Journal of Information Systems Engineering and Management
2025, 10(20s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Challenges and Opportunities in Including Sustainability in the Pre-Owned Automobile Value Chain

Ajitha K[1], Dr. C Samuel Joseph[2] , Dr. K. Lakshmi priya[3], Dr. D Mahila Vasanthi Thangam[4]
[1] *Research Scholar– Dept. of Commerce of International Trade, Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu. Email- ajithakaju007@gmail.com*
[2] *Professor & Head - MCC- Boyd Tandon School of Business, Chennai, Tamil Nadu. Email- samueljoseph@mccbtsb.edu.in*
[3] *Assistant Professor, Dept. of Commerce of International Trade, Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu. Email- lakshmipriya@karunya.edu*
[4] *Associate Professor, Dept. of Commerce of International Trade, Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu. Email- mahila@karunya.edu*

ARTICLE INFO

Received: 20 Dec 2024
Revised: 01 Feb 2025
Accepted: 14 Feb 2025

ABSTRACT

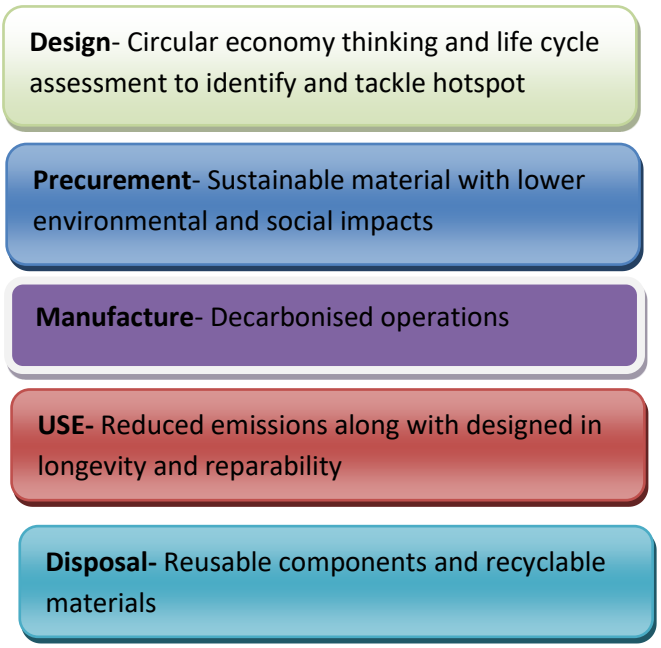
In this research, the author studies on preowned automobile value chain with sustainability and Recent innovations, such as carbon-neutral production and the electrification of vehicles, demonstrate the growing importance of sustainability in the automotive business. In this study, they used different variables of methodology for data collection for research and also used the SPSS and Excel tools for analyzing and presenting the data. The author used the primary data for their research and prepared their study with the help of questionnaires. The result of the study is Environmental Impact" presents the responses to a series of questions regarding the perceived environmental impact of pre-owned vehicles and "Financial Benefits and Drawbacks" presents responses to a series of questions evaluating the financial implications of incorporating sustainability measures about pre-owned vehicles.

Keywords: Preowned automobile, Sustainability, Resource utilization, Environmental impact, Consumer behavior.

1. Introduction

Sustainability is becoming more important in the automobile sector, as seen by current developments like carbon-neutral manufacturing and the electrification of vehicles. More stringent emissions regulations are one factor propelling these trends, but heightened public awareness of sustainability and environmental problems is also a major factor, as is the rising demand from consumers for environmentally friendly vehicles that are both more sustainably made and less harmful to the environment both during use and when they are retired.

1.1 Sustainability must be incorporated at every stage throughout the value chain.



As people move toward low-carbon mobility, the automotive industry is undergoing a paradigm change in terms of both the production process and the types of vehicles it produces.

At its core, this change is about three things, according to Ricardo:

1. Climate change and carbon emissions in the automotive sector

2. Sustainable materials for automotive manufacture

3. Sustainability and circularity across the automotive value chain

1.1.1 Climate change and carbon emissions in the automotive sector

There has been a larger social discussion about climate change and its consequences for a while. Companies are facing mounting demands from stakeholders, shareholders, regulators, and consumers for a solid decarbonization strategy.

Both the production process and the automobiles' emissions of carbon dioxide must be reduced by the automobile industry. Using alternative powertrains, such as fuel cells and batteries, is crucial in this regard. To meet these climate and sustainability targets, the automotive industry must tackle emissions in three different areas: product design, suppliers, and operations.

Manufacturers are starting to realize the benefits of using life cycle techniques to find and evaluate emission "hotspots" all along the value chain. Gaining insight into these "hotspots" will show that efforts must go beyond propulsion to find upstream decarbonization options in the supply chain and with new material selections (Chan,2021).

1.1.2. Sustainable materials for automotive manufacture

To reduce carbon emissions during operation, electromobility is essential, but the materials used to build a vehicle are equally critical. Traditional materials with high embodied carbon that are difficult to recycle are being phased out in the automotive industry. Sustainable resources are getting greater attention, but they still have a way to go before they can say goodbye to material emissions.
Research indicates that by 2040, materials utilized in production will account for 60% of emissions in the automobile industry (Palencia, et. al, 2012). Therefore, it is crucial to intensify decarbonization initiatives in this domain.

