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Article

From Linear to Circular: Leveraging Digital Technologies to Transform the Used Car Retail Value Chain

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Abstract

Circular economy (CE) principles have a lot of potential to improve sustainability in the Second-Hand (SHA) retail industry. This study looks at how digital tools like blockchain, AI, and online platforms can improve operational effectiveness, transparency, and environmental performance while addressing important issues in the SHA value chain. A systematic literature review, a consumer survey (n = 212), and 12 semi-structured stakeholder interviews were all part of the mixed-methods approach.

Five main consumer barriers are identified by the findings: pricing opacity, digital inexperience, inconvenience, trust deficits, and worries about the cleanliness and condition of the vehicle. Convenience as well as scalability have been effectively increased by digital innovations such as blockchain-enabled ownership records, customer education tools, AI-based pricing along with virtual inspections. But difficulties with transparency as well as trust still exist, mainly in the valuation procedures along with documentation.

According to the study, start-ups that use CE concepts, like Vehicle-as-a-Service (VaaS), predictive diagnostics as well as refurbishment models, are more flexible in meeting sustainability goals than traditional dealerships. Digital interventions' alignment with sustainability pillars in ownership transfer, sourcing, purchase as well as marketing is demonstrated by a value chain mapping. This study adds to the expanding body of knowledge on the CE–Industry 4.0 nexus in the context of used car retailing and offers industry stakeholders practical insights.

Keywords: *Technological adoption; Circular economy; Second-hand automobiles; Block-chain; Digital platforms; Artificial Intelligence; Industry 4.0; Value chain analysis; Sustainability; Used automobile retailing*

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Introduction

The market for used goods has grown due to growing environmental consciousness and the pressing need for sustainable consumption habits. There are many risks in the used goods industry to increase the concepts of the circular economy, prolong product lifecycles, and reduce waste. Particularly, used car sales provide the automotive sector a valuable way to decrease its environmental impact and meet consumers' rising demand for accessible and reasonably priced mobility options (Hristova & Hristova, 2019). Reusing and reselling vehicles adds new complexity and difficulties along the value chain, even though they also raise resource efficiency and generate economic value.

One of the major concerns in the used car market is the continuity of problems like odometer fraud, vehicle identification (VIN) tampering, and information asymmetry. These difficulties decrease buyer confidence along with threatened openness. In response, researchers have used technological developments to raise the reliability of car transactions, specifically blockchain technology and cloud-based systems. Its decentralization and fixed structure allow transparent vehicle history reporting and fraud mitigation; improve consumer confidence in used car transactions (Y. Yu et al., 2021; Butera et al., 2023).

Despite the numerous technological developments, the used car market industry still uses outdated approaches, which contribute to ambiguity and fraudulent activity. For example, it is assessed that odometer fraud alone costs European consumers €8.9 billion annually, emphasizing the need for systematic technological interventions (Butera et al., 2023). The blockchain applications have the potential to completely change this market by securely logging vehicle usage data, confirming traceability, and verifying authenticity throughout the value chain. At the same time, the growth of digital retail platforms has transformed customer experiences through successful convenience, operational efficiency, and personalization. However, this shift has also presented important challenges for brand manufacturers. Online intermediaries often charge high transaction fees, discrete the producers from direct consumers' interaction, and introduce private-label products to disrupt competition (Reinartz et al., 2019). Because of this, many brands are now looking for digitally integrated retail models that support sustainability objectives and maintain brand equity.

Businesses that adopt new business models can better manage corporate sustainability-related concerns. Adaptability, flexibility, and strategic autonomy are highly valued organizational values that often serve as the foundation for innovation and sustainability initiatives. It suggests that business model innovation and

sustainable practices are not distinct endeavors but are closely related to the core principles that guide an organization's structure and decision-making processes (Pedersen et al., 2018). Businesses are increasingly implementing circular business models like resource recovery, product-as-a-service, and re-commerce to meet the growing demands for ethical consumption. These tactics change consumer behavior and business practices by encouraging shared access, prolonging product lifespans, and permitting reuse (Hollitt & Shaw, 2006). Remanufacturing and recycling are sustainable practices increasingly essential to the automotive industry's operational success. The integration of these practices has been accelerated by adopting advanced technologies, particularly during the COVID-19 pandemic, even though the immediate financial returns may still be modest (Z. Yu et al., 2022).

