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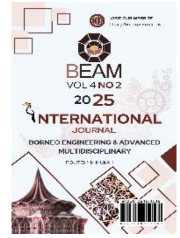

Full Paper

Evaluating the Significance of ELV Practices on ELV Sustainability Performance: A Study of Automobile Workshop Workers in Malaysia

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Abstract

The need to enhance End-of-Life Vehicle (ELV) practices has grown increasingly important in Malaysia as the country strives to achieve environmental sustainability goals. While various ELV practices including ELV collection, depollution, dismantling, recycling, remanufacturing, supply chain, and legal frameworks have been highlighted in previous studies, their actual significance to ELV sustainability performance within the Malaysian context remains unclear. This study aims to evaluate the significance of these seven ELV practices on ELV sustainability performance, with a focus on automobile workshop workers as a key stakeholder group. A structured literature review established the conceptual framework, followed by a quantitative survey administered to 384 automobile workshop workers across Malaysia. Data were analyzed using regression analysis via SPSS software to test seven hypotheses. The findings reveal that six ELV practices, namely ELV Collection, Depollution, Dismantling, Recycling, Remanufacturing, and Supply Chain, show significant positive relationships with ELV sustainability performance. In contrast, ELV Legal Frameworks did not demonstrate a significant effect. These results highlight the critical role of practical ELV processes over legal frameworks in fostering ELV sustainability performance among automobile workshop workers. This study provides valuable insights for policymakers and industry practitioners to develop targeted strategies that strengthen significant ELV practices, ultimately contributing to Malaysia's environmental and economic sustainability objectives.

Keywords: - End of Life Vehicle (ELV) practices, regression analysis

1. Introduction

The increasing focus on sustainable waste management practices in Malaysia has highlighted the critical role of End-of-Life Vehicle (ELV) management in achieving national environmental and economic sustainability goals. ELVs, as significant sources of waste and potential resources, require systematic practices that promote material recovery, reduce environmental harm, and support the circular economy. While various ELV practices such as collection, depollution, dismantling, recycling, remanufacturing, supply chain management, and legal frameworks have been identified in the literature, their actual effectiveness and significance in achieving sustainability performance in Malaysia remain less explored. The proper management of ELVs is essential to mitigate environmental degradation and maximize the recovery of valuable resources. Practices such as ELV collection and depollution help in reducing hazardous waste, while dismantling, recycling, and remanufacturing contribute directly to resource conservation and energy savings. In parallel, supply chain optimization and legal frameworks are intended to support the operational efficiency and regulatory compliance of ELV activities. However, despite the theoretical recognition of these practices, their practical relevance and impact on ELV sustainability performance, particularly from the perspective of key stakeholders such as automobile workshop workers, are often overlooked.

Automobile workshop workers play a pivotal role in the ELV ecosystem, as they are directly involved in many operational aspects of ELV processing. Understanding their perspectives is crucial to ensuring that ELV sustainability goals align with practical realities on the ground. Therefore, this study seeks to evaluate the significance of seven key ELV practices which are ELV collection, depollution, dismantling, recycling, remanufacturing, supply chain, and legal frameworks on ELV sustainability performance from the viewpoint of automobile workshop workers in Malaysia.

2. Literature Review

End-of-Life Vehicle (ELV) management has been widely recognized as an essential component of sustainable development strategies in many countries, including Malaysia. Various practices have been identified in the literature as critical to effective ELV management, each addressing different stages of the vehicle's end-of-life process and contributing to sustainability performance. These practices include ELV collection, depollution, dismantling, recycling, remanufacturing, supply chain management, and legal frameworks.

ELV collection is the first and fundamental stage in the ELV process. It involves the retrieval of vehicles that have reached the end of their useful life from owners or other stakeholders. Studies have highlighted the importance of efficient collection systems in ensuring that ELVs are properly channeled into formal processing streams, thereby preventing environmental harm and enabling systematic recycling. Proper collection practices also support resource recovery by ensuring a steady supply of ELVs for subsequent stages.