As part of their efforts to achieve carbon neutrality, automakers are switching to renewable and recyclable materials that are easier on the environment (Ghosh & Roy, 2020). Vehicles should transition away from materials derived from fossil fuels and toward sustainable high-performance materials by the year 2030. The best way to handle these materials when they reach the end of their useful life is to utilize, reuse, and recycle them for as long as possible.

1.1.3. Sustainability and circularity across the automotive value chain

Due to the increasing scarcity of natural resources, the automotive industry is beginning to prioritize sustainable value chains. As mentioned in last year's IEA report on The Role of Key Minerals in Energy Transitions, global shortages of lithium and cobalt might happen as soon as 2025 unless sufficient investments are made to boost production. Maximizing materials' retention in the value chain via tactics like repair, reuse, and recycling is the central tenet of a circular economy. Everything from the tires to the vehicle's frame is part of this effort to make vehicles last longer (Torbjornsen,2010).

By extending the lifetime and maintaining value, new business models can be developed to support a circular economy model. These models include sharing, leasing, fixing, refurbishing, or recycling materials and products.

1.2 Sustainability along the value chain

Due to the depletion of natural resources, "sustainable supply chains" are becoming more and more important in the automotive industry. Reusing and recycling are the foundational principles upon which they are based. The supply chain as a whole need to be made more transparent. Only by doing this can they ensure sustainability all the way through the value chain and know exactly where components came from. This has prompted innovative solutions such as biodegradable components, battery recycling, economies of circularity, and sustainable R&D and production methods to be considered by car companies and their suppliers.

1.3 Challenges for Car Manufacturing Companies Regarding Sustainability

Sustainable automotive practices are the end goal, but getting there will be difficult and will require creative solutions from the auto industry:

1.4 Strategic Planning for Long-Term Viability

Promoting long-term viability requires consistent effort rather than a one-and-done project. In the face of constantly shifting customer tastes, new technologies, and government regulations, the automotive industry faces the

formidable task of developing long-term sustainability strategies. A comprehensive strategy taking into account social, economic, and environmental facets is necessary to overcome these obstacles.

1.4.1 Sustainability vs. Cost Efficiency

The delicate balancing act of incorporating environmentally friendly techniques while keeping production costs down is one that the automotive industry must master. An upfront cost is often associated with the pursuit of environmentally friendly projects. Consumers, who should be able to purchase reasonably priced vehicles made in an eco-friendly manner, share this sentiment. Nonetheless, eco-friendliness and economy need not be mutually exclusive. More sustainable products, on the other hand, can be economically beneficial for businesses and consumers alike, thanks to measures like reduced energy and material use.

1.4.2 Meeting Consumer Expectations

Automobile manufacturers confront a dilemma in trying to meet the demands of environmentally concerned consumers while simultaneously achieving their own sustainability objectives. Getting the word out to customers about these initiatives is crucial. Transparency regarding sustainability activities is essential for building trust and loyalty since it gives consumers confidence in their choice of eco-friendly vehicles.

1.4.3 Environmental Compliance and Risk Assessment

Automobile makers face a complex environment of ever-changing norms and standards in this age of environmental protection. Finding a happy medium between improving and being in compliance with these laws is essential for getting new, sustainably made cars into the right markets.

1.4.4 Supply Chain Complexity

The sustainability challenge is compounded by the intricate nature of automotive supply networks. The supply chain is full of potential for improvement at every stage, from the extraction of raw materials to the final assembly. To establish a more sustainable end-to-end process, OEMs must navigate complex supplier networks, each with its own environmental impact.

1.4.5 Data Availability and Quality

Given the global nature of the materials and components used in automobiles, it is no surprise that the industry's intricate supply chains include many levels of suppliers. The absence of openness and uniform reporting along the supply chain makes it difficult to compile statistics on the environmental effects of each part, covering elements like the extraction of raw materials, production, shipping, and disposal at the end of life.

1.4.6 End-of-Life Considerations

A car's useful life doesn't stop when it leaves the showroom. There is a significant problem with the disposal of old cars. To ensure that the environmental impact of an automobile is reduced over its entire existence, sustainable procedures should include recycling and appropriate disposal of components, such as the interior.

1.4.7 Carbon Emissions and Environmental Impact

The biggest problem is the industry's impact on the environment. The usage of fossil fuels in conventional manufacturing processes is a major cause of global warming. Pollutants including volatile organic compounds (VOCs) from paint and solvents are another byproduct of the automobile manufacturing process. Water consumption, land use, habitat loss, air pollution, and water contamination are just a few of the many environmental consequences linked to the automobile industry.

2. Literature of review

Lee, K. H. (2011) said that the automobile sector leaves a substantial environmental imprint. It is necessary to handle all of the risks that are concentrated at the lowest levels of the supply chain. Producing steel, aluminum, glass, & batteries are just a few of the many upstream operations that use up vast amounts of water and energy. Mining for metals and minerals, as well as plastic, natural rubber, or leather, is also essential in the production of vehicles. Many contentious activities have been associated with where these raw materials were sourced. Allegations of child labor, unsafe working conditions, among pollution have dogged the extraction of mica for paints, cobalt for battery manufacture, and several other conflict minerals used in electronics. The usage of potentially harmful compounds is also common.

