial outlay and IDR 12,219,054 annual savings produced a 12.28-year payback and did not recover the investment within five years. All sensitivity scenarios remained above the analysis horizon. The results show that aggregate operating efficiency is not equivalent to the feasibility of purchasing a new unit. The study contributes a decision framework that explicitly separates fleet-level and investment-level evidence. A mixed-fleet strategy is recommended: ownership for stable, highly utilized routes and leasing for flexibility and service continuity.

Keywords: total cost of ownership, vehicle operating cost, lease or own, investment feasibility, fleet strategy.

INTRODUCTION

Operational vehicle fleets serve as a link between production activities, warehousing, internal distribution, and supporting services. Procurement decisions affect cash flow, service availability, maintenance burden, and the risk of operational disruptions. Evaluations that merely compare rental rates with purchase prices may lead to biased decisions because life-cycle costs encompass acquisition, depreciation, energy, maintenance, licensing, insurance, downtime, overhead, and residual value. Total cost of ownership (TCO) provides a structured approach for consistently identifying these costs and supporting more transparent resource

allocation decisions (Bachmann et al., 2024; Rodrigues & da Silva, 2024; Sharma, 2016; Woldt et al., 2025).

The application of TCO to vehicles demonstrates that energy costs, depreciation, and usage patterns can alter which alternative is the most economical (Hagman et al., 2016). At the same time, leasing provides economic value beyond the rental rate: lease contracts can transfer technical risks, improve budget predictability, and preserve financing capacity (Hu et al., 2023; Ma & Thomas, 2023). Broader studies of vehicle costs further highlight the sensitivity of total costs to technology and operating patterns (Liu et al., 2021; Palmer et al., 2018), while the ability to repossess leased assets affects debt capacity (Eisfeldt & Rampini, 2009). Comparisons of powertrain technologies for heavy-duty vehicles also demonstrate that operating context plays a decisive role in determining TCO outcomes (Wang et al., 2024). Therefore, the alternative with the lowest direct cost does not necessarily have the most appropriate service and risk profile.

Fleet governance is also dynamic. Balancing operational workload and maintenance activities can reduce costs when vehicle utilization and condition are continuously monitored (Crespo del Castillo & Parlikad, 2024). The principles of life-cycle costing require a clearly defined time horizon, cost system boundaries, and consistent assumptions (ISO, 2017), while investment evaluation requires distinguishing operational savings from project cash flows while accounting for the time value of money (Ross et al., 2022). This distinction is important because fleet-level data cannot always be directly translated into the cash flows associated with purchasing a single vehicle.

The practical research gap lies in the inconsistent integration of operating cost structures with investment feasibility indicators. Companies may recognize that owned vehicles are operationally less expensive than leased vehicles, but they may not know whether purchasing a new unit can recover the investment within the relevant policy horizon. This study contributes by explicitly separating two levels of evidence: an aggregate fleet operating cost comparison to assess operational efficiency and alternative-specific cash flow scenarios to assess investment recovery. This separation prevents aggregate cost differences from being treated as project savings without proper reconciliation.

The objectives of this study are to: (1) compare the operating cost structures of leased and owned vehicles; (2) calculate cumulative costs over a five-year period; (3) evaluate the feasibility of vehicle acquisition based on payback and the implications for net present value (NPV); (4) test the robustness of the conclusions under changes in cost savings; and (5) formulate a fleet strategy that balances cost efficiency, flexibility, and service continuity.

METHOD

Research Design, Object, and Data Sources

The study employed a quantitative descriptive design using a case study of the logistics/operational unit of a consumer products manufacturing company. The unit of analysis consisted of four-wheeled operational vehicles used for internal logistics. All active vehicles were included using a census technique. Data were obtained from company documents, operational records, and structured interviews with the administrative and logistics departments during the data collection period of October 21–25. The identity of the company was anonymized.