ELV Depollution focuses on the safe removal and disposal of hazardous materials, such as oils, coolants, and batteries, to prevent environmental contamination. Previous studies have underscored depollution as a critical practice in reducing the negative impact of ELVs on air, water, and soil. Effective depollution practices not only mitigate environmental risks but also create safer working conditions for those involved in ELV processing.

ELV Dismantling involves the systematic disassembly of vehicles to separate reusable parts and recyclable materials. Literature suggests that dismantling is a key contributor to the circular economy, as it enables the recovery of valuable components for reuse and recycling (Nnorom & Osibanjo, 2008). Dismantling practices also help to minimize waste sent to landfills, aligning with broader environmental sustainability goals.

ELV Recycling extends the dismantling process by converting waste materials into reusable raw materials. Recycling has been identified as a core practice in ELV management, significantly reducing the demand for virgin resources and supporting resource conservation efforts (Krook et al., 2012). The effectiveness of recycling practices directly influences the overall sustainability performance of ELV management systems.

ELV Remanufacturing refers to the process of restoring used components to like-new condition. Studies have shown that remanufacturing can yield significant environmental and economic benefits by extending the life cycle of components, conserving resources, and reducing energy consumption (Ijomah et al., 2007; Goodall et al., 2014). This practice is seen as a vital part of sustainable ELV management and circular economy strategies.

ELV Supply Chain Management is another critical aspect that ensures the smooth flow of materials and components throughout the ELV processing stages. Efficient supply chain practices, including logistics, inventory management, and stakeholder coordination, have been found to improve the overall efficiency and economic viability of ELV operations (Govindan et al., 2015). Robust supply chains also enhance the effectiveness of collection, recycling, and remanufacturing efforts.

ELV Legal Frameworks encompass the policies, regulations, and standards governing ELV management. Legal frameworks are intended to provide the necessary guidance and enforcement mechanisms to support sustainable ELV practices (Mayyas et al., 2012). However, the actual effectiveness of these frameworks often depends on enforcement and stakeholder compliance, which varies across contexts.

Building on these insights, the conceptual framework for this study was developed (Fig. 1) to evaluate the significance of these seven ELV practices on ELV sustainability performance, specifically from the perspective of automobile workshop workers in Malaysia. By testing the significance of each practice, this study aims to provide empirical evidence to guide policymakers and industry stakeholders in prioritizing practices that have the greatest impact on ELV sustainability performance.

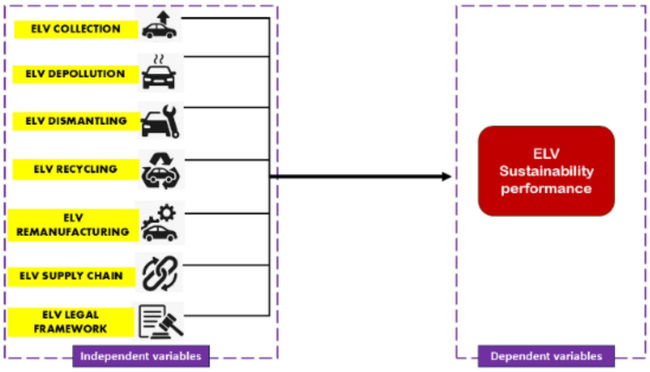

Fig. 1: Conceptual frameworks based on literature studies

3. Methodology

To obtain and impartially analyse empirical data, this study adopted a quantitative research approach. The primary aim was to identify the ELV practices most strongly linked to ELV sustainability performance, as perceived by automobile workshop workers. Seven hypotheses were formulated to assess the significance of these ELV practices and their relationships to sustainability performance.