When considering their whole lifecycle, cars rank among the most resource-intensive products. The industry still primarily follows the "take–make–waste" linear model, seriously degrading the environment. Just 2% of end-of-life vehicles are recycled into new ones through closed-loop recycling, as shown in Figure 1. In the meantime, 27% of these cars wind up in landfills or as non-recyclable residues, which shows significant inefficiencies and lost chances to improve sustainability and recover value.

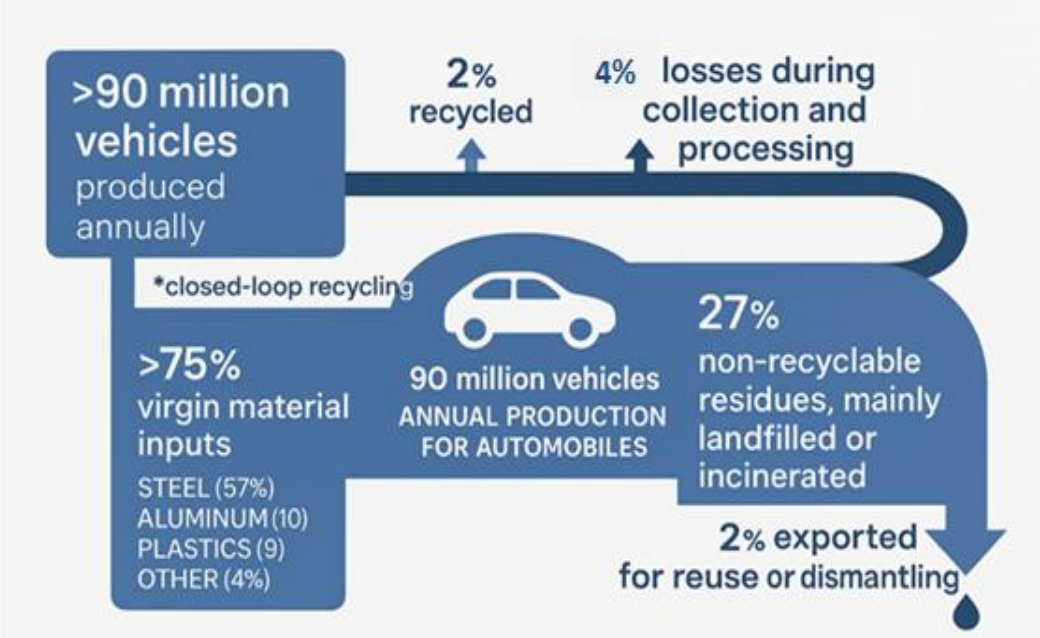

Figure 1. Global material flows for automobiles

The second-hand car retail industry faces mounting pressure to implement sustainable practices due to the world's expanding population and demand for natural resources. The sector's environmental impact will keep growing unless there is a clear

shift away from the linear model. Improving sustainability requires integrating circular economy concepts into the value chain, such as remanufacturing, reuse, and technology integration.

The CE-I4.0 nexus, which combines Industry 4.0 (I4.0) technologies with Circular Economy (CE) principles, is becoming increasingly recognized as a viable and strategic approach to sustainable development. Transparency, improving efficiency, and resource optimization across value chains, this nexus combines circular practices like recycling, reuse, and remanufacturing with digital tools like blockchain, big data, IoT, and AI. It closely corresponds with several UN Sustainable Development Objectives, such as SDGs 7, 8, 9, 11, 12, and 13, and provides scalable solutions to challenging sustainability problems. Consequently, the CE-I4.0 nexus offers a thorough framework for improving economic and environmental sustainability in contemporary industries (Dantas et al., 2021).

