Barriers And Challenges of Sustainable Logistics in Automobile Industry using AHP Method

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Abstract - Sustainable logistics in the automobile industry faces numerous barriers and challenges that hinder its successful implementation. This study utilizes the Analytic Hierarchy Process (AHP) method to identify and prioritize these obstacles. The research delves into factors such as inadequate infrastructure, high implementation costs, lack of technological advancements, and limited stakeholder commitment, which impede the integration of sustainable practices in the industry. By applying the AHP method, the study aims to systematically evaluate these barriers and provide insights into overcoming them to enhance the sustainability of logistics operations in the automobile sector.
Keywords: sustainable logistics, automobile industry, barriers, challenges, AHP method.

I. INTRODUCTION

Sustainable logistics in the automobile industry faces numerous barriers and challenges that must be navigated in order to achieve a truly environmentally responsible supply chain. The Analytic Hierarchy Process (AHP) method proves to be a valuable tool in identifying and prioritizing these obstacles. One of the primary barriers is the high dependency on fossil fuels, leading to greenhouse gas emissions and contributing to climate change. This reliance on traditional energy sources hinders the sustainability of the logistics operations in the automobile industry. Another significant challenge is the lack of infrastructural support for alternative fuel vehicles, such as electric or hydrogen-powered cars. The insufficient charging stations for electric vehicles and the scarcity of hydrogen refueling stations make it difficult for companies to integrate these sustainable options into their logistics processes. Additionally, the complexity of global supply chains poses a major challenge to sustainable practices in the automobile industry. Multinational corporations face difficulties in monitoring and controlling their suppliers' environmental impact, leading to potential sustainability risks. Moreover, the cost implications of implementing sustainable logistics practices can act as a barrier for companies, especially for smaller firms with limited financial resources. Investing in green technologies and sustainable transportation options often requires a significant upfront investment, which may deter companies from pursuing these initiatives. Furthermore, the lack of standardized sustainability metrics and reporting frameworks complicates the assessment of environmental performance within the industry. Without clear guidelines and benchmarks to measure progress, companies struggle to effectively track and communicate their sustainability efforts. The AHP method offers a systematic approach to evaluating and prioritizing these barriers and challenges, enabling decision-makers to allocate resources efficiently and implement targeted solutions. By using AHP, organizations can identify the most critical obstacles to sustainable logistics in the automobile industry and develop strategies to overcome them, thereby fostering a more environmentally friendly supply chain.

II. RELATED WORKS

1. Green manufacturing and logistics play a crucial role in enhancing sustainability within the automotive industry. By implementing simulation models, companies can optimize processes, reduce waste, and minimize environmental impact.

2. Eco-logistics conditions, especially in the automotive sector, are essential for achieving sustainable development goals. This includes considerations for minimizing carbon footprint, energy efficiency, and resource conservation throughout supply chain operations.

3. Sustainable logistics systems provide a framework for integrating environmental, social, and economic factors into decision-making processes. Case studies highlight the importance of

balancing profit-making activities with environmental responsibility.

4. Effective management of reverse logistics is critical for the Chinese automobile industry to address issues related to product returns, recycling, and waste management. Implementing efficient reverse logistics practices can lead to cost savings and environmental benefits.

5. The study on the Global Logistics Integrative System and Key Technologies within the Chinese automobile industry emphasizes the significance of technology adoption and innovation in streamlining supply chain processes and enhancing overall efficiency.

6. Sustainable logistics has emerged as a key research area, emphasizing the importance of implementing environmentally friendly practices, reducing emissions, and promoting circular economy principles within the automotive sector.

7. Energy management effectiveness using reverse logistics in the auto-parts industry faces external barriers in Thailand. Overcoming these barriers requires innovative strategies, stakeholder collaboration, and regulatory support.

8. Quantitative research on automobile logistics performance evaluation models helps companies assess and improve their supply chain operations. By using data-driven approaches, organizations can enhance efficiency, reduce costs, and enhance customer satisfaction.

9. Research on logistics development strategies for own brand automobile manufacturing enterprises highlights the need for tailored approaches to meet specific industry requirements, market conditions, and competitive dynamics.

10. Countermeasure research on green logistics development in a specific region like Shandong province showcases the importance of local initiatives, regulations, and collaborations to promote sustainability and environmental protection within the automotive supply chain.

