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Investigating the mediating role of environmental efficiency in the impact of data privacy practices on enhancing reverse logistics: Evidence from the automotive engineering sector

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This research investigated how data privacy practices may impact reverse logistics in the automotive engineering sector, particularly by examining whether environmental efficiency plays a mediating role. This research uses the Resource-Based View (RBV) and Dynamic Capabilities Theory (DCT) to understand how data privacy-driven processes support environmental practices and reverse logistics optimization. Primary research is done through structured questionnaires of automotive engineering professionals. The partial least squares structural equation modeling (PLS-SEM) approach tested the relationships amongst data privacy, environmental efficiency, and reverse logistics. However, the results further clarify how key intermediate outcomes, after all, improved environmental efficiency, affected by robust data privacy practices, may enhance reverse logistics processes. The nexus of data privacy and environmental efficiency highlights the critical need to embed respect for private sector information into logistics strategies that achieve superior business performance and also protect corporate sustainability. The findings suggested that environmental consequences must be considered in the flexibility of data-privacy measures with important strategic implications for firms operating in a complex and more environmentally conscious market. This study makes a novel contribution to the extant literature by empirically detecting how environmental efficiency mediates data privacy practices and reverse logistics. These findings will be useful for industry practitioners to use data privacy to enable sustainable logistics management of business operations within automotive engineering.

1. Introduction

Sustainable supply chains heavily rely on reverse logistics, which is particularly problematic in automotive engineering (Hsu et al., 2016). Growing scrutiny has emphasized the importance of enforcing stringent data privacy regulations in tightening these methods (Wang et al., 2019). Preventing any environmental standards violations and optimizing reverse logistics with data privacy managed properly will help ensure a better, transparent flow, foster innovation, and grow efficiency more efficiently in this sector (Patel, 2023). Historically seen only through the lens of compliance and security, data privacy practices are now also accepted as having a role to play in an environmentally efficient future (Musarat et al., 2024). It can reduce reverse logistics waste and optimize resource utilization while protecting sensitive data (Wang et al., 2021). Data privacy initiatives in using logistics processes and environmental outcomes as mediators. Thus, environmental efficiency's mediating role helps explain how data privacy practices contribute to reverse logistics (Ahmad et al., 2023). This reality is structured on a case for data privacy becoming the foundation of an all-holistic strategy for sustainability (De Boeck et al.,

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2023). This dynamic is especially important to understand in the automotive engineering sector, where logistical operations can be incredibly complex. Currently, extant literature investigates the direct effects of practices related to reverse logistics on a firm's operational performance and, no less importantly, how environmental efficiency under data privacy background influences those relationships. The current study examines environmental efficiency as a mediator linking data privacy practices and reverse logistics performance in automotive engineering (Alrifai et al., 2023). This study collected data from automotive companies using an empirical quantitative method and applied statistical methods to measure the relationships. The results provided useful indications for academic and industrial practitioners about how data privacy approaches, in conjunction with environmental Good Logistics Practices, can extract the benefits of full-potential reverse logistics studies (Khan et al., 2024). This research not only enriches the understanding of data privacy but, more importantly, puts forward a blueprint for automotive companies in practice and ambles on while discussing an ecological way to simultaneously improve top-line revenue outcomes like efficiency and environmental responsibility under competitive global market pressures (Qin et al., 2023). Based on the problem statement, the following research questions are formulated:

RQ1: How do the data privacy measures influence the efficiency and quality of reverse logistics processes in automotive engineering?
RQ2 What is the role of mediator environmental effectiveness between data privacy practices and reverse logistics improvement in automotive engineering?
RQ3: How data privacy-driven Environmental Efficiency Practices improving reverse logistics would add value to organizational performance?

The organization of this research is as follows: Section 2 covered the literature on data privacy practices and, based on this background, presented conceptual development along with hypotheses about environmental efficiency as a mediator of influence between data privacy practices towards reverse logistics was reviewed in the automotive engineering sector. Section 3 described the research methodology used for data collection, analytical approaches, and hypothesis testing. The research results, which support or not those taken from the literature review, will be presented and analyzed in section 4. The results presented in Section 5 illustrated the theoretical and practical significance of data privacy-driven reverse logistics for automotive engineering.