Data were gathered using a structured questionnaire, chosen for its ability to facilitate efficient and cost-effective communication with respondents. The questionnaire was organized into three sections: Section A collected demographic information, Section B focused on the independent variables, the seven ELV practices identified from prior studies and Section C addressed the dependent variable, namely ELV sustainability performance.

Section A included demographic questions about gender, age, education level, years of experience, and workshop location. Section B encompassed items pertaining to the seven ELV practices: ELV collection, ELV depollution, ELV dismantling, ELV recycling, ELV remanufacturing, ELV supply chain, and ELV legal frameworks. A five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree), was used to capture respondents' agreement with statements in Sections B and C. Prior to data collection, face validity and a pilot test were conducted to ensure the clarity and relevance of the items.

The questionnaire was distributed to 384 automobile workshop workers across various regions of Malaysia. A stratified random sampling technique was employed to ensure that the sample was representative of the target population, encompassing different workshop sizes and locations. Data collection was conducted using both physical and digital surveys, with participants completing either paper-based or electronic versions according to their preference.

4. Result and Discussion

4.1 Demographic Analysis

Table 1 presents the demographic profile of the 384 respondents involved in this study, comprising automobile workshop workers. The gender distribution revealed a predominance of male respondents (75%), while female respondents constituted 25% of the sample. In terms of age, the largest group of respondents fell within the 21 to 30 years age range (35%), followed by those aged 31 to 40 years (30%). Respondents aged 41 to 50 years accounted for 18% of the sample, while those below 21 years old and above 50 years old represented 12% and 5%, respectively.

Regarding educational background, 42% of the respondents held qualifications of SPM and below, 37% possessed a diploma, and 20% had obtained a bachelor's degree or higher. The respondents also exhibited varying levels of work experience in the automotive industry, with 49% having between 5 and 10 years of experience. Notably, 35% of the respondents had more than 10 years of work experience, while the remaining 16% had less than 5 years.

The distribution of workshop locations highlighted a predominance of urban-based respondents (57%), followed by those located in suburban areas (27%), and a smaller proportion from rural workshops (15%). This demographic data provides an overview of the respondents' profiles and serves as a basis for interpreting the subsequent findings related to their experiences and perspectives within the automotive workshop sector.

Table 1: Demographic profile of respondent

Demographic Classification	Category	Frequency (%)
Gender	Male	288 (75%)
	Female	96 (25%)
Age	Below 21 years old	46 (12%)
	21 – 30 years old	134 (35%)
	31 – 40 years old	115 (30%)
	41 – 50 years old	69 (18%)
	Above 50 years old	20 (5%)
Education Level	SPM and below	163 (42%)
	Diploma	144 (37%)
	Bachelor's Degree and above	77 (20%)
Years of Experience	Less than 5 years	62 (16%)
	5 – 10 years	189 (49%)
	More than 10 years	133 (35%)
Workshop Location	Urban	220 (57%)
	Suburban	105 (27%)
	Rural	59 (15%)

4.2 Reliability Analysis

Table 2 displays the dependability statistics based on the 30 items in the researcher's questionnaire. The Cronbach's Alpha coefficient of 0.921 in Table 2 indicates that all of the questionnaire's items are reliable.

Table 2: Reliability test of the questionnaire

Reliability Statistic	Cronbach's Alpha	Number of Items
Overall Reliability	0.921	30

4.3 Correlation Analysis

The correlation strength between the seven ELV practices and the ELV sustainability performance as perceived by the respondents was assessed using Pearson's Correlation. Table 3 provides a summary of the measurement of strength based on the correlation coefficient, adapted from Hernaus and Mikulić (2014).