Hall, J. (2000) explained a sea change in the automotive industry's discourse on sustainability in recent years. Annual car sales have long been a proxy for the health of the industry as a whole. However, maintaining a sustainable supply chain that benefits local communities and the environment has often clashed with selling more cars at a higher price from a reduced production cost. Attempts to become more sustainable, according to this view, reduce profits. Nobody can stop it. Some non-governmental organizations (NGOs) argue that reducing vehicle ownership and emissions is essential assuming they are to stave off a global warming disaster.

Zhao, F., & Liu, Z. (2022) explored Recent developments, such as carbon-neutral production and vehicle electrification, highlight the rising significance of sustainability within the car sector. More stringent emissions regulations are one factor propelling these trends, but heightened public awareness of sustainability and environmental concerns is also a major factor, as is the rising demand from consumers for environmentally friendly vehicles that are both more sustainably made and less harmful to the environment both during use and when they are retired.

Frank Czerwinski; (2021) evaluated Car lightweight trends are driven by cost, performance, and sustainability, and they reflect the circular economy's solutions for modern mobility and transportation, which include a high need for materials that are lightweight and design ideas. In addition to focusing on weight reduction, modern techniques also consider the structure's functionality, cost, and environmental impact. Environmentally friendly materials, substitution guidelines, and the concept of a multi-material design paradigm are used to explain them. "Lightweight steel," regular aluminum, and magnesium alloys are just a few examples of metals that have recently attracted a lot of interest from researchers around the world. Other notable topics include future-oriented part manufacturing technologies and electric vehicle adaptation strategies. The project's objectives can be accomplished by discussing the benefits and drawbacks of lightweight components, metal-matrix composite materials, laminates, sandwich buildings, and structural engineering solutions based on bionic principles.

Mathew, G. (2021) states that Everyone now requires an automobile for their day-to-day activities due to the modern lifestyle. Checking the vehicle's history is a must before purchasing a secondhand vehicle. At this time, used car lots are the best places to get a vehicle's background information. Because they don't keep accurate records, dealers' data isn't required to be correct. The buyer has little choice but to trust the dealer and go through with the purchase. To address these issues, they put up a distributed system that verifies the vehicles' histories using blockchain technology. The person responsible for producing the car registration with a unique VIN is the creator or deployer in the system. They will update the information on the shared ledger. After a smart contract in the supply chain is executed, the automobiles are dispersed to the system's trusted dealers before being given to the user. Insurance, real-time data, maintenance services, and any legal difficulties are documented in the running phase of the proposed model. Reducing the likelihood of fraud or counterfeit papers is the primary benefit of vehicle verification via the blockchain.

A'aeshah Alhakamy; (2023) stated that owning a car is essential since it serves as a means of transportation for many human needs, such as getting to and from work and medical appointments. The present economic climate, however, makes the purchase of luxury automobiles a more difficult prospect. More cheap secondhand cars are now dominating the market. The ever-increasing demand for pre-owned vehicles has driven up their prices, which poses a threat to their eco-friendly lifestyle. By applying a range of machine learning approaches and big data technologies to the pricing of used automobiles, this project aims to comprehend the problem's impact and discover practical solutions.

Webber, R.J. (2020) investigates the relationship between customer satisfaction and the intention to repurchase in the secondary vehicle market in specific South African provinces. High service levels are anticipated in this market, which is highly competitive and price-sensitive. A used car dealership's competitiveness can be greatly affected by service quality, pricing competition, and product diversity. The major need, therefore, was for a study to ascertain the present levels of client satisfaction at a used-car business. This literature review analyzed customer satisfaction and repurchase intention within a single company with multiple dealerships, after compiling an industry profile of the used vehicle industry. Customer satisfaction and its relationship to repurchase intention were also major topics in the literature.

Alireza Shahedi & Mohammad Mahdi Nasiri; (2021) developed a model for a sustainable, closed-loop supply chain that is tailored to the automobile industry and has a single, modular product. The approach to the closed-loop

network layout problem is based on sustainability criteria. they aim to maximize total network profit, minimize environmental pollutants, and maximize employment through the establishment of necessary facilities. Additionally, the author maximizes the weighted sum of the shortest distance of places from residential areas. The research is further supported by a case analysis of the Iranian automotive sector. Furthermore, to address the unpredictability of both demand and the quantity of returned inoperative automobiles, a scenario-based strategy employing stochastic programming is employed. The outcomes prove that stochastic programming is an effective method for reducing uncertainty. In addition, the proposed model is addressed using augmented ε-constraint approaches. While the economic goal value increases by just 0.2% compared to the equivalent optimal value, the environmental target value decreases by 55.1% with the recommended Pareto optimal option.

3. Objective of the study

RO.1 To look into how the automobile industry affects the environment compared to new ones, paying special attention to important sustainability measures like carbon footprint and resource use.

RO.2 To analyze the financial benefits and drawbacks of incorporating sustainable principles into the automobile industry.

RO.3 To investigate novel approaches and technology that improve sustainability all through the used car lifespan, from acquiring the vehicle to disposing of it.

4. Hypothesis of the study

H1- There is a significant impact of how the automobile industry affects the environment compared to new ones, paying special attention to important sustainability measures like carbon footprint and resource use.

Ho- There is no significant impact of how the automobile industry affects the environment compared to new ones, paying special attention to important sustainability measures like carbon footprint and resource use.

H2- There is a significant impact of Analyzing the financial benefits and drawbacks of incorporating sustainable principles into the automobile industry.