This study looks at how the strategic use of technologies, particularly blockchain and digital retail platforms, can increase the retailing of used automobiles. The study uses a value chain analysis to identify the important interventions where technology can develop transparency, solve inefficiencies, and promote a more sustainable and circular automotive environment.

Consumers often opt for used cars due to practical needs such as general transportation, business, and travel (Sudha, 2020). Furthermore, many people favor used goods because they are more convenient and take less time and effort to buy (Padmavathy et al., 2019). An important research question arises from this: To what extent does the retail sector of used automobile industry use technological adoption to improve its operations and sales?

Technology and sustainability have come to a practical version to solve real-world business problems. Due to the simultaneous shifts towards a circular economy and digital transformation, businesses are being presented with exciting opportunities to innovate and rethink their value propositions. Businesses can create shared societal value and maintain economic growth by integrating emerging technologies with sustainable practices (Hollitt & Shaw, 2006). It poses a crucial research query: How does this strategy stack up against the conventional value chain, and does the use of technology improve sustainability in the used car sector?

The aim of this research and the guiding research questions are addressed through the following objectives:

- To examine the extent of technological adoption in the second-hand automobile retail sector.

- To compare traditional and technology-enabled value chains within the used car industry.
- To evaluate how technology contributes to sustainability in second-hand car retailing.
- To identify key challenges and best practices for leveraging technology to enhance efficiency and transparency.

This study uses a mixed-methods approach to address the research questions and objectives. A thorough analysis of more than forty scholarly journals, industry reports, and research articles is first carried out to investigate the degree of technological adoption, obstacles to efficiency and transparency, and best practices in the retail sector of used cars. A survey was given after the literature review to get consumer opinions on how technology affects used car purchases. To learn more about how technology is incorporated into the different phases of the used car value chain, in-depth interviews are also conducted with important stakeholders, such as dealers and platform operators.

This approach seeks to identify the opportunities and problems related to technology adoption and how it affects operational performance and sustainability. In addition to providing practical suggestions for industry stakeholders looking to improve consumer trust, efficiency, and sustainability through digital innovation, the findings add to the scant empirical research on technology-enabled practices in used car retailing.

The structure of the paper is as follows: Section 2 presents a review of relevant literature on technology integration and sustainability in the used car market; Section 3 details the research methodology; Section 4 analyses the primary research findings; and Section 5 concludes with insights and implications for the digital transformation of second-hand automobile retailing.

Literature Review

In this literature review part, the papers dealing with technological innovation integration are summarized. The keywords such as *"second-hand cars," "blockchain," "digital platforms," "consumer trust,"* and *"circular economy,"* were used to get academic publications, industry reports, and peer-reviewed journals from 2010 to 2024. The

review identifies important trends and challenges and digital solutions that aim to improve operational efficiency, transparency, and trust across the value chain.

Emerging Trends and Conceptual Developments in the Second-Hand Automobile Market

As a result of growing environmental consciousness and the need to reduce carbon emissions, people's consumption patterns have changed significantly, leading to an interest in sustainable mobility solutions in recent years. One notable thing is the rise in reuse and resale practices in the automotive sector, especially in the second-hand market. This shift requires the adoption of circular economy (CE) principles, which encourage prolonging product lifecycles through recycling, remanufacturing, reuse, and refurbishment (Ellen MacArthur Foundation [EMF], 2021). The circular economy threatens the widely used linear "take-make-dispose" model by emphasizing waste reduction and resource optimization throughout the vehicle lifecycle.

These days, the technological advancements brought about by Industry 4.0 (I4.0) are closely related to creating this sustainability-driven model. A robust framework enabling businesses to improve environmental performance, operational efficiency, and traceability is the CE-I4.0 nexus, which combines CE and I4.0 (Dantas et al., 2021). Technologies like blockchain, artificial intelligence (AI), data analytics, and the Internet of Things (IoT) are gradually supporting CE initiatives across the automotive value chain. Real-time tracking of vehicle components, predictive maintenance, and sustainable resource management are all made possible by these digital tools, which offer a comprehensive and data-driven approach to used car management.