2. Literature Review

2.1 Reverse Logistics

Reverse logistics refers to the process of sending goods from their final destination to the manufacturer or other points within the supply chain for repair, replacement, remanufacturing, recycling, and disposition (Shang, 2024) where reverse logistics is important in the remanufacturing and automotive engineering sectors. Cost-effective reverse logistics management has become higher, with an attractive program for the organization and society since it meets industry best practices that allow better resource utilization, environmental benefit, and compliance (Moshood et al., 2024). In automotive, merging reverse logistics with the larger scope of supply chain management could open a significant opportunity to improve overall performance by enabling more effective material reuse (Zavala-Alcívar et al., 2020). But even getting that efficient often means incorporating complex technologies such as privacy-oriented AI systems for automation.

2.2 Data Privacy Practices

Responsible reverse logistics in automotive engineering depends on data privacy practices. These processes ensure the safe and responsible handling of sensitive data, particularly concerning customer privacy or product returns. Moreover, Data Protection in the Supply Chain Reverse logistics is one of several ways data can be protected (Sayginer & Ercan, 2020). In addition, data privacy regulations can improve decision-making *processes by ensuring* appropriate and secure information is easily available, which drives better results for reverse logistics management (Hammes et al., 2020).

2.3 Data Collection

Data collection is Specific data reception, and knowledge of the information is a must in many cases, particularly in areas like automotive engineering, to streamline operations. This compliance-enforced data collection methodology ensures that any necessary returns, repairs, or recycling activities are effectively collected while protecting and respecting privacy guidelines. Without data collection, companies cannot keep track of patterns and trends to be used for the optimization of reverse logistics processes. Advanced AI-enabled data collection capabilities to support automated, compliant reverse logistics operations with more efficiency and sustainably (Ozkaya, 2020).

2.4 Data Storage

One of the critical aspects of data privacy practices in reverse logistics is Data Storage. Data on product returns, customer information and logistics activities are key in the automotive engineering area (Pham et al., 2020). Any solution that stores data must store the data available on demand and protect it from being accessed. Encrypted databases and secure cloud storage do the proper data mechanisms to ensure reliable reverse logistics support. Still, they also maintain either an on-premise encrypted database or utilize ultra-secure options of a cloud-storage solution. A well-functioning system for ensuring that stored data can comply with dominant norms of privacy also helps increase the overall environmental efficiency of reverse logistics by enabling more informed and secure decision-making (Thakur & Breslin, 2020).

2.5 Data Sharing

Data-sharing between different entities related to reverse logistics should comply with the established norm (Khan et al., 2023). In automotive engineering, sharing is key in reverse logistics activities that mostly need information from different departments and suppliers or partners (Brandon-Jones et al., 2014). However, the sharing must be secure to keep sensitive information safe and ensure all involved parties comply with relevant data privacy laws. Creating safe data-sharing protocols and employing automated, AI-driven systems to carry out their mission allows for the rapid exchanging of secure required information (Richter et al., 2022). In doing so, we support the optimization of reverse logistics processes and help make them more efficient and environmentally friendly.

2.6 Environmental Efficiency

Data privacy practices mediate the relationship between environmental efficiency and reverse logistics in automotive engineering. These data privacy elements form an important part of reversing logistics to improve the environmental effectiveness of firms by reducing waste and allowing better use of resources (Park & Li, 2021). To reduce the negative effects of reverse logistics concerning environmental efficiency. This is further supported by effective data privacy practices, which ensure that decisions are based on reliable and secure information, enabling companies to apply more sustainable logistics solutions (Dzwigol et al., 2021). The Streamer integration aligns with the bigger picture of environmental sustainability and operational efficiency.

2.7 The Automotive Engineering Sector

The automotive engineering field is a good candidate for reverse logistics and data privacy practices because of its intricate supply chains (Staniszewska et al., 2020). The sector relies heavily on reverse logistics to handle product returns, recover, recycle materials, and reduce waste, so it represents an ideal field for investigating the repercussions of data privacy practices within business operations. The data privacy part is efficient in an environmental sense, so as the sector uses AI-driven technologies, this discusses the intersection of both important sectors (Shahparvari et al., 2021). This research investigates whether reduced data privacy practices could moderate the relationship between reverse logistics and environmental outcomes, offering unique implications for academia and industry practitioners.