Ho- There is no significant impact of Analyzing the financial benefits and drawbacks of incorporating sustainable principles into the automobile industry.

H3- There is a significant impact of Investigating novel approaches and technology that improve sustainability all through the used car lifespan, from acquiring the vehicle to disposing of it.

Ho- There is no significant impact of Investigating novel approaches and technology that improve sustainability all through the used car lifespan, from acquiring the vehicle to disposing of it.

5. Methodology

5.1 Variables of the study -:

- **Preowned automobile:**

A vehicle that has been sold at least once before is known as a pre-owned vehicle or a used car (Miller, & Brannon,2022). Many different places sell used cars: private parties, auctions, rental car agencies, buy-here-pay lots, leasing offices, and franchise and independent car dealerships. With "certified" pre-owned vehicles, extra warranties or service plans, and "no-haggle prices," some dealerships attract customers.

- **Sustainability:**

The long-term coexistence of all life on Earth is the ultimate aim of sustainability efforts. The literature, context, and time all play a role in the debate over this term's precise definition (Denison, 1996). In most cases, environmental, economic, or social considerations form the basis of sustainability. The environmental dimension is highlighted by many definitions. Key environmental issues, such as warming temperatures and biodiversity loss, can be addressed in this way.

- **Resource utilization:**

A well-utilized resource is one that has been efficiently deployed and managed to produce the best possible results (Xiao, et. al. 2012). Picture this: a software services company is suddenly inundated with client projects of all sizes,

with different due dates and resource needs. For on-time deliveries, skill optimization, and satisfied clients, they need to divide up their software development teams, delegate responsibilities, and keep track of all project resources efficiently. Balancing workloads, achieving project goals, and preserving the organization's reputation for providing excellent software solutions all depend on effective resource management.

• Environmental impact:

Any energy source, whether used or not, will have some negative impact on the environment (Abbasi, & Abbasi,2000). How much of an impact depends on factors like the current state of the ecosystem, the population's health, the technology used to generate and consume energy, and the chemical composition of the energy source or converter. A simplified way to express the ecological footprint of energy generation and consumption is as follows: I=P·A·T, where P is the total human population, A is the standard of living of the populace (for example, per capita income), and T is technological advancement (for example, energy efficiency, pollution rates in air and water). Globally, geographers have used case studies to operationalize such implications. These studies have occasionally made use of input-output and regional econometric models.

• Consumer behavior:

In order to understand people's wants and consumption habits, the study of consumer behavior thoroughly investigates "demographics, personality traits, lifestyles, and behavioral factors" (such as usage frequency, times of use, loyalty, brand approval, and willingness to suggest). The influence of various social groupings, such as those pertaining to family, friends, athletics, or reference groups, and society at large (including opinion leaders and brand influencers), is also investigated in consumer behavior (Valente, & Pumpuang,2007).

5.2 Study Area-:

The author chooses India as the study area for the research. In India, there are many opportunities to study on preowned automobile sectors. The author of this study looks at the possibilities and difficulties of incorporating sustainability into the used car market in India. India is a fascinating subject to research because of its expanding market and varied socioeconomic environment. Examining sustainable practices in the used car market is made easier by the nation's automobile industry's explosive growth. The author can investigate the distinct environmental, economic, and social factors impacting the adoption of sustainable practices in the resale and reuse of autos by concentrating on India.

5.3 Targeted Population-:

The author has decided to focus on India in this study. In places across India, where second-hand car markets are widespread, they prefer approved sellers of used vehicles who have worked with car makers. Since there is a large market for used cars in India and several dealers operating in this sector, the author focuses on them for the sake of the research. They offer pre-owned cars that have been upgraded to make them more environmentally and economically friendly, so they can be used for many years to come.

5.4 Sample of the study-:

The author conducted the study to get information about sustainability uses in the preowned automobiles value chain. They selected India for the study and chose authorized preowned vehicle distributors of India, the author selects only authorized sellers who have collaborated with companies of automobiles. In the study, the author targets many preowned vehicle distributors but picks up only 16 distributors. Based on 16 selected distributors the author conducts their ahead study.

5.6 Sampling Technique-:

• *simple random sampling*

Selecting a subset of a population at random from the whole is known as simple random sampling in probability theory. A random selection technique ensures that every individual in the population has an equal opportunity. Collecting data from a substantial subset of this randomly chosen sample is the next stage. Random sampling involves the researcher doing research in any given location and selecting objects related to the research topic at random. Selecting a subset of a population so that every individual has an equal probability of being chosen is the goal of a

simple random sample in statistics. To acquire an accurate view of the entire, it is necessary to take a basic random sample.

5.7 Collection of data-:

In this study where the author studies about challenges and opportunities in including sustainability in the pre-owned automobile value chain. For data collection for the study, the author reviews sustainability in pre-owned automobile value from sellers of second-hand vehicles in India. For data collection the author used the quantitative method of data collection, The quantitative method is the type of primary data in this author made a questionnaire with the help of Google form. In the questionnaire, the author asked about the challenges and opportunities when sustainability is included in the preowned automobile sector to sellers of preowned vehicles. in the questionnaire, the author was given 5 options to share their review. There are 5 options to share review: (Strongly disagree), (Disagree), (Neutral), (Agree), (Strongly agree).