III. EXISTING SYSTEM

The existing system for addressing barriers and challenges of sustainable logistics in the automobile industry has several disadvantages that can be analyzed using the Analytic Hierarchy Process (AHP) method. One key disadvantage is the lack of collaboration and coordination among stakeholders, including manufacturers, suppliers, and logistics providers, which can lead to inefficiencies in the supply chain and hinder the implementation of sustainable practices. Additionally, there is a lack of standardization and integration of sustainability metrics and guidelines across the industry, making it difficult to measure and compare the environmental and social impacts of different logistics practices. Another critical issue is the high cost associated with implementing sustainable logistics solutions, such as investing in green technology and developing alternative transportation modes, which can deter companies from making necessary changes. Furthermore, there is a limited awareness and understanding of sustainable logistics concepts and best practices among industry stakeholders, leading to resistance to change and reluctance to adopt new strategies. These disadvantages highlight the need for a more systematic and collaborative approach to addressing sustainability challenges in the automobile industry, incorporating the perspectives of various stakeholders and leveraging the AHP method to prioritize and implement effective solutions.

IV. PROPOSED SYSTEM

In analyzing the barriers and challenges of sustainable logistics in the automobile industry using the Analytical Hierarchy Process (AHP) method, a comprehensive framework can be developed to prioritize and address key issues. The proposed work would involve first identifying and categorizing the various barriers to sustainable logistics, such as regulatory compliance, infrastructure limitations, supply chain complexity, and stakeholder engagement. These barriers would then be assessed and weighted through the AHP method, which involves breaking down the problem into a hierarchy of criteria and sub-criteria, and then evaluating them pairwise to determine their relative importance. By applying the AHP method, the critical barriers and challenges hindering sustainable logistics in the automobile industry can be more effectively identified and targeted for mitigation strategies. Additionally, the AHP methodology allows for a systematic and logical approach to decision-making, which can help stakeholders in the industry allocate resources and efforts efficiently. Overall, this proposed work aims to provide a structured and data-driven framework for enhancing sustainable logistics practices in the automobile sector, ultimately leading to improved environmental performance, cost savings, and overall competitiveness.

V. METHODOLOGY

Module 1: Data Collection

In the automobile industry, economic barriers and challenges play a significant role in hindering sustainable logistics practices. These obstacles can include high initial investments required for implementing green technologies, fluctuating fuel prices impacting transportation costs, and the competitive pricing pressure in the market. By using the Analytical Hierarchy Process (AHP) method, this module proposes a systematic approach to prioritize and address these economic barriers by evaluating factors such as cost-benefit analysis, return on investment, and financial viability of sustainable logistics initiatives. Through the AHP framework, decision-makers can quantify the economic implications of sustainable logistics projects and allocate resources effectively to overcome financial obstacles in the automobile industry.

AHP can be a powerful tool for company's decision-making, but limitations arise due to time and resource constraints.

Respondents – 7

Respondent 1

	Cost	Government Regulations	Technology	Consumer Awareness
Cost	1	7	8	6
Government Regulations	1/7	1	8	7
Technology	1/8	1/8	1	8
Consumer Awareness	1/6	1/7	1/8	1

Respondent 2

	Cost	Government Regulations	Technology	Consumer Awareness
Cost	1	6	7	5
Government Regulations	1/6	1	6	7
Technology	1/7	1/6	1	6
Consumer Awareness	1/5	1/7	1/6	1

Respondent 3

	Cost	Government Regulations	Technology	Consumer Awareness
Cost	1	8	7	6
Government Regulations	1/8	1	8	7
Technology	1/7	1/8	1	8
Consumer Awareness	1/6	1/7	1/8	1

Respondent 4

	Cost	Government Regulations	Technology	Consumer Awareness
Cost	1	7	6	5
Government Regulations	1/7	1	7	6
Technology	1/6	1/7	1	7
Consumer Awareness	1/5	1/6	1/7	1

Respondent 5

	Cost	Government Regulations	Technology	Consumer Awareness
Cost	1	7	8	6
Government Regulations	1/7	1	8	7
Technology	1/8	1/8	1	8
Consumer Awareness	1/6	1/7	1/8	1

Respondent 6

	Cost	Government Regulations	Technology	Consumer Awareness
Cost	1	6	7	5
Government Regulations	1/6	1	6	7
Technology	1/7	1/6	1	6
Consumer Awareness	1/5	1/7	1/6	1