3. Hypothesis Development

3.1 Data Collection and Reverse Logistics

Effective data collection systems related to reverse logistics are becoming increasingly important in automotive engineering. These data collection vehicles provide visibility to the return process, customer behaviors of returned goods, and feedback on logistics operations that are crucial for effective returns management and material reuse (Bennett et al., 2022). Research indicates that strong data collection can enhance reverse logistics with its ability to provide valuable insights for forecasting and strategic planning. In this study, the author argues that reverse logistics methods improve their effectiveness within the automotive sector due to higher-quality data collection systems. Consequently, the research adopts the following hypotheses:

H_1: *Data collection systems have a significantly positive effect on reverse logistics.*
H_2: *Data collection systems have a significantly positive effect on environmental efficiency.*
H_3: *Data collection systems have a significantly positive effect on reverse logistics, mediated by environmental efficiency.*

3.2 Data Storage and Reverse Logistics

Data storage needs a solution to manage and utilize reverse logistic information. As in automotive engineering, the first wave is getting experienced with data storage technologies that are creating new possibilities for firms to analyze large datasets that were not feasible earlier (Alrjoub et al., 2021). The possibility of better inventory management can allow dealers to both predict returns from more accurate analysis and optimize their processes (Jawabreh et al., 2023). The capability of a strong data storage system to enable better reverse logistics via real-time analytics and operational efficiency is an area that has found its way into research conducted across the world. This study suggests the significant effect of data storage on environmental efficiency due to reverse logistics. Consequently, the research adopts the following hypotheses:

H_4: *Data storage systems have a significantly positive effect on reverse logistics.*
H_5: *Data storage systems have a significantly positive effect on environmental efficiency.*
H_6: *Data storage systems have a significantly positive effect on reverse logistics, mediated by environmental efficiency.*

3.3 Data sharing and Reverse Logistics

In automotive engineering improvement of reverse logistics operations requires data sharing. The faster data is shared, the better you can track materials that are returned and streamline reverse logistics processes. Several types of data show that good information sharing between supply chain segments increases overall coordination and decreases delays and waste. Data sharing is empowering fast, easily traceable reverse logistics and the corresponding positive impact on environmental sustainability through massive reductions in greenhouse gas emissions. Thus, the following hypotheses are posited: Therefore, the following hypotheses are proposed:

H$_7$: *Data sharing has a significantly positive effect on reverse logistics.*

H$_8$: *Data sharing has a significantly positive effect on environmental efficiency.*

H$_9$: *Data sharing has a significantly positive effect on reverse logistics, mediated by environmental efficiency.*

3.4 Environmental Efficiency and Reverse Logistics

Environmental efficiency is a huge part of improving reverse logistics in automotive engineering. As companies start implementing data privacy around their environmental priorities, they may find some efficiencies in managing reverse logistics. One effective way resources and waste are managed while decreasing the environmental impact is through robust environmental policy, which enhances reverse logistics processes. The greater focus on environmental efficiency in reverse logistics helps improve a firm's sustainability outcomes and operational performance. This demonstrates the mediating effect of environmental efficiency on data privacy practice usage and further shows a strong potential that embracing sustainable practices can increase overall effectiveness & impact for reverse logistics systems in the automotive domain. Consequently, the following hypothesis is proposed:

H$_{10}$: *There is a positive relationship between environmental efficiency and reverse logistics.*

3.5 Integrating Theoretical Perspectives: Dynamic Capabilities and Resource-Based View in Automotive Engineering

This research proposes a theoretical framework linking dynamic capabilities theory (DCT) and the resource-based view (RBV) in light of environmental efficiency to investigate the relationship between data privacy practices and reverse logistics for their impact on the automotive engineering sector. Dynamic capability theory (DCT) stresses the necessity of a firm and its resources to adapt and reconfigure due to dynamic environments and technological changes. Therefore, the DCT will help to know how data privacy practices can enhance reverse logistics operations in an automaker's context and drive sustainability goals. The RBV expands on this by emphasizing that resources are valuable, rare, inimitable, and non-substitutable (VRIN) so that, e.g., advanced data privacy systems can become strategic assets (Alrjoub et al., 2021). RBV highlights that these resources are important in achieving a competitive advantage and improving organizational performance. When viewed as a strategic asset, data privacy practices are extremely important to manage reverse logistics effectively complementing the aim for environmental efficiency. Combining DCT with RBV provides a broader view of how automotive engineering enterprises can leverage data privacy best practices to improve reverse logistics processes. Regarding the adaptability and strategic reconfiguration for effective reverse logistics, DCT provides key understandings here. At the same time, RBV is applied within a sustainability goal to view data privacy practices as a resource of competitive advantage. The model is theoretically underpinned and helps to understand the application of data privacy for enhancing reverse logistics performance on environmental grounds within an automotive sector, thus providing useful implications in offering sustainable and competitive capabilities (Khaled et al., 2024).