The variables collected included rental or investment costs, vehicle labor, fuel, minor and major servicing, tires, taxes/licensing, tolls, travel consumption, mileage, operating days, usage horizon, and service risks. The analysis used a reference distance of 640 km per day

over 312 operating days, equivalent to 199,680 km per year. The fuel price was set at IDR 5,150 per liter, with an average fuel consumption of 10 km per liter based on the study data.

Vehicle Operating Cost (BOK) and TCO Model

Annual costs were categorized into fixed costs (BT), variable costs (BTT), and overhead costs (BO). Annual vehicle operating costs (BOK) were formulated as $BOK = BT + BTT + BO$. Assuming constant annual costs based on the source data, the five-year cumulative cost was calculated as $TCO_5 = 5 \times BOK$. The efficiency of owned vehicles was calculated as $(BOK_{\text{leased}} - BOK_{\text{owned}}) / BOK_{\text{leased}} \times 100\%$. This structure follows the principles of life-cycle cost identification but does not incorporate price escalation, taxes, or residual value because these parameters were not consistently available at the aggregate level.

Investment Feasibility and Sensitivity

The investment analysis used alternative-specific scenarios from the results document: an initial investment of IDR 150,000,000 and annual savings of IDR 12,219,054. The simple payback period was calculated as the initial investment divided by annual savings. Because the cumulative cash inflow over five years was lower than the initial investment, the NPV would be negative at any non-negative discount rate. Sensitivity analysis was conducted by varying annual savings by -20%, -10%, +10%, and +20%, while keeping the initial investment and time horizon constant.

Interpretation Boundaries

The BOK comparison used aggregate data for the entire fleet, whereas investment feasibility was evaluated using alternative-specific scenarios. The two results were analyzed complementarily rather than reconciled arithmetically. Therefore, the aggregate BOK difference was not treated as the annual cash flow generated by the purchase of a new vehicle. The final decision was formulated by considering cost, flexibility, maintenance, replacement vehicle availability, and asset risk.

RESULT AND DISCUSSION

Operational Characteristics

Table 1. Operational Parameters and Assumptions

Parameter	Value/Description
Object	Four-wheeled operational vehicle for internal logistics
Sampling method	Census of all active vehicles
Data collection period	October 21–25
Analysis horizon	5 years
Reference travel distance	640 km/day; 312 days/year; 199,680 km/year
Fuel price and consumption	IDR 5,150/liter; 10 km/liter

The use of the same operational basis ensures that the comparison between leased and owned vehicles is not affected by differences in distance or working days. The high annual mileage also explains why energy costs become material under the ownership scheme.

However, these figures represent aggregate benchmarks and need to be calibrated for each vehicle before making individual purchase decisions.

Comparison of Annual and Five-Year Costs

Table 2. Comparison of Vehicle Operating Costs

Component	Rent	Self-owned	Lease – ownership
Fixed costs	Rp612,000,000	Rp153,000,000	Rp459,000,000
Variable costs	Rp111,734,400	Rp134,025,600	–Rp22,291,200
Overhead costs	Rp124,800,000	Rp124,800,000	Rp0
Total annual operating costs	Rp848,534,400	Rp411,825,600	Rp436,708,800
Monthly operating costs	Rp70,711,200	Rp34,318,800	Rp36,392,400
Daily operating costs	Rp2,719,662	Rp1,319,954	Rp1,399,708

Owned vehicles generate annual vehicle operating costs (BOK) that are 51.46% lower than those of leased vehicles. The primary source of savings is fixed costs, amounting to IDR 459,000,000. In contrast, the variable costs of ownership are IDR 22,291,200 higher because the company directly bears maintenance and tire costs. This finding illustrates the trade-off between the service premium embedded in leasing contracts and the internalization of technical risks.