One of the biggest tasks faced in the used car market is the problem of data asymmetry. Buyers often lack access to verified information about a car's history, including odometer rollbacks, tampered VINs, missing maintenance records, and hidden accident histories (Yu et al., 2021). Due to the mistrust that results from this information gap, transactions are discouraged, and the overall expansion of the used car market is hindered. Blockchain technology has developed as a revolutionary solution to these difficulties. Its decentralized, transparent, and unchangeable nature allows secure documentation of vehicle ownership, part replacements, service history, and mileage data (Butera et al., 2023). By providing cars with verifiable digital identities, blockchain has the potential to decrease fraud and reconstruct consumer trust significantly.

The way buyers engage with used cars has also changed due to the digitalization of retail. The buyers can now browse schedules, view vehicle details,

compare prices, and even display them for deliveries or inspections from their home. These platforms usually use automated financing tools, virtual showrooms, and AI-driven recommendation engines to provide seamless, personalized user experiences. These digital platforms have expanded market reach and improved convenience, but they have also created tasks for original equipment manufacturers (OEMs) and authorized dealers. According to Reinartz et al. (2019), there is growing concern over fragmented supply chains, high intermediary costs, a loss of control over customer relationships, and after-sales services.

As an outcome, many automakers are shifting to omnichannel, integrated business models that combine the advantages of online shopping with circular and sustainable business approaches. From certified pre-owned programs and AI-based diagnostics to blockchain-verified vehicle histories and ecologically friendly disposal or repurposing, these models seek to provide end-to-end services. These increases not only satisfy the changing demands of environmentally conscious and tech-savvy consumers but also promote long-term brand loyalty and regulatory compliance.

The market for used cars is changing due to the convergence of sustainability, consumer expectations, and digital innovation. These new trends and conceptual advancements set the stage for more open, effective, and ecologically friendly mobility models as academic and industry study continues to advance.

Challenges in the Used Car Sector

The used car market is plagued by structural and operational problems, even though it provides important sustainability profits, such as minimizing resource extraction and lowering environmental burdens through longer product lifecycles. Information asymmetry, which Akerlof (1970) first proposed in his groundbreaking book The Market for "Lemons," is a key difficulty. Customers are frequently reluctant to participate in markets where sellers have greater knowledge than buyers about the value of the products, because they are buying out of concern that they might wind up buying inferior or misrepresented goods. It is especially problematic in the used car industry, where vehicle histories are usually fabricated or incomplete.

Odometer tampering, VIN (Vehicle Identification Number) cloning, and fabricating service or accident records are examples of shared fraudulent activities (Zhou et al., 2021). In addition to distorting the perceived value of cars, these practices undermine consumer confidence, resulting in inefficiencies and mispricing

throughout the market. As a result, the automotive industry's adoption of sustainable consumption models is slowed, and legitimate transactions are depressed.

Moreover, because buyers often lack technical know-how or resources to control a vehicle's condition, these integrity issues put them in a high-risk situation. Although they provide some assurance, even certified pre-owned programs might not be able to thoroughly address the fundamental problems with transparency in the larger market ecosystem. The automotive industry's ability to devise circular economy principles is hindered by this systemic opacity, which also impedes the shift to a more resource-efficient and morally sound consumption model.

As a result, tackling information asymmetry is not only an issue of market regulation but also a vital first step in producing a reliable, sustainable, and technologically advanced ecosystem for used cars.

Technological Solutions and Blockchain Integration

Technological growth is critical in addressing the long-standing difficulties with the used car market, particularly those related to trust, transparency, and operational inefficiencies. Blockchain technology is considered one of the significant recent innovations in technology. Important vehicle data, such as odometer readings, accident histories, and ownership changes, can be safely recorded using its decentralized, unchangeable ledger system (Yu et al., 2021). By eliminating the possibility of data manipulation and allowing greater transparency, blockchain creates a more reliable marketplace where buyers and sellers can do business with more confidence. According to Butera et al. (2023), integrating blockchain technology throughout the automotive supply chain recovers overall traceability and compliance while preventing fraudulent activities like odometer fraud and VIN tampering.