3.5 Research Framework

This research has been carried out to explore the effect of data privacy practices and environmental efficiency on reverse logistics in the automotive engineering sector. This research framework offers significant direction to researchers and practitioners on how to plan strategies for improving reverse logistics and meeting the zenith practices of sustainability (Demirbag et al., 2006). The study focused on data privacy and environmental efficiency as enablers for implementing reverse logistics in supply chains. Fig. 1 shows the conceptual model of the proposed framework for integrating data privacy practices, environmental efficiency, and reverse logistics process. The framework also assumes environmental efficiency as an important mediator, linking data privacy practices with reverse logistics outcomes. In this way, the effects of data privacy and energy efficiency are discussed as improved factors for enhanced reverse logistics performance through sustainability in the automotive industry (Hair et al., 2013; Hatamlah et al., 2023).

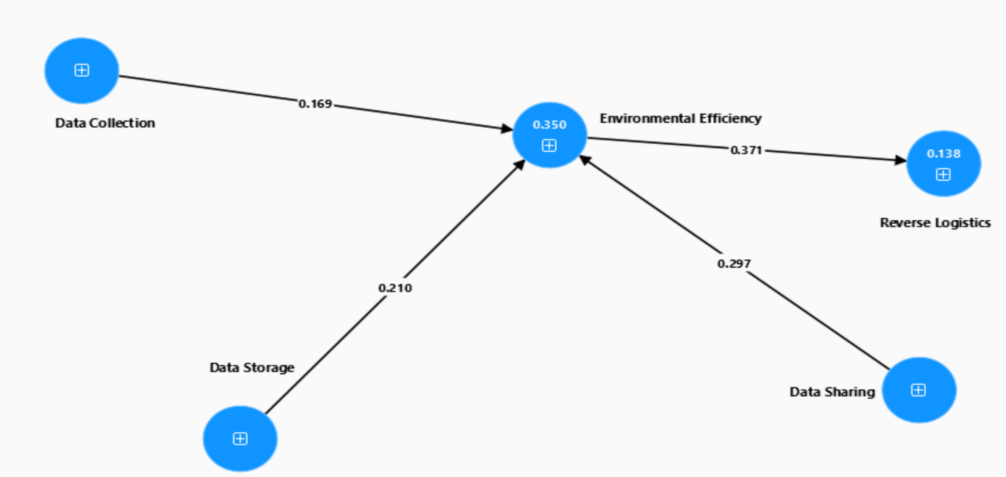

Fig. 1. Conceptual model

4. Research Methodology

4.1. Questionnaire and Pre-Testing

Data Privacy Practice was measured using 8 adapted items from previous studies, while Environmental Efficiency was assessed using 8 measurement-derived instruments taken from the available literature. We again created latent constructs for reverse logistics and environmental efficiency using 12 items taken from similar studies of these two areas. For content validity, the questionnaires were appraised by expert academicians and professionals with in-depth knowledge of data privacy, reverse logistics, or sustainability practices within the automotive engineering sector. A pre-test was also conducted with academic experts and professionals from the automotive engineering sector following an area of expertise in data privacy applications, reverse logistics, and sustainability. The pre-test assesses this in terms of comprehension, relevance, and applicability of the items on our questionnaire. The measures were assessed as appropriate and not in need of revision based on feedback, indicating the survey was ready to be administered more broadly.

4.2. Sample Design and Data Collection

This includes managers/key decision-makers from automotive engineering, supply chain management, and reverse logistics. This group was chosen due to its pertinence to sustainability and the increasing implementation of automotive activity and data privacy practices. 300 useful responses were gathered from automotive project managers, supply chain personnel, and logistics coordinators with long-term experience in data privacy practices for reverse logistics and sustainability performance. The structured survey tool used for data collection was tailored specifically to these professionals, which makes the results more accurate because it can adeptly capture insights into environmental efficiency as a mediating variable between the effective use of data privacy practices and reverse logistics effectiveness in the automotive engineering sector.

