DETERMINING A VEHICLE OPERATING COST MODEL FOR SRI LANKA

Mahesh Kulasinghe, Amal Kumarage
Department of Transport Management and Logistics
Engineering, University of Moratuwa, Sri Lanka.
181430b@uom.lk, amalk@uom.lk

ABSTRACT - Vehicle Operating Cost (VOC) models are essential tools for individuals, businesses, fleets operators, and policymakers who want to accurately estimate the costs associated with owning and operating a vehicle. These models consider various factors, such as fuel consumption, maintenance costs, and depreciation, to provide a comprehensive view of the total cost of ownership. However, selecting the best one can be challenging with so many models available. This research aims to evaluate and compare different global vehicle operating cost models to identify the best one. The study will use a qualitative method, including expert opinions. The evaluation criteria will include accuracy, ease of use, flexibility, and cost-effectiveness. The findings of this research will provide valuable insights for those who rely on vehicle operating cost models to make informed decisions about their transportation needs. By using the best model, they can minimize their costs, optimize their resources, and improve their overall efficiency.

Keywords: Vehicle operating cost; Cost benefit analysis; HDM-4

1. INTRODUCTION

Vehicle Operating Cost (VOC) models are mathematical models that estimate the costs associated with operating and maintaining a vehicle. These models typically consider various factors, such as vehicle type, fuel type, distance traveled, road conditions, and maintenance requirements. By considering these factors, VOC models can provide estimates of the direct and indirect costs associated with vehicle operation, such as fuel expenses, maintenance costs, and time lost due to traffic congestion or accidents. These models are used because VOC per kilometer varies with travel speed, road curvature, gradient, and surface roughness. The model selection can significantly influence the magnitude of the benefit anticipated in the cost-benefit analysis because each model generates different estimates of VOC. [1] Several VOC models are available in the literature, such as HDM-3, COBA9, NIMPAC, ARFORM, TRDF, and HDM-4. Each model has advantages and limitations, making it challenging to select the most appropriate model for a specific application. This research aims to evaluate and compare the selected vehicle operating cost models and identify the best model for applicability in Sri Lanka [2]–[4]. This is important because, VOC studies done in Sri Lanka so far, have not focused on this matter [2]–[4]–[5]. The selected models are HDM-3, COBA9, NIMPAC, ARFORM, TRDF, and HDM-4. The evaluation of these models will be based on two main criteria, namely, the practicality and statistical soundness of the model.

The practicality evaluation of the models considered several factors: ease of use, availability of appropriate input data, and the ability of the model to incorporate pavement-surface conditions as currently being measured [5]. Ease of use is considered how user-friendly the models were. The availability of appropriate input data evaluated how readily available the necessary data were to apply the models, while the ability of the model to incorporate pavement-surface conditions as currently being measured assessed how well the models could include current pavement-surface condition data. These factors were crucial in determining the models' practicality and suitability for practical applications in the transportation sector.

The statistical soundness evaluation of the models focused on theoretical validity and accuracy. To this end, several factors were assessed, including data reliability, original sample size, model assumptions, model formulation, estimation techniques, goodness-of-fit of the model, estimated standard error of the predictions, and statistics of the parameters [5]. This research will justify why HDM-4 is the best model among the selected models. HDM-4 is a comprehensive vehicle operating cost model considering various factors such as pavement deterioration, vehicle characteristics, traffic volume, and environmental impact.

Figure 3. Selected VOC Formulas from HDM-4 Model

HDM-4 Fuel Consumption Model	$IFC = f(P_{tr}, P_{accs} + P_{eng}) = \max(\alpha, \xi \times P_{tot} \times (1 + d_{Fuel}))$
HDM-4 Tire Consumption Model	$TC = \frac{NW * EQNT}{MODFAC}$
Repair and Maintenance Costs Model	$\mathrm{PARTS} = \left(\mathrm{K0}_{pc}\left[\mathrm{CKM}^{kp}\left(a_0 + a_1\mathrm{RI}\right)\right] + \mathrm{K1}_{pc}\right)$ $\left(1 + \mathrm{CPCON} \times \mathrm{dFUEL}\right)$

It has been widely used for road management and planning in many countries due to its accuracy and flexibility. The outcome of this research will provide valuable insights into selecting the best vehicle operating cost model for practical applications.