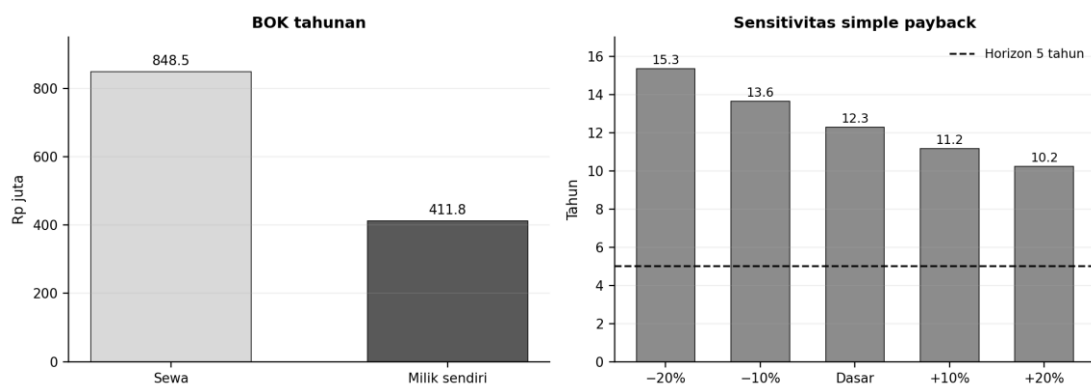


Figure 1. Comparison of Annual BOK and Simple Payback Sensitivity

Table 3. Five-Year Cumulative Costs

Alternatives	Annual Operating Costs	5-Year Accumulation
Rental Vehicle	Rp848.534.400	Rp4.242.672.000
Personal Vehicle	Rp411.825.600	Rp2.059.128.000
Potential Savings	Rp436.708.800	Rp2.183.544.000

Under the assumption of constant costs, the cumulative difference over five years reaches IDR 2,183,544,000. This substantial difference is relevant to fleet portfolio policy but does not automatically represent the cash flow associated with purchasing a single vehicle. The literature also indicates that vehicle TCO comparisons are highly sensitive to usage patterns, energy prices, depreciation, and technology (Hagman et al., 2016; Liu et al., 2021; Palmer et al., 2018; Wang et al., 2024); therefore, individual decisions require unit-level data.

Drivers of Ownership Costs

Table 4. Variable Cost Structure of Owned Vehicles

Component	Annual Cost	Proportion
Light Service	Rp21.000.000	15,67%
Major Service	Rp4.200.000	3,13%
Fuel	Rp102.835.200	76,73%
Tires	Rp5.990.400	4,47%
Total	Rp134.025.600	100,00%

Fuel accounts for 76.73% of the variable costs of owned vehicles. This dominance directs cost-control priorities toward consumption per kilometer, route discipline, vehicle load, tire pressure, driver behavior, and preventive maintenance. The integration of operational workload with maintenance, as suggested by Crespo del Castillo and Parlikad (2024), is relevant to preventing purchasing-related savings from being eroded by downtime and reactive repairs.

Investment Feasibility and Robustness Testing

Table 5. Investment Feasibility Results

Indicator	Results
Initial Investment	Rp150,000,000
Annual Savings	Rp12,219,054
5-Year Cash Inflows	Rp61,095,270
Unrecovered Balance at Year 5	Rp88,904,730
Simple Payback Period	12.28 Years
NPV at a Discount Rate $\geq 0\%$	Negative

Table 6. Sensitivity of Annual Savings

Scenario	Annual Savings	Payback	5-Year Inflows
-20%	Rp9.775.243	15,34 Tahun	Rp48.876.216
-10%	Rp10.997.149	13,64 Tahun	Rp54.985.743
Baseline	Rp12.219.054	12,28 Tahun	Rp61.095.270
+10%	Rp13.440.959	11,16 Tahun	Rp67.204.797
+20%	Rp14.662.865	10,23 Tahun	Rp73.314.324

All scenarios result in a payback period longer than five years. Even when savings increase by 20%, the payback period remains 10.23 years. Because the undiscounted cash flows alone are insufficient to recover the investment, applying a discount rate would further increase the negative NPV (Ross et al., 2022). Therefore, the conclusion that the investment is not feasible within a five-year horizon is robust across the range of changes tested.