4.3. Data Analysis

The data analysis describes its target group, players in automotive engineering, specifically regarding data privacy practices, Supply chain management, and reverse logistics. This cohort was chosen because it is topical to sustainability, and privacy is becoming more important in all facets of automotive operations. This research examined the role of data privacy for reverse logistics in sustainable performance among automotive project managers, supply chain professionals, and logistics coordinators by using a primary sample size of 300 completed responses that have been integrated. The PLS-SEM analysis will highlight the relationships between data privacy practices, environmental efficiency, and reverse logistics. Survey research of reverse logistics data from automotive engineering institutes will offer a comprehensive view of contributing endogenous variables in sustainability practices.

4.4. Common Method Bias

Common method bias is a common issue that arises and potentially influences the observed relationships between variables when data are collected from one source. To overcome this issue, the study performs a collinearity test to examine common method variance (CMV) as suggested for PLS-SEM analysis. To check potential common method bias, Variance Inflation Factors (VIF) were calculated. As a criterion, VIF values over 3.3 would suggest common method bias. In this study, all VIF values are below 3.3, which demonstrates that common method bias does not appear to be a concern in exploring the mediating role of environmental efficiency in enhancing RL through data privacy practices in the automotive engineering industry.

4.5 Assessment of the Measurement Model

Table 1
Measurement items and reliability

Constructs	Items	Factor loadings	Cronbach's Alpha	C.R.	(AVE)
AI-Driven Trust	CD1	0.862	0.869	0.906	0.658
	CD2	0.794			
	CD3	0.825			
	CD5	0.861			
	CD6	0.796			
	CD8	0.751			
Collection of Data	DM1	0.823	0.899	0.922	0.665
	DM2	0.815			
	DM3	0.762			
	DM4	0.794			
	DM5	0.749			
Digital Marketing	DT1	0.827	0.852	0.892	0.623
	DT2	0.86			
	DT3	0.821			
	DT4	0.812			
	DT5	0.73			
Transparency	TR1	0.794	0.901	0.924	0.669
	TR2	0.833			
	TR3	0.817			
	TR4	0.866			
	TR5	0.803			
	TR6	0.794			
Usage of Data	UD1	0.795	0.919	0.935	0.673
	UD2	0.835			
	UD3	0.812			
	UD4	0.838			
	UD5	0.834			
	UD6	0.836			
	UD7	0.789			

Before examining relationships between the variables in this study demonstrating that Data Privacy Practices significantly influence encouraging Reverse Logistics w.r.t to the Automotive Engineering Sector, confirmatory factor analysis (CFA) was conducted first for testing the measurement model. Table 1. Results of the analysis showed that all factor loadings for constructs AI-Driven Trust, Collection of Data, Digital Marketing, Transparency, and Usage matched data above the suggested 0.708 value, laying within range of 0.749 to a high in-sample estimate on latent construct usage was noted at this stage with maximum recordation = 0 The Average Variance Extracted (AVE) values were ranging from 0.623 to 0.673, all above the 0.50 threshold respectively endorsed by these constructs adequately; Composite Reliability (CR) values also exceeded the recommended 0.70 threshold, ranging from.892 to..935, which indicated strong internal consistency as well. The Cronbach's Alpha values, over 85.2% ≥ α | Table 2, further proved the reliability of the constructs as shown below. These results imply strong convergent validity and reliability of the measurement model that is expected to influence subsequent structural analysis, particularly on analyzing the mediating effect between Environmental Efficiency.

Table 2
HTMT

	AI-Driven Trust	Collection of Data	Digital Marketing	Transparency	Usage of Data
AI-Driven Trust					
Collection of Data	0.587				
Digital Marketing	0.412	0.648			
Transparency	0.608	0.827	0.716		
Usage of Data	0.534	0.679	0.467	0.605	

Table 2: For the discriminant validity of the model, the HTMT ratio is considered to be more precise than the Fornell-Larcker criterion (Fornell & Larcker, 1981). It is recommended in the literature to have a cut-off equal to 0.90, which means that constructs are SB than HC; χ2 reports the HTMT values for all constructs AI-driven trust, Collection of Data, Digital Marketing, Transparency, and Usage of Data in Table 3, ranging between a minimum value are less than threshold point which is 827 between collection of data-items transparent and below .90. It confirms the model has discriminant validity, identifying that constructs are separate enough to assess them separately in this study. Disparate constructs of AI-driven trust, Collection of Data, Digital Marketing, Transparency, and Usage of Data are pronounced enough to allow for meaningful analysis that can be done accurately.