5.8 Statistical Tools-:

- ***Statistical Package for the Social Sciences (SPSS)***

A program called SPSS (Statistical Package for the Social Sciences), which is also known as IBM SPSS Statistics, is available for use in analyzing statistical data. As the name implies, SPSS has expanded beyond its original social science use case and is now used in a variety of data industries. The data analysis features of SPSS include numerical outcome prediction, group identification, description, and bivariate statistics.

- ***Excel***

Data processing and basic mathematical computations are made easier by Microsoft Excel's standard features, which include a grid with cells grouped in rows and columns with numbers and letters. With its pre-installed features, it can handle the workloads of statistical analysis, engineering, and finance. The software can display data in line graphs, charts, and histograms, and it also has limited support for three-dimensional graphics.

5.9 Statistical Technique

- ***Regression***

The purpose of regression analysis in statistical modeling is to examine the relationships between a dependent variable (or "label" in AI parlance) and several independent variables (or "predictors," "covariates," "explanatory variables," or "features"). Linear regression is a widely used method of regression analysis that aims to determine the line (or a more intricate linear combination) that provides the greatest fit to the data based on a certain mathematical criterion. For instance, the standard least squares approach focuses on finding the unique line (or hyperplane) which reduces the sum of squared differences between the data and a specific line.

- ***Analysis of variance (ANOVA)***

The statistical test to execute when comparing the means of many groups is an analysis of variance (ANOVA). A one-way analysis of variance only makes use of one independent variable. A two-way ANOVA is performed with two independent variables. The purpose of this statistical method is to compare the means of several groups or treatments. One such use case is looking for statistically significant changes between group means. To find out how effective different diabetes medications are, researchers make and test assumptions regarding the relationship between the type of treatment and the following blood sugar level.

5.10 Result and Interpretation

How the automobile industry affects the environment compared to new ones, paying special attention to important sustainability measures like carbon footprint and resource use

Table 1 Environmental Impact

Questions	Response					Sig. (2-tailed)
	Strongly	Disagree	Neutral	Agree	Strongly	

	Disagree				**Agree**	
Q1 Carbon footprint	1 (6.3%)	1 (6.3%)	1 (6.3%)	3 (18.8%)	10 (62.5%)	<0.001
Q2 Use of resources	1 (6.3%)	0	0	2 (12.5%)	13 (81.3%)	<0.001
Q3 Recycling parts	1 (6.3%)	2 (12.5%)	0	1 (6.3%)	12 (75.0%)	<0.001
Q4 Landfill wastes	2 (12.5%)	2 (12.5%)	0	1 (6.3%)	11 (68.8%)	<0.001
Q5 Environmental policies	0	1 (6.3%)	1 (6.3%)	2 (12.5%)	12 (75%)	<0.001
Q6 Automotive resource	0	2 (12.5%)	0	2 (12.5%)	10 (62.5%)	<0.001
Q7 Government incentives	1 (6.3%)	1 (6.3%)	0	5 (31.3%)	9 (56.3%)	<0.001

Table 1 titled "Environmental Impact" presents the responses to a series of questions regarding the perceived environmental impact of pre-owned vehicles.

About carbon footprint, the vast majority of respondents (62.5%) strongly agreed that pre-owned vehicles have a lesser carbon footprint than new ones, while smaller percentages (6.3%) disagreed or remained neutral. Strong overall support for this assertion was indicated by the notable 18.8% who agreed, with the results being of statistical significance ($p < 0.001$).

Regarding resource usage, which measured the opinion that using resources to produce new cars harms the environment more than using them to maintain existing cars, 81.3% strongly agreed and 12.5% agreed, showing a statistically significant consensus on this point ($p < 0.001$).

When asked if recycling parts from used cars can significantly lessen its impact on the environment, 75.0% strongly agreed, 6.3% agreed, and 18.8% disagreed or strongly disagreed. This indicates a strong positive consensus via statistically significant results ($p < 0.001$).

In the landfill wastes category, 68.8% strongly agreed and 6.3% agreed that used cars contributed less to landfill garbage than new cars. Nonetheless, 25% of respondents disagreed or strongly disagreed, indicating some differences in opinions, even though the overall pattern is substantially positive ($p < 0.001$).

Regarding environmental policies, 75% strongly agreed, 12.5% agreed, and just 12.6% disagreed or remained neutral regarding how strict the policies were for the pre-owned car market. This indicates significant belief in the appropriateness of current policies, with statistically significant results ($p < 0.001$).

12.5% of respondents agreed and 62.5% strongly agreed with the statement made by automotive resources regarding the contribution of used cars to lower overall resource usage. Nevertheless, 12.5% of respondents disagreed and stayed indifferent, indicating a plurality in favor of the study with statistically significant results ($p < 0.001$).

In conclusion, when it came to government incentives, 56.3% of respondents highly agreed, 31.3% agreed, and only 12.6% disagreed or strongly disagreed with the idea that employing government-sponsored vehicles would improve environmental outcomes. This statement has statistically significant implications ($p < 0.001$) in the overall consensus.

The information shows that used cars have a favorable environmental impact in many different ways overall, and every response has reached statistical significance.

Table. Level of the response towards environmental impact

	Maximum Score	**Average Level**
Environmental Impact	35	30.18±2.66

Data regarding the degree of response to environmental impact are displayed in the table. The response can have a maximum score of 35. 30.18 is the average response level that was observed, having a standard deviation of ±2.66. This suggests that participants had a generally strong and positive knowledge or concern about environmental problems, as evidenced by the high average scores they received when asked about the influence of the environment. The comparatively low standard deviation indicates the majority of scores are near the mean, indicating that participants' replies were consistent.