This result does not contradict the cost advantage of owned vehicles. Aggregate BOK addresses the question of the overall fleet operating scheme, whereas payback addresses whether a new investment can be recovered from the cash flows that can genuinely be attributed to that investment. This distinction represents a key managerial finding: fleet decisions should use data at the same level of aggregation as the decision being made.

Managerial Implications

Applying a mixed-fleet strategy: owned vehicles for stable routes and high utilization; leased vehicles for fluctuating requirements, critical services, and situations requiring replacement units. Implementing phased purchases once unit-level cost and utilization data, residual value, economic life, maintenance capacity, and attributable savings are available. Controlling fuel consumption through vehicle-level km/liter indicators, route validation, kilometer-liter reconciliation, periodic inspections, and feedback on driving behavior. Negotiating lease contracts based on service levels, utilization, downtime, replacement vehicle availability, and maintenance risk allocation rather than solely on monthly rental rates.

Fleet Decision-Making and Governance Framework

The findings can be translated into a two-dimensional decision-making framework that combines usage intensity and service criticality. Usage intensity determines how quickly the fixed costs of owned vehicles are spread across productive kilometers, while criticality indicates the magnitude of the impact when a vehicle is unavailable. Vehicles with high utilization and stable routes are candidates for ownership because BOK savings can be consistently realized. Conversely, fluctuating or seasonal requirements are more suitable for leasing, allowing capacity to be increased or reduced without adding idle assets. For highly critical services, decisions should not be determined by cost alone; the value of replacement units, provider response time, and disruption recovery capabilities should be explicitly weighted.

Table 7. Fleet Policy Matrix Based on Utilization and Criticality

Demand Characteristics	Key Strategies	Rationale for the Decision	Required Controls
High Utilization; Routine Service	Own	Fixed costs spread across high operating volumes	Fuel, mileage, maintenance, and residual value
Low or Seasonal Utilization	Lease	Avoidance of idle assets and maintenance of flexibility	Effective rates, mileage limits, and termination
Critical Service; Stable Demand	Own + backup contract	Efficiency combined with continuity protection	Replacement unit SLA and recovery plan
Critical Service; Fluctuating Demand	SLA-based lease	Transfer of capacity and technical risks	Availability, response time, downtime, and penalties

Implementing this framework requires monthly data reconciliation at the vehicle level. Each unit should have a cost identity linking kilometers, liters of fuel, downtime hours, service costs, tires, taxes, accidents, and the work performed. These data enable the company to calculate costs per productive kilometer and distinguish vehicles that appear inexpensive because they are infrequently used from those that are genuinely efficient. The difference between contract costs and internal costs can then be treated as a service premium that should be justified by availability, replacement units, risk transfer, and reduced administrative burden, rather than automatically being considered wasteful.

Decision governance should be conducted through portfolio reviews at least every six months. The review should cover projected requirements, asset age and condition, actual costs against budget, maintenance compliance, provider performance, and changes in energy prices. New purchases should proceed only when unit-level cash flows have been reconciled, the payback period is consistent with the policy horizon, and the organization has sufficient maintenance capacity. Lease contracts should be renewed when the service premium remains proportionate to the level of availability and risks transferred. This approach is consistent with life-cycle costing, which views decision-making as an iterative process throughout the asset's life cycle (Bachmann et al., 2024; Rodrigues & da Silva, 2024; International Organization for Standardization [ISO], 2017).

From a sustainability perspective, cost indicators can be expanded to include energy consumption and emissions per kilometer. Financial savings derived from older vehicles do not necessarily correspond to better environmental or safety performance. Therefore, future TCO models should internalize the costs of emissions, service failures, accidents, and end-of-life management. Such an expansion would transform TCO from a cost comparison tool into an asset governance instrument that links efficiency, operational resilience, and environmental responsibility (Bachmann et al., 2024; Rodrigues & da Silva, 2024; Wang et al., 2024).

Limitations of the Study

The analysis uses a single case study, a five-year horizon, and constant cost assumptions. The aggregate data do not include price escalation, taxes, residual value, emissions, measured downtime, or failure probabilities. The investment scenarios also differ in their level of aggregation from the BOK comparison. Future research should develop unit-level cash flows, explicitly incorporate residual value and discount rates, and conduct risk simulations and fleet composition optimization.