Table 3
Fornell-Larcker

	AI-Driven Trust	Collection of Data	Digital Marketing	Transparency	Usage of Data
AI-Driven Trust	0.811				
Collection of Data	0.522	0.816			
Digital Marketing	0.371	0.551	0.789		
Transparency	0.541	0.748	0.609	0.818	
Usage of Data	0.48	0.618	0.4	0.555	0.82

As given in Table 3, the discriminant validity of the constructs was tested using the Fornell-Larcker criterion. Based on this measure, discriminant validity can be claimed when the square root AVE of a construct is more than the correlation of constructs. Table 3 reveals that AI-driven trust 0.811, Collection of Data 0.816, Digital Marketing 0.789, Transparency 0.818, and Usage of Data 0.82 showed higher values at diagonals compared with the inter-correlations of these constructs. This reveals that the constructs are highly different from other constructs. For instance, AI-driven trust, with a diagonal value of 0.811, is higher than its correlated traction with another construct, 0.541 with Transparency. Similarly, the Collection of data, with a diagonal value of 0.816, is higher than its correlation with transparency, which is 0.748. That sufficiently verifies that all constructs in the model are likely measuring different concepts within the model being tested, mainly related to the impact of consumers' data privacy concerns on reverse logistics in auto engineering.

Table 4
R^2 Adjusted

Variable	R-square	R-square adjusted
AI-Driven Trust	0.35	0.343
Digital Marketing	0.138	0.135

The Model fitting of the study was checked using r-square and its adjusted values, which are shown in Table 4. AI-Driven Trust: The R-square is 0.35 which means that these independent variables explain around 35% of the variance, with adjusted R-squared =.343 which adds a bit of correction to a number of predictors this re-confirms stability in the model also In Digital Marketing, R-square is 0.138 which indicates only this much of variation will be explained by the model and adjusted R square being 0.135 justifies that we have a quite good network model in place!! Both of these p-values are less than 0.05, which means these model explanations explain the relationship much better for AI-driven trust but not as strong relationships with Digital Marketing in the case of data privacy practices instead of reverse logistics in the automotive engineering area.

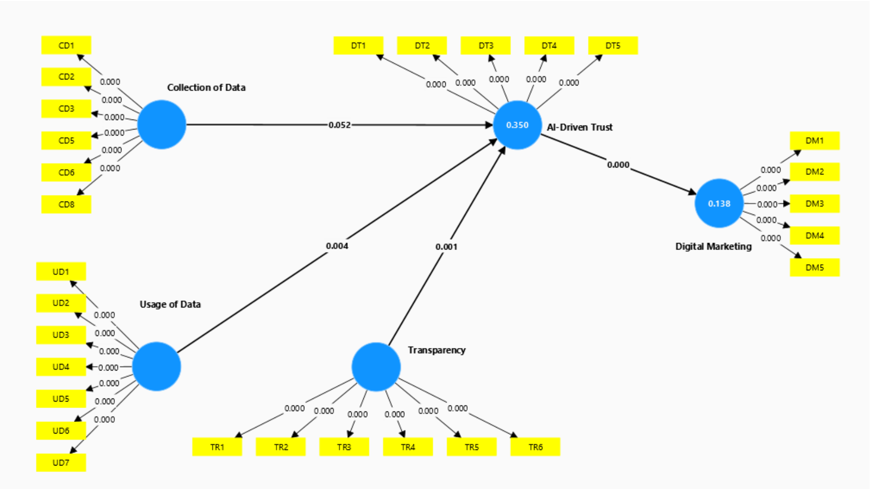

Fig. 2. Measurement model

4.6 Assessment of the Measurement Model

The current study analyzed data privacy practices by emphasizing the mediating role of environmental efficiency between enablers and reverse logistics, providing a measurement model in automotive engineering. To reflect live parameters, the constructs were operationalized into the observed variables using a measurement scale adapted from previous studies on Data Privacy and environmental Efficiency related to Reverse Logistics principles based on a literature review in RBV. As part of the item generation, experts in the automotive engineering field piloted-tested the constructs. To validate the survey-based measurement model confirmed through confirmatory factor analysis, we relied on data collected from across automotive companies representing engineers and decision-makers. Based on this bombarded analysis, the discriminant validity and reliability for all constructs confirmed the robustness of measures. After going through extensive validation at the abstract stage, the results were comprehensive enough for testing structural equation modeling (SEM) and they more clearly revealed how data privacy practices in automotive engineering become part of environmental efficiency and reverse logistics that can assist strategists in offering strategies relating or deviating according to particular green goals.