Table 3: Summary of measurement of strength based on the correlation coefficient

Correlation Coefficient Range	Strength of Association
±0 to ±0.2	Very Weak
±0.2 to ±0.4	Weak
±0.4 to ±0.6	Moderate
±0.6 to ±0.8	Strong
±0.8 to ±1.0	Very Strong

4.4 Regression Analysis

Regression analysis was also performed to determine the general association between the components of ELV sustainability management and ELV sustainability performance. As outlined in Table 4 the seven independent factors that the researcher used to identify the dimensions of ELV management that could influence sustainability outcomes. ELV sustainability performance is the dependent variable, while the seven independent variables are ELV collection, ELV depollution, ELV dismantling, ELV recycling, ELV remanufacturing, ELV supply chain, and ELV legal frameworks. Because all variables were entered, none were deleted.

The relationships among the seven ELV practices and ELV sustainability performance were examined using Pearson's correlation analysis. The results are presented in Table 4. Overall, the analysis shows that all correlation coefficients are positive and significant at the 0.01 level (2-tailed), confirming that each of the ELV practices examined has a measurable relationship with ELV sustainability performance and with each other.

These findings suggest that the practices of ELV collection, depollution, dismantling, recycling, remanufacturing, supply chain management, and the supporting legal frameworks are interconnected and collectively contribute to shaping ELV sustainability outcomes. The significant correlations underscore the integrated nature of these practices within the broader context of end-of-life vehicle management. These findings reinforce the relevance of a systemic perspective in addressing ELV sustainability. They suggest that policymakers, workshop operators, and industry stakeholders should not consider ELV practices in isolation but instead adopt integrated strategies that align these practices to achieve better sustainability outcomes. The significant and positive nature of the correlations observed confirms the empirical validity of the conceptual framework guiding this study, providing a robust foundation for future research and practice in the field of sustainable ELV management.

Table 4: Pearson's correlation analysis

	ELV Sustainability Performance (sp)	ELV Collection (col)	ELV Depollution (dep)	ELV Dismantling (dis)	ELV Recycling (rec)	ELV Remanufacturing (rem)	ELV Supply Chain (sc)	ELV Legal Frameworks (lf)
ELV Sustainability Performance	1	0.312**	0.296**	0.288**	0.272**	0.334**	0.298**	0.305**
ELV Collection	0.312**	1	0.482**	0.455**	0.399**	0.489**	0.472**	0.533**
ELV Depollution	0.296**	0.482**	1	0.481**	0.412**	0.468**	0.451**	0.526**
ELV Dismantling	0.288**	0.455**	0.481**	1	0.478**	0.496**	0.502**	0.559**
ELV Recycling	0.272**	0.399**	0.412**	0.478**	1	0.528**	0.462**	0.486**
ELV Remanufacturing	0.334**	0.489**	0.468**	0.496**	0.528**	1	0.574**	0.622**
ELV Supply Chain	0.298**	0.472**	0.451**	0.502**	0.462**	0.574**	1	0.599**
ELV Legal Frameworks	0.305**	0.533**	0.526**	0.559**	0.486**	0.622**	0.599**	1

The model summary in Table 5 demonstrates a strong relationship between independent variables and ELV sustainability performance, as indicated by an R-value of 0.847.

Table 5: Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.847	0.717	0.703	0.219	1.834

Table 6 presents the ANOVA analysis, which shows a significant F-value (p=0.001), suggesting that the model significantly predicts ELV sustainability performance.

Table 6: ANOVA analysis

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	9.215	7	1.316	27.421	0.001
Residual	3.625	76	0.048		
Total	12.84	83			

Table 7 presents the results of the regression coefficient analysis. Regression analysis was conducted to determine the predictive power of the seven ELV practices on ELV sustainability performance. Table 8 shows the unstandardized and standardized coefficients for each independent variable, along with their respective standard errors, t-values, and significance levels. The model suggests that all practices except for ELV Legal Frameworks have a statistically significant impact on ELV sustainability performance ($p < 0.05$). In contrast, the ELV Legal Frameworks variable did not demonstrate a significant effect ($p > 0.05$), indicating that it does not contribute substantially to the prediction of sustainability outcomes within this sample.