Financial benefits and drawbacks of incorporating sustainable principles into the automobile industry.

Table. 2 Financial Benefits and Drawbacks

Questions	**Response**					**Sig. (2-tailed)**
	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	
Q1 Incorporating sustainability	0	5 (31.3%)	2 (12.5%)	1 (6.3%)	8 (50.0%)	<0.001
Q2 Sustainability measures	1 (6.3%)	2 (12.5%)	0	1 (6.3%)	12 (75.0%)	<0.001
Q3 Managed pre-owned vehicles	0	2 (12.5%)	1 (6.3%)	4 (25.0%)	9 (56.3%)	<0.001
Q4 Financial incentives	2 (12.5%)	0	1 (6.3%)	1 (6.3%)	12 (75.0%)	<0.001
Q5 Long-term cost savings	2 (12.5%)	1 (6.3%)	2 (12.5%)	1 (6.3%)	10 (62.5%)	<0.001
Q6 Resale value	0	2 (12.5%)	0	1 (6.3%)	13 (81.3%)	<0.001
Q7 Sustainability certifications	0	1 (6.3%)	2 (12.5%)	6 (37.5%)	7 (43.8%)	<0.001
Q8 Financial benefits	1 (6.3%)	0	1 (6.3%)	3 (18.8%)	11 (68.8%)	<0.001

Table 2 titled "Financial Benefits and Drawbacks" presents responses to a series of questions evaluating the financial implications of incorporating sustainability measures about pre-owned vehicles.

For Incorporating sustainability, Data regarding the degree of response to environmental impact are displayed in the table. The response can have a maximum score of 35. 30.18 is the average response level that was observed, having a standard deviation of ±2.66. This suggests that participants had a generally strong and positive knowledge or concerned about environmental problems, as evidenced by the high average scores they received when asked about the influence of the environment. The comparatively low standard deviation indicates the majority of scores are near the mean, indicating that participants' replies were consistent.

In Sustainability measures, when highlighted the financial advantages of sustainability measures, 75.0% of respondents strongly agreed, 6.3% agreed, and 18.8% disagreed or strongly disagreed overall. This indicates considerable support, with statistical significance ($p < 0.001$), for the financial advantages of sustainability.

For Managed pre-owned vehicles, Regarding the administration of used cars inside a sustainable framework, 25.0% agreed and 56.3% strongly agreed. In contrast, 6.3% were neutral and 12.5% disagreed, demonstrating a statistically significant strong favorable emotion ($p < 0.001$).

Financial incentives, which evaluated how financial incentives affected sustainability found that 75.0% strongly agreed, 6.3% agreed, 12.5% disagreed strongly, and 6.3% were neutral. This indicates that there was strong general agreement about the importance of financial incentives ($p < 0.001$).

Regarding **L**ong-term cost savings, having examined long-term cost savings with sustainable practices, 18.8% strongly disagreed or were neutral, compared to 62.5% who strongly agreed and 6.3% who agreed. There is a significant statistical belief ($p < 0.001$) in the long-term savings in costs from sustainability, as demonstrated by this.

In Resale value, 81.3% strongly agreed, 6.3% agreed, and 12.5% disagreed with the resale value of pre-owned cars that have been sustainably managed; this indicates a significant favorable response with statistical significance ($p < 0.001$).

In Sustainability certifications, 43.8% of respondents strongly agreed, 37.5% agreed, and 18.8% disagreed or were neutral when asked about the significance of sustainability certifications. This indicates a majority opinion of the worth of certificates with a statistical significance ($p < 0.001$).

Finally, In Financial benefits 68.8% strongly agreed, 18.8% agreed, and 12.6% were either neutral or strongly disagreed, suggesting strong support for the financial benefits of sustainability measures overall. This difference is statistically significant ($p < 0.001$).

All of the replies achieved statistical significance, indicating substantial support for the economic benefits of integrating sustainability measures overall.

Table. Level of the Response towards Financial Benefits and Drawbacks

	Maximum Score	**Average Level**
Financial Benefits and Drawbacks	40	33.81±3.56

An overview of respondents' perceptions of financial benefits and drawbacks is given in the table labeled "Level of Response towards Financial Benefits and Drawbacks". The responses can have a maximum score of 40. With a standard deviation of ±3.56, the average score was 33.81. This high average score—which is almost at the top—indicates that, when it comes to pre-owned cars, most respondents seem to see the financial advantages of sustainability measures favorably. The comparatively low standard deviation suggests that respondents generally believe that the financial advantages outweigh the disadvantages.

Novel approaches and technology improve sustainability all through the used car lifespan, from acquiring the vehicle to disposing of it.