5. Path Result

5.1 Specific Indirect Effects

Table 6
Hypotheses testing estimates

	Original	Sample mean	Standard	T statistics	P values	Result
AI-Driven Trust → Digital Marketing	0.371	0.379	0.086	4.297	0	Supported
Collection of Data → AI-Driven Trust	0.169	0.176	0.087	1.943	0.052	Unsupported
Collection of Data → Digital Marketing	0.063	0.067	0.038	1.639	0.101	Unsupported
Transparency → AI-Driven Trust	0.297	0.296	0.089	3.335	0.001	Supported
Transparency → Digital Marketing	0.11	0.114	0.046	2.377	0.017	Supported
Usage of Data → AI-Driven Trust	0.21	0.208	0.073	2.885	0.004	Supported
Usage of Data → Digital Marketing	0.078	0.078	0.032	2.448	0.014	Supported

Results in Table 6 indicate that AI-driven trust has a significant and positive influence on digital marketing $\beta = .371$, $p < .001$, where a higher level of trust improved the effectiveness of digital marketing. We also find that transparency is a strong driver of trust in AI $\beta = 0.297$, $p = 0.001$ and digital marketing $\beta = 0.11$, p indicating positive effects on it too; hence, the reinforcement from both sides leads to higher value for money conscience buyers as evident at other research noted above. Data usage and AI-driven trust $\beta = 0.21$, $p < .01$ are also positively associated, as well as data usage and digital marketing $\beta = 0.078$; which indicates the importance of effective use for increasing the required level of Trust through utilization necessary to improve Marketing efforts respectively. Conversely, the relationships of data collection with AI-trust $\beta = 0.169$, $p > .05$ and digital marketing $\beta = .063$, $p > +1$ are found to be insignificant, which states that only relying on data alone may not significantly generate trust in outcomes derived from AI or Digital Marketing. While showing the vitality of AI-driven trust, transparency and use case relevant data leads to elements when it is about digital marketing as these essential agnostic identifiers are irrelevant because this type does not make any sense on their own.

5.2 Specific Indirect Effects

Table 7
Hypotheses testing estimates

	Original sample	Sample mean	Standard deviation	T statistics	P values	Result
Collection of Data → AI-Driven Trust → Digital Marketing	0.063	0.067	0.038	1.639	0.101	Unsupported
Transparency → AI-Driven Trust → Digital Marketing	0.11	0.114	0.046	2.377	0.017	Supported
Usage of Data → AI-Driven Trust → Digital Marketing	0.078	0.078	0.032	2.448	0.014	Supported

Table 7 presents the results of the specific indirect effects on the automotive engineering sector and, more precisely, how AI-driven trust operates within the factor variables in terms of digital marketing. According to the analysis, the direct effect of the factor variable of data collection on the digital marketing factor is not significant, which means that data collection is not a source significantly improving the digital marketing dimension of improving AI-driven trust. Indeed, the specific indirect effect of transparency on AI-driven trust is significant, which means that if transparency is increased, it will provide a better functioning of AI-driven trust as it improves the factor variable of AI-driven trust, which is digital marketing. In this way, the specific indirect effect of data usage on digital marketing is also significant, which implies that if data usage is effective, as it causes the variable of AI-driven trust, it will also provide better performance of digital marketing. Thus, the results of the analysis suggest that data collection is not enough to improve the factor variables of AI-driven trust that also affect the digital marketing factor.