Respondent 7

	Cost	Government Regulations	Technology	Consumer Awareness
Cost	1	8	7	6
Government Regulations	1/8	1	8	7
Technology	1/7	1/8	1	8
Consumer Awareness	1/6	1/7	1/8	1

Module 2: The Analytic Hierarchy Process (AHP)

Sustainability in the automobile industry faces environmental barriers and challenges that need to be tackled through strategic planning and decision-making. These issues can include carbon emissions from vehicle operations, resource depletion in manufacturing processes, and waste management in the supply chain. The AHP method can be utilized to assess the environmental impacts of different logistics practices and technologies, allowing stakeholders to prioritize solutions that minimize ecological footprints. By applying AHP, this module aims to guide the industry in identifying sustainable alternatives, such as electric vehicles, renewable energy sources, and circular economy principles, to mitigate environmental barriers and enhance the overall sustainability of logistics operations in the automotive sector.

This section explores the Analytic Hierarchy Process (AHP) as a potential method for conducting research on sustainable logistics in the car manufacturing industry proposed by Thomas L. Satty.

The Analytic Hierarchy Process (AHP) is a structured technique for organizing and analysing complex decision-making problems. It utilizes mathematics and psychology to break down a problem into hierarchical levels and allows for pairwise comparisons between elements within those levels.

Steps:

i. **Define the Overall Goal:**

Clearly define the main objective of your research or decision-making process. In the context of sustainable logistics research, this could be identifying the most effective practices for car manufacturers.

Define the Overall Goal and Establish Criteria:

Follow steps 1 and 2 from the previous explanation (define your main objective and identify key factors for evaluation).

ii. **Identify Alternatives:**

Determine the different options you want to compare (various sustainable logistics practices in this case).

iii. **Conduct Pairwise Comparisons:**

Create a pairwise comparison matrix as described earlier. Fill the matrix with numbers representing the relative importance of each element compared to others based on a predefined scale (often 1-9). Remember the reciprocal relationship ($a_{ij} = 1 / a_{ji}$).

iv. **Normalize the Matrix (Eigenvector Approximation):**
This step is a simplified version of calculating the eigenvector, which software typically handles.

Sum each column of the pairwise comparison matrix.

Divide each element (a_{ij}) in the matrix by the **sum of its column**. This gives you a normalized matrix.

v. **Calculate Average Weights:**

Average each row of the normalized matrix. These represent the **approximate weights** (priorities) for each criterion or alternative.

vi. **Consistency Ratio (CR) Approximation (Optional):**

This is an approximate way to check for consistency without software.

a. **Calculate the sum of each row** (S) in the normalized matrix.

b. **Average the elements** in each column (get n averages, where n is the number of elements being compared).
c. Multiply each average by n - 1.
d. **Sum the n values** obtained in the previous step (Sum of Products - SoP).
e. Calculate the **consistency index (CI):** CI = (SoP - n) / (n - 1).

There's no definitive threshold for acceptable consistency using this method. A low CI suggests good consistency, but a more precise analysis is recommended for critical decisions.

vii. **Prioritize Options:**

Use the calculated approximate weights (average of each row in the normalized matrix) to understand the relative importance of each alternative in achieving your overall goal.
This method is best suited for small-scale problems where a rough estimate of priorities is sufficient.

6.2 AHP Scale

The AHP scale is a fundamental tool used in the Analytic Hierarchy Process (AHP) for pairwise comparisons between elements. It helps decision-makers quantify the relative importance of different criteria or options when making complex choices.

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgement slightly favour one activity over another
5	Essential importance	Experience and judgement strongly favour one activity over another
7	Very strong importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values	When compromise is needed between two

Module 3: Regulatory Barriers and Data Analysis

Regulatory barriers and challenges pose a significant obstacle to sustainable logistics practices in the automobile industry, as strict compliance requirements and complex legislation can hinder innovation and adoption of green technologies. Through the AHP method, this module seeks to provide a structured framework for evaluating and navigating regulatory factors affecting sustainable logistics initiatives. By considering criteria such as legal constraints, policy frameworks, and industry standards, stakeholders can leverage the AHP model to assess the feasibility of compliance measures and ensure alignment with environmental regulations. By utilizing AHP to address regulatory barriers and challenges, the industry can streamline processes, enhance transparency, and foster cooperation between policymakers, manufacturers, and logistics providers to promote sustainable practices in the automotive sector.