Table. 3 Novel Approaches and Technologies

Questions	**Response**					**Sig. (2-tailed)**
	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	
Q1 Recycling Technologies	0	4 (25.0%)	4 (25.0%)	2 (12.5%)	6 (37.5%)	<0.001

Q2 Refurbishment processes	0	1 (6.3%)	0	0	15 (93.8%)	<0.001
Q3 Electric and hybrid technologies	0	1 (6.3%)	0	6 (37.5%)	9 (56.3%)	<0.001
Q4 Digital platforms	0	3 (18.8%)	1 (6.3%)	0	12 (75.0%)	<0.001
Q5 Value chain	2 (12.5%)	0	0	3 (18.8%)	11 (68.8%)	<0.001
Q6 Effective tracking systems	1 (6.3%)	0	0	4 (25.0%)	11 (68.8%)	<0.001
Q7 pre-owned automobile industry	1 (6.3%)	4 (25.0%)	0	1 (6.3%)	10 (62.5%)	<0.001
Q8 Public awareness	1 (6.3%)	0	5 (31.3%)	1 (6.3%)	9 (56.3%)	<0.001
Q9 Investments in research	2 (12.5%)	1 (6.3%)	1 (6.3%)	2 (12.5%)	10 (62.5%)	<0.001
Q10 Collaborations between stakeholders	1 (6.3%)	0	1 (6.3%)	5 (31.3%)	9 (56.3%)	<0.001
Q11 Sustainability metrics	0	0	0	5 (31.3%)	11 (68.8%)	<0.001
Q12 Integration of IoT and AI	0	3 (18.8%)	1 (6.3%)	2 (12.5%)	10 (62.5%)	<0.001
Q13 Use of blockchain technology	1 (6.3%)	3 (18.8%)	1 (6.3%)	1 (6.3%)	10 (62.5%)	<0.001
Q14 Sustainable disposal	2 (12.5%)	3 (18.8%)	0	1 (6.3%)	10 (62.5%)	<0.001
Q15 Government regulations	0	0	0	2 (12.5%)	14 (87.5%)	<0.001

The "Novel Approaches and Technologies" table displays the answers to a set of questions evaluating how new techniques and technologies are seen in relation to their effects on the environment. The distribution of answers for each question (Q1 through Q15) is displayed together with the significance level (Sig.) for each of the five categories: strongly disagree, disagree, neutral, agree, and strongly agree.

In Recycling Technologies, in response to a question regarding the efficacy of recycling technology, similar proportions (25.0%) disagreed and stayed neutral, while 37.5% strongly agreed and 12.5% agreed. This suggests a somewhat inconsistent but generally affirmative reaction, with statistically significant results ($p < 0.001$).

In Refurbishment processes, Refurbishment techniques are overwhelmingly effective; 93.8% strongly agree and 6.3% disagree, indicating a significant consensus with statistically significant ($p < 0.001$) about their efficacy.

For Electric and hybrid technologies, which assessed the uptake of hybrid and electric technologies, 56.3% strongly agreed, 37.5% agreed, and 6.3% disagreed. This suggests that there is substantial support ($p < 0.001$) for these technologies.

In Digital platforms, 75.0% strongly agreed and 18.8% disagreed with a statement about the usage of online platforms in the previously owned car industry, indicating substantial approval with some dissent and statistically significant ($p < 0.001$).

In Value chain, 68.8% strongly agreed, 18.8% agreed, and 12.5% strongly disagreed with the value chain improvements. This indicates majority support with some resistance and statistical significance ($p < 0.001$).

In Effective tracking systems, which examined the efficacy of tracking systems, 68.8% strongly agreed, 25.0% agreed, and 6.3% strongly disagreed. This indicates a majority of respondents who were in favor of the system with statistically significant results ($p < 0.001$).

For the pre-owned automobile industry, 62.5% strongly agreed, 6.3% agreed, 25.0% disagreed, and 6.3% strongly disagreed with regards to the pre-owned car market. This indicates a majority positive answer with considerable disagreement, with statistically significant results ($p < 0.001$).

In public awareness, 56.3% highly agreed, 6.3% agreed, 31.3% were neutral, and 6.3% strongly disagreed with the statement "public awareness of environmental benefits." This indicates a generally favorable but variable answer, with a statistically significant result ($p < 0.001$).

In Investments in research, 62.5% strongly agreed, 12.5% agreed, 18.8% disagreed, and 6.3% stayed neutral on research investments. This indicates substantial support with some opposition and is statistically significant ($p < 0.001$).

In Collaborations between stakeholders, which looked at stakeholder collaborations found that, of those who responded, 31.3% agreed, 56.3% strongly disagreed, and 12.6% were indifferent or strongly disagreed. This indicates substantial support having statistically significant results ($p < 0.001$).

For Sustainability metrics, regarding sustainability metrics, there was unanimity in favor, with statistically significant results ($p < 0.001$) and 68.8% strongly agreeing and 31.3% agreeing.

In Integration of IoT and AI, regarding integrating of IoT and AI technologies, there was high overall support with some dissent ($p < 0.001$), with 62.5% strongly agreeing, 12.5% agreeing, and a combined 25.1% disagreeing or being indifferent.

In Use of blockchain technology, As assessed the application of blockchain technology, 25.1% disagreed or were neutral, whereas 62.5% strongly agreed and 6.3% agreed. This suggests high support with moderate opposition and statistically significant ($p < 0.001$).

In Sustainable disposal, regarding environmentally friendly disposal methods, 62.5% highly agreed, 6.3% agreed, and 31.3% disagreed or strongly disagreed. This indicates a combination of support and opposition from the majority, with statistically significant results ($p < 0.001$).

Finally, In Government regulations, 87.5% strongly agreed and 12.5% agreed with government policies supporting innovative ideas, showing substantial support for these initiatives with statistically significant ($p < 0.001$).

Overall, the data shows that innovative strategies and technological advancements targeted at lessening the used car market's environmental impact are strongly supported, with every response reaching statistical significance.