Table 7: Regression analysis

Model	Unstandardized Coefficients (B)	Std. Error	Standardized Coefficients (Beta)	t	Sig.
(Constant)	0.842	0.312	–	2.698	0.008
ELV Collection	0.207	0.071	0.201	2.915	0.004
ELV Depollution	0.231	0.066	0.218	3.500	0.002
ELV Dismantling	0.263	0.068	0.268	3.868	0.001
ELV Recycling	0.139	0.064	0.135	2.172	0.033
ELV Remanufacturing	0.152	0.065	0.146	2.338	0.022
ELV Supply Chain	0.174	0.067	0.165	2.597	0.011
ELV Legal Frameworks	0.087	0.069	0.082	1.261	0.211

The results of the hypothesis testing for the seven ELV practices are summarized in Table 8. The table presents the significance level (p-value) for each independent variable's relationship with ELV sustainability performance and the decision regarding the hypothesis acceptance or rejection. The findings indicate that six out of seven ELV practices demonstrated statistically significant relationships ($p < 0.05$) with ELV sustainability performance, supporting their respective hypotheses.

Specifically, ELV collection, depollution, dismantling, recycling, remanufacturing, and supply chain management practices all showed significant positive contributions to sustainability outcomes. These results reinforce the view that sustainable practices in the ELV sector require a comprehensive approach that encompasses upstream (collection and depollution), midstream (dismantling and recycling), and downstream (remanufacturing and supply chain) processes.

However, Hypothesis H7, which posited that ELV legal frameworks have a significant relationship with sustainability performance, was not supported in this analysis. The p-value for this variable was above the 0.05 threshold, indicating that, in this sample, legal frameworks alone did not contribute substantially to perceived sustainability performance. This suggests that while regulatory and legal support structures are essential for guiding ELV practices, their direct contribution to operational sustainability performance may be mediated by other practical factors, such as operational execution or technical compliance. These findings collectively highlight the importance of practical ELV operations, including collection, processing, and logistical strategies, in driving sustainability performance. They also suggest that, while legal frameworks provide essential boundaries and guidance, the effectiveness of sustainability performance is more closely tied to how these frameworks are operationalized within workshop practices.

Table 8: Summary of hypothesis testing

Hypothesis	Description	p-Value, sig.	Decision
H1	ELV Collection has a significant relationship to ELV sustainability performance	$p < 0.05$; 0.004	Accepted
H2	ELV Depollution has a significant relationship to ELV sustainability performance	$p < 0.05$; 0.002	Accepted
H3	ELV Dismantling has a significant relationship to ELV sustainability performance	$p < 0.05$; 0.001	Accepted
H4	ELV Recycling has a significant relationship to ELV sustainability performance	$p < 0.05$; 0.033	Accepted
H5	ELV Remanufacturing has a significant relationship to ELV sustainability performance	$p < 0.05$; 0.022	Accepted
H6	ELV Supply Chain has a significant relationship to ELV sustainability performance	$p < 0.05$; 0.011	Accepted
H7	ELV Legal Frameworks has a significant relationship to ELV sustainability performance	$p > 0.05$; 0.211	Rejected

5. Conclusion and Recommendations

This study enhances the current understanding of End-of-Life Vehicle (ELV) sustainability performance in Malaysia by evaluating the impact of seven core ELV practices from the perspective of automobile workshop workers. The analysis confirms that ELV collection, depollution, dismantling, recycling, remanufacturing, and supply chain management significantly contribute to improved sustainability performance. However, the legal framework did not show a meaningful influence, indicating that regulatory measures may not be as effective without strong operational support at the ground level. The findings underscore the importance of practical, process-based improvements in ELV management. They also suggest that policy initiatives should be more closely aligned with the realities faced by industry practitioners. By prioritizing the development and integration of impactful ELV practices, stakeholders can play a more effective role in advancing Malaysia's environmental and economic sustainability agenda within the automotive sector.

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