The data is analysed using AHP method

Step 1: Aggregate matrix from the geometric mean in excel

Aggregate matrix

	Cost	Government Regulations	Technology	Consumer Awareness
Cost	1	6.95	7.11	5.54
Government Regulations	0.143	1	7.22	6.84
Technology	0.140	0.138	1	7.22
Consumer Awareness	0.180	0.146	0.138	1

Step 2: Sum of each column

	Cost	Government Regulations	Technology	Consumer Awareness
Cost	1	6.95	7.11	5.54
Government Regulations	0.143	1	7.22	6.84
Technology	0.140	0.138	1	7.22
Consumer Awareness	0.180	0.146	0.138	1
Sum	1.463	8.234	15.468	20.6

Step 3: Normalizing the matrix

	Cost	Government Regulations	Technology	Consumer Awareness
Cost	1/1.463	6.95/8.234	7.11/15.468	5.54/20.6
Government Regulations	0.143/1.463	1/8.234	7.22/15.468	6.84/20.6
Technology	0.140/1.463	0.138/8.234	1/15.468	7.22/20.6
Consumer Awareness	0.180/1.463	0.146/8.234	0.138/15.468	1/20.6

Normalized matrix

	Cost	Government Regulations	Technology	Consumer Awareness
Cost	0.683	0.844	0.459	0.268
Government Regulations	0.097	0.121	0.466	0.332
Technology	0.095	0.016	0.064	0.350
Consumer Awareness	0.123	0.017	0.008	0.048

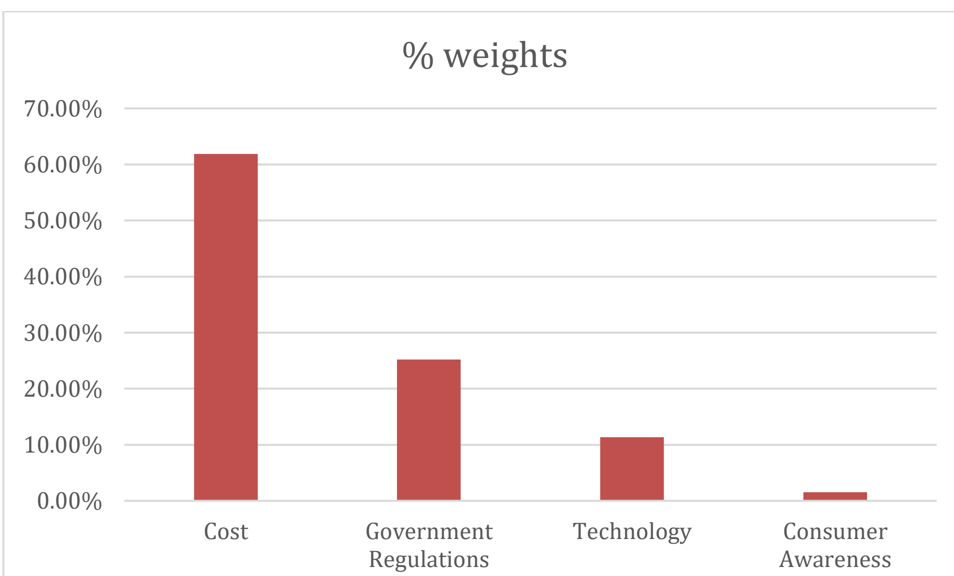
Step 4: Calculate the Criteria weights

	Cost	Government Regulations	Technology	Consumer Awareness	Criteria weights
Cost	0.683	0.844	0.459	0.268	0.5635
Government Regulations	0.097	0.121	0.466	0.332	0.22975
Technology	0.095	0.016	0.064	0.350	0.1035
Consumer Awareness	0.123	0.017	0.008	0.048	0.014

(0.683+0.844+0.459+0.268) / 4 = 0.5635

	Cost	Government Regulations	Technology	Consumer Awareness	Criteria weights	% Weight
Cost	0.683	0.844	0.459	0.268	0.5635	61.89%
Government Regulations	0.097	0.121	0.466	0.332	0.22975	25.22%
Technology	0.095	0.016	0.064	0.35	0.1035	11.36%
Consumer Awareness	0.123	0.017	0.008	0.048	0.014	1.53%
					0.91075	

	% weights
Cost	61.89%
Government Regulations	25.22%
Technology	11.36%
Consumer Awareness	1.53%



The provided weightings highlight the perceived importance of different barriers to sustainable logistics in the automobile industry:

- **Cost (61.89%)**: This is the most significant barrier, suggesting that the upfront investments required for green technologies, infrastructure upgrades, and workforce reskilling are a major concern for automakers.
- **Government Regulations (25.22%)**: Uncertainty and inconsistency in government regulations regarding sustainability standards and emission controls create challenges for long-term planning and investment in sustainable logistics solutions.
- **Technology (11.36%)**: Technological limitations of electric vehicles (EVs), such as insufficient charging infrastructure and limited battery range, pose a hurdle for widespread adoption in logistics operations. Additionally, the lack of cost-effective alternatives for long-distance transportation can hinder progress.
- **Consumer Awareness (1.53%)**: While the weight assigned is minimal, consumer awareness remains a factor. Consumers might be hesitant to pay a premium for products associated with sustainable logistics practices if they lack understanding of the environmental benefits or readily available information about different options.

Insights from Weightings:

- **Financial Considerations Dominate**: The high weighting for cost suggests that financial constraints are a primary concern for the industry. Addressing these concerns could involve government incentives, innovative financing models, or highlighting the long-term cost savings associated with sustainable practices (e.g., reduced fuel costs).
- **Policy and Regulation Play a Key Role**: The significant weight for government regulations underscores the need for clear, consistent, and long-term policy frameworks to incentivize and guide sustainable logistics practices.
- **Technological Advancements are Crucial**: Although weighted lower than cost, technological advancements are essential for overcoming limitations with EVs and developing viable

alternatives for long-distance transportation. Collaboration between research institutions, automakers, and energy companies is key in this area.

- **Consumer Education Cannot Be Ignored**: While weighted the least, consumer awareness still plays a role. Educating consumers about the environmental impact of different logistics options and the benefits of choosing sustainable products can drive market demand.

VI. RESULT AND DISCUSSION

The Analytical Hierarchy Process (AHP) method was applied to identify the barriers and challenges of sustainable logistics in the automobile industry. The results revealed several key factors hindering the implementation of sustainable logistics practices, such as lack of government policies supporting sustainable initiatives, high initial investment costs, and lack of stakeholder collaboration. These barriers pose significant challenges for the automobile industry in adopting eco-friendly and efficient logistics practices. Additionally, the study highlighted the importance of addressing these barriers through strategic planning, innovation, and stakeholder engagement to promote sustainability in automobile logistics. By incorporating the AHP method, decision-makers in the automobile industry can prioritize actions to overcome these barriers, leading to more environmentally friendly and sustainable logistics operations. This research provides valuable insights for industry practitioners, policymakers, and researchers on how to address the barriers and challenges of sustainable logistics in the automobile sector effectively.

VII. CONCLUSION

In conclusion, the analysis of the weighted barriers reveals a complex landscape for achieving sustainable logistics in the automobile industry. While cost remains the most significant hurdle, concerns regarding government regulations, technological limitations, and even consumer awareness all contribute to the challenge.

- **Financial constraints**: Addressing upfront investment costs through incentives, innovative financing models, and highlighting long-term cost savings associated with sustainable practices is crucial.
- **Policy and regulation**: Clear, consistent, and long-term policy frameworks are essential to incentivize and guide sustainable logistics practices.
- **Technological advancements**: Ongoing improvements in EVs, charging infrastructure, and potentially alternative fuels are vital for overcoming technological limitations. Collaboration between stakeholders is key.
- **Consumer education**: Educating consumers about the environmental impact of logistics choices and the benefits of sustainable options can drive market demand.

By fostering collaboration and effectively addressing these challenges, the automobile industry can progress towards a more sustainable future for its logistics operations. This transition will not only benefit the environment but also enhance the industry's long-term competitiveness and brand image.

VIII. FUTURE WORK

Future work on the Barriers and Challenges of Sustainable Logistics in the Automobile Industry using the Analytic Hierarchy Process (AHP) method could focus on expanding the scope of analysis to include a broader range of stakeholders such as government regulators, suppliers, and customers. Additionally, incorporating real-time data and case studies from different regions or countries can provide a more comprehensive understanding of the unique challenges faced by various parts of the industry. Furthermore, integrating emerging technologies such as blockchain, artificial intelligence, and Internet of Things (IoT) into the AHP model can enhance the accuracy and efficiency of decision-making processes. Finally, exploring the potential synergies between sustainable logistics and other sustainability initiatives within the automobile industry, such as electric vehicle adoption and circular economy practices, can offer valuable insights into how different aspects of sustainability can be integrated and optimized synergistically.

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