2. MATERIALS AND METHODS

The methodology used in this research involves a comprehensive review of the literature and qualitative analysis. The analysis will include comparing the selected models based on the abovementioned criteria. These models differ in their underlying assumptions, input parameters, and modeling approaches, which can result in differences in their accuracy and reliability.

The selection criteria include practicality and statistical soundness. The practicality evaluation of the models considered the ease of use, availability of appropriate input data, the ability of the model to incorporate pavement-surface conditions as currently being measured, and reasonableness and applicability to USA conditions. The statistical soundness evaluation of the models considered the theoretical validity and accuracy, which includes data reliability, original sample size, model assumptions, model formulation, estimation techniques, goodness-of-fit of the model, estimated standard error of the predictions, and statistics of the parameters.

3. RESULTS AND DISCUSSION

The literature review and analysis results indicate that HDM-4 is the best vehicle operating cost model among HDM-3, COBA9, NIMPAC, ARFORM [6], TRDF [7], and HDM-4 based on its superior features and applicability to US conditions. HDM-4 incorporates pavement-surface conditions, which is critical for the accurate prediction of vehicle operating costs, and has a robust statistical framework that ensures the accuracy and reliability of the model [8]. In addition, HDM-4 is easy to use and has appropriate input data available. While other models have also been shown to be accurate and reliable, they are limited in their applicability to US conditions and need to incorporate pavement-surface requirements.

Figure 4. Comparison Between Selected VOC Models Based on Features

Features / VOC model	Level of aggregation			Vehicle operation				Road related variables						VOC components					
	Simulation	Project level	Network level	Uniform Speed	Curves	Speed change	Idling	Gradient	Curvature	Superelevation	Roughness	Pavement type	Texture	Fuel, Oil, Tires, Repair/Maintenance, Depreciation	Interest	Cargo damage	Overhead	Fleet shock	Exhaust emissions
HDM-3		■	■	■	■			■	■	■	■	■		■	■		■		
COBA9		■	■	■				■	■					■		■	■		
NIMPAC		■	■	■	■	■	■	■	■		■	■		■	■				
ARFORM	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
TRDF		■		■	■	■	■	■	■		■			■					
HDM-4	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■				■

The discussion of the results highlights the importance of selecting the appropriate vehicle operating cost model for a given context, considering practicality and statistical soundness. The limitations of the selected models are also discussed, which include the availability of appropriate input data and the need for validation against field data.

4. CONCLUSION

The best vehicle operating cost model selection is crucial for decision-making in transportation planning and management. An accurate and reliable model can lead to more efficient and cost-effective solutions for maintaining and improving transportation infrastructure. Finally, HDM-4 is determined as the best VOC model out of the selected models. Before applying HDM-4, it needs to be calibrated for use in Sri Lanka, which is ongoing research.

REFERENCES

1. R. Vehicle and O. Costs, "Transport for NSW Technical Note on Calculating Road Vehicle Operating Costs This document applies to all agencies within the," no. June, pp. 1–40, 2020.
2. S. Ranawaka and H. R. Pasindu, "Estimating the Vehicle operating cost used for economic feasibility analysis of highway construction projects," *3rd Int. Moratuwa Eng. Res. Conf. MERCon 2017*, no. May, pp. 347–350, 2017, doi: 10.1109/MERCon.2017.7980508.
3. A. Fernando and T. Wijesiri, "Vehicle operating cost in Sri Lanka with a special reference on short haul Prime Mover Transportation," *Int. J. Sci. Res. Innov. Technol.*, vol. 1, no. 3, pp. 97–111, 2014, [Online]. Available: http://www.railway.gov.lk.
4. Kumarage, A. S. (2002). Criterion for a fares policy and fares index for bus transport in Sri Lanka. International Journal of Regulation and Governance, 2(1), 53-73.
5. K. Chatti and I. Zaabar, *Estimating the Effects of Pavement Condition on Vehicle Operating Costs*. National Academies Press, 2012.
6. Vehicle operating cost (VOC) models | Australian Transport Assessment and Planning. https://www.atap.gov.au/parameter-values/road-transport/5-vehicle-operating-cost-voc-models (accessed Apr. 28, 2023).
7. P. Bein and D. C. Biggs, "Critique of Texas Research and Development Foundation Vehicle Operating Cost Model," *Transp. Res. Rec.*, no. 1395, pp. 114–121, 1993.