Table. Level of the Response towards Novel Approaches and Technologies

	Maximum Score	**Average Level**
Novel Approaches and Technologies	75	33.81±3.56

An evaluation of respondents' opinions of novel techniques and technologies in relation to environmental impact is given in the table labeled "The level of the Response regarding Novel Approaches and Technologies". The responses can have a maximum score of 75. Having a standard deviation of ±3.56, the average score was 33.81. Less than half of the total potential score, or the average, indicates that respondents recognize and accept the usefulness of new methods and technology to a moderate extent. The comparatively low standard deviation suggests that, despite the general lack of strong positive or negative feeling, respondents' opinions were generally consistent.

5.11 Conclusion

To sum up, incorporating sustainability into the value chain of pre-owned cars comes with a lot of opportunities as well as big hurdles. This industry's shift to greener methods necessitates tackling problems like the need for better recycling procedures, lowering carbon footprints, and increasing vehicle lifetime transparency. But these difficulties also present chances to lead and innovate in the field of sustainability, such creating cutting-edge technology for refurbishing, implementing the concepts of the circular economy, and capitalizing on consumer demand for eco-friendly products. Stakeholders in the pre-owned car industry can benefit economically and competitively while simultaneously fostering a more sustainable future by overcoming these obstacles and grasping these opportunities.

5.12 References:

[1] Chan, S. K. (2021). Investigating the Hydrogen Supply Chain for Low-Carbon Power Generation Under Future Uncertainties: A Tradespace Exploration Approach (Doctoral dissertation, Massachusetts Institute of Technology).
[2] Ghosh, M., Ghosh, A., & Roy, A. (2020). Renewable and sustainable materials in automotive industry. Encyclopedia of Renewable and Sustainable Materials, 3, 162-179.
[3] Jacobs, C., Soulliere, K., Sawyer-Beaulieu, S., Sabzwari, A., & Tam, E. (2022). Challenges to the circular economy: Recovering wastes from simple versus complex products. Sustainability, 14(5), 2576.
[4] Torbjornsen, T. (2010). How to Make Your Car Last Forever: Avoid Expensive Repairs, Improve Fuel Economy, Understand Your Warranty, Save Money. Motorbooks.
[5] Brockhaus, S., Kersten, W., & Knemeyer, A. M. (2013). Where do we go from here? Progressing sustainability implementation efforts across supply chains. Journal of Business Logistics, 34(2), 167-182.
[6] Zhu, Q., Sarkis, J., & Lai, K. H. (2007). Green supply chain management: pressures, practices and performance within the Chinese automobile industry. Journal of cleaner production, 15(11-12), 1041-1052.
[7] Lee, K. H. (2011). Integrating carbon footprint into supply chain management: the case of Hyundai Motor Company (HMC) in the automobile industry. Journal of cleaner production, 19(11), 1216-1223.
[8] Hall, J. (2000). Environmental supply chain dynamics. Journal of cleaner production, 8(6), 455-471.
[9] Zhao, F., Liu, X., Zhang, H., & Liu, Z. (2022). Automobile industry under China's carbon peaking and carbon neutrality goals: challenges, opportunities, and coping strategies. Journal of Advanced Transportation, 2022(1), 5834707.
[10] Czerwinski, F. (2021). Current trends in automotive lightweighting strategies and materials. Materials, 14(21), 6631.
[11] PG, V. G., & Mathew, G. (2021, June). Blockchain based verification of vehicle history for pre-owned vehicle industry. In 2021 international conference on communication, control and information sciences (ICCISc) (Vol. 1, pp. 1-6). IEEE.
[12] Alhakamy, A. A., Alhowaity, A., Alatawi, A. A., & Alsaadi, H. (2023). Are Used Cars More Sustainable? Price Prediction Based on Linear Regression. Sustainability, 15(2), 911.
[13] Webber, R. J. (2020). Measuring the effect of customer satisfaction on customer re-purchase intention in the second-hand motor industry (Doctoral dissertation, North-West University (South Africa)).
[14] Shahedi, A., Nasiri, M. M., Sangari, M. S., Werner, F., & Jolai, F. (2022). A stochastic multi-objective model for a sustainable closed-loop supply chain network design in the automotive industry. Process Integration and Optimization for Sustainability, 6(1), 189-209.
[15] Palencia, J. C. G., Furubayashi, T., & Nakata, T. (2012). Energy use and CO2 emissions reduction potential in passenger car fleet using zero emission vehicles and lightweight materials. Energy, 48(1), 548-565.
[16] Miller, C. J., & Brannon, D. C. (2022). Pursuing premium: Comparing pre-owned versus new durable markets. Journal of Product & Brand Management, 31(1), 1-15.

[17] Denison, D. R. (1996). What is the difference between organizational culture and organizational climate? 21(3), 619-654.
[18] Xiao, Z., Song, W., & Chen, Q. (2012). Dynamic resource allocation using virtual machines for cloud computing environment. IEEE transactions on parallel and distributed systems, 24(6), 1107-1117.
[19] Abbasi, S. A., & Abbasi, N. (2000). The likely adverse environmental impacts of renewable energy sources. Applied energy, 65(1-4), 121-144.
[20] Valente, T. W., & Pumpuang, P. (2007). Identifying opinion leaders to promote behavior change. Health education & behavior, 34(6), 881-896.