CONCLUSION

An owned vehicle incurs an annual operating cost of IDR 411,825,600 – IDR 436,708,800 (or 51.46%) lower than that of a leased vehicle. Over a five-year horizon, the aggregate cost difference amounts to IDR 2,183,544,000. Fuel is the primary driver of variable ownership costs, accounting for 76.73% of the total. However, a purchase scenario involving an investment of IDR 150,000,000 and annual savings of IDR 12,219,054 results in a payback period of 12.28 years; a $\pm 20\%$ variation in savings does not alter the conclusion that the investment is not recovered within five years.

The study's key contribution is the affirmation that aggregate operational efficiency and the feasibility of purchasing new units represent two distinct decision levels that must be analyzed separately. A mixed-fleet strategy and phased replacement align best with the available evidence. Implementation must be preceded by unit-cost measurement, fuel governance, service risk evaluation, and the reconciliation of investment cash flows.

REFERENCES

- Bachmann, T. M., van der Kamp, J., Bianchi, M., Pihkola, H., & Saavedra del Oso, M. (2024). Life cycle costing as part of a life cycle sustainability assessment of products: Methodology and case studies. *The International Journal of Life Cycle Assessment*, 29, 1863–1879.
- Crespo del Castillo, A., & Parlikad, A. K. (2024). Dynamic fleet management: Integrating predictive and preventive maintenance with operation workload balance to minimise cost. *Reliability Engineering & System Safety*, 249, 110243.
- Eisfeldt, A. L., & Rampini, A. A. (2009). Leasing, ability to repossess, and debt capacity. *The Review of Financial Studies*, 22(4), 1621–1657.
- Hagman, J., Ritzén, S., Stier, J. J., & Susilo, Y. (2016). Total cost of ownership and its potential implications for battery electric vehicle diffusion. *Research in Transportation Business & Management*, 18, 11–17.
- Hu, W., Li, K., & Xu, Y. (2023). Leasing and the allocation efficiency of finance. *Journal of Empirical Finance*, 74, 101426.
- International Organization for Standardization. (2017). ISO 15686-5:2017 Buildings and constructed assets – Service life planning – Part 5: Life-cycle costing. ISO.
- Liu, Z., Song, J., Kubal, J., Susarla, N., Knehr, K. W., Islam, E., & Ahmed, S. (2021). Comparing total cost of ownership of battery electric vehicles and internal combustion engine vehicles. *Energy Policy*, 158, 112564.
- Ma, M. S., & Thomas, W. B. (2023). Economic consequences of operating lease recognition. *Journal of Accounting and Economics*, 75(2–3), 101566.
- Palmer, K., Tate, J. E., Wadud, Z., & Nellthorp, J. (2018). Total cost of ownership and market share for hybrid and electric vehicles in the UK, US and Japan. *Applied Energy*, 209, 108–119.

- Rodrigues, S. L., & da Silva, E. A. (2024). Implementation of environmental life cycle costing: Procedures, challenges, and opportunities. *The International Journal of Life Cycle Assessment*, 29, 803–837.
- Ross, S. A., Westerfield, R. W., & Jordan, B. D. (2022). *Corporate finance* (13th ed.). McGraw-Hill Education.
- Sharma, S. K. (2016). Risk adjusted total cost of ownership model for strategic sourcing decisions. *International Journal of Procurement Management*, 9(2), 123–145.
- Wang, Z., Acha, S., Bird, M., Sunny, N., Stettler, M. E. J., Wu, B., & Shah, N. (2024). A total cost of ownership analysis of zero emission powertrain solutions for the heavy goods vehicle sector. *Journal of Cleaner Production*, 434, 139910.
- Woldt, J. J., Prasad, S., & Stapleton, A. (2025). Practice makes perfect: Using the total cost of ownership to teach global locational decision making. *Journal of Purchasing and Supply Management*, 31(2), 100972.