6. Finding

6.1 Discussion and Conclusions

The research confirms several important findings about how data privacy management can contribute to improving reverse logistics practice, specifically in automotive engineering supply chains and using environmental performance mediation. This study treats data privacy as a latent variable.(Sukati et al., 2012) It operationalizes three aspects of the practices in question, data collection transparency and usage precision, to assess their consequences on reverse logistics from an environmental efficiency perspective. The results also suggest that data privacy practices substantially and positively influence reverse logistics outcomes, demonstrating the need to embed strong data privacy measures into sustainable logistics more broadly (Nurgazina et al., 2021) . This trend is consistent with the use of data management technologies to create more efficient and environmentally sustainable reverse logistics operations. The results also indicate that even if far less pronounced than environmental efficiency type of mediation effects enhancing the efficacy of data privacy practices in achieving more sustainable outcomes, this directly known factor accounted only for at most moderate margins adequate amount could deliver to reverse logistics. It highlights that although data privacy practices have a favorable impact on reverse logistics, their influence is more realized when moderated through environmental efficiency. Additionally, it evidences the role of environmental efficiency for the company in developing its productivity and influencing reverse logistics. The results underline the need to integrate environmental efficiency with technological progress to boost reverse logistics performance. This research provides important implications for the automotive engineering field, illustrating that combining environmental concerns in data privacy practices with reverse logistics can lead to enhanced organizational performance alongside attaining a competitive edge. These findings are important to manufacturers and supply chain managers, as they can help reduce emissions of greenhouse gases from the transport process.

6.2 Theoretical Implications

The research contributes several important theoretical insights to AI integration and environmental efficiency in the context of reverse logistics, especially within the automotive engineering sector. The paper contributes to research that examines the role of AI-driven systems in reverse logistics by shedding light on how data privacy practices and their environmental efficiency mediate the connection between data privacy practice quality and performance in this domain. This research investigates how technological advances and environmental sustainability factors factor into reverse logistics outcomes, specifically through the role of shared efficiency in this mediation. It demonstrates a new angle by which green efficiency can be conducted during reverse logistics strategies. Therefore, the results gained from this analysis provide new theory insights about what AI and sustainable elements can impact the process of RL to improve data privacy with environmentally friendly conditions as well as hints at several possible avenues for future research into how AI-based solutions could be used in order to foster sustainability practice within an organization should be studied by further researchers across various sectors related to reverse logistics.

6.3 Managerial Implications

This study offers valuable insights for managers in the automotive engineering sector, particularly those leading SMEs, on leveraging AI for enhanced reverse logistics and improved environmental efficiency. The findings underscore the importance of integrating AI-driven technologies with sustainable practices to optimize reverse logistics processes. Managers are advised to prioritize environmental efficiency as both a key mediator and central factor in driving reverse logistics performance. By aligning AI capabilities with sustainability goals, organizations can achieve more effective and resilient operations. Additionally, balancing AI implementation with current business practices is crucial for consistent and efficient reverse logistics. Empowering automotive engineering SMEs with these AI-driven solutions will not only boost operational performance but also enhance market competitiveness and contribute to economic growth.

6.4 Limitations of Study

Nonetheless, since neither data nor resources were consumed concerning the combination of AI to optimize reverse logistics and sustainability in the automated engineering domain, the findings of this study generalize only to this industry. The automotive sector has specific conditions pre-crisis development and currency impact on costs and prices, which can differ from other sectors in structure and operation. The general conclusions may, therefore, be difficult to extrapolate between different sectors. Also, sustainability performance was used in this study as a mediator between AI-driven systems such as Customer Management relationships (CRM) and Decision Support Systems (DSS). However, other technologies that could impact this point were not examined. The sample size may have been constrained by funding and time, which limited the data saturation. In addition, the sample is largely composed of middle and first-line managers who may provide a partial view compared to senior executives on AI, data privacy concerns, and sustainability in reverse logistics. This is heterogeneity that might be described either in the social or educational backgrounds of the managers and which may have allowed us to get a nuanced understanding from finished perceptions. These limitations are for future research required to determine the general trends in these findings and that of other constructs, which influence directly or indirectly how AI and data privacy impact reverse logistics.

6.5 Conclusions

This study provides a novel contribution to the environmental efficiency of reverse logistics relationships and develops knowledge regarding how data privacy practices improve reverse logistics outcomes in automotive engineering settings. Using AI-driven systems, especially such as Customer Relationship Management (CRM) and Decision Support Systems (DSS), the research exposes to what extent these technologies can support activities throughout reverse logistics processes in accordance with environmental efficiency objectives by examining their integration. The results illustrated the great benefits of AI for reverse logistics in combination with environmental performance, which triggers improved operational performances and lower adverse impacts on the environment. The results provide key takeaways for automotive engineering companies to help them incorporate AI technologies into sustainability objectives and provide a structured way of improving reverse logistics in particular, but supply chain performance as a whole. These results also highlight the need to incorporate data privacy measures and sustainability into organizations' AI strategies in order to improve reverse logistics routines, leading us even more steps (or miles) forward regarding automotive sector performance.

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