In addition to blockchain, Industry 4.0 (I4.0) technologies like the Internet of Things (IoT), cloud computing, and big data analytics have revolutionized the used car market. These technologies support better vehicle lifecycle management and more informed purchasing decisions by allowing real-time vehicle diagnostics, dynamic pricing models, and predictive maintenance alerts (Chauhan et al., 2022). For instance, IoT-enabled sensors can track a car's performance over time, sending data to cloud platforms where analytics tools can produce insights on wear and tear or maintenance.

This data-driven method decreases unexpected failures while increasing customer satisfaction and trust.

These digital technologies are transforming traditional used car markets into more customer-focused, transparent, and efficient ecosystems that align with the principles of the circular economy and sustainability areas.

The CE-I4.0 Nexus and Value Chain Optimization

The CE-I4.0 nexus, or the grouping of the Circular Economy (CE) and Industry 4.0 (I4.0), is a growing interest for sustainability studies. Dantas et al. (2021) propose this framework as a deliberate method to simultaneously achieve economic and environmental goals. Businesses can optimize resource flows and decrease lifecycle emissions by integrating digital tools (such as AI, blockchain, and IoT) with circular practices (such as reuse, recycling and remanufacturing). In the automotive sector, this integration provides measurable gains in efficiency, transparency, and sustainability (Stock & Seliger, 2016).

Digital Platforms and Market Disruption

Digital platforms are transforming consumer experience in the used car market with convenience, personalization, and trust-building features like verified seller ratings (Padmavathy et al., 2019). However, by removing intermediaries' original manufacturers and encouraging dependency over extreme transaction fees, these platforms also oppose the recognized value chains (Reinartz et al., 2019). As an outcome, manufacturer-led or hybrid platforms that offer digital capabilities without compromising brand equity or sustainability areas are more suitable and more popular.

Sustainable Business Model Innovation

The relationship between sustainability and business model innovation has received increased attention in academic and industrial discussions as the circular economy's principles are being adopted. Sustainable business model innovation, or SBMI, redesigns creation and delivery, and captures. Companies that adopt flexible and dynamic business models are more likely to use circular strategies like Product-as-a-Service (PaaS), which swaps traditional ownership with shared usage (Pedersen et al., 2018). This shift produces long-lasting client relationships and consistent revenue streams and reduces waste and resource consumption.

Apart from PaaS, other circular business models like resource recovery (getting value from used materials) and re-commerce (selling used goods again) are becoming

more popular in various industries, including the automotive sector. These models are categorized by Bocken et al. (2014) as critical innovations that explain the firm's role in attaining sustainable outcomes. Furthermore, Hollitt and Shaw (2006) noted that these strategies mainly depend on cultural acceptance and consumer involvement, emphasizing the importance of matching value propositions to alter user expectations. All things considered, SBMI pushes businesses to reconsider how they provide value to consumers, society, and the environment by promoting durability, effectiveness, and cooperative consumption.

Post-pandemic Acceleration of Technological Adoption

Digital transformation in industries, including used car retail, has been further accelerated by the COVID-19 pandemic. Long-term shifts towards digitization were sparked by the need for remote purchasing, digital contracts, and virtual inspections (Yu et al., 2022). The pandemic has created a technological foundation that promotes sustainable growth and consumer trust, even though the financial benefits may still be gradual.

Materials and Methods

The findings from the literature review informed the development of a mixed-methods research design (Figure 2), which was employed to address the research objectives comprehensively over four months. This approach integrates primary and secondary data collection and analysis. It combines qualitative and quantitative techniques to provide a holistic understanding of how technological adoption

enhances sustainability in the second-hand automobile retail and its overall impact across the used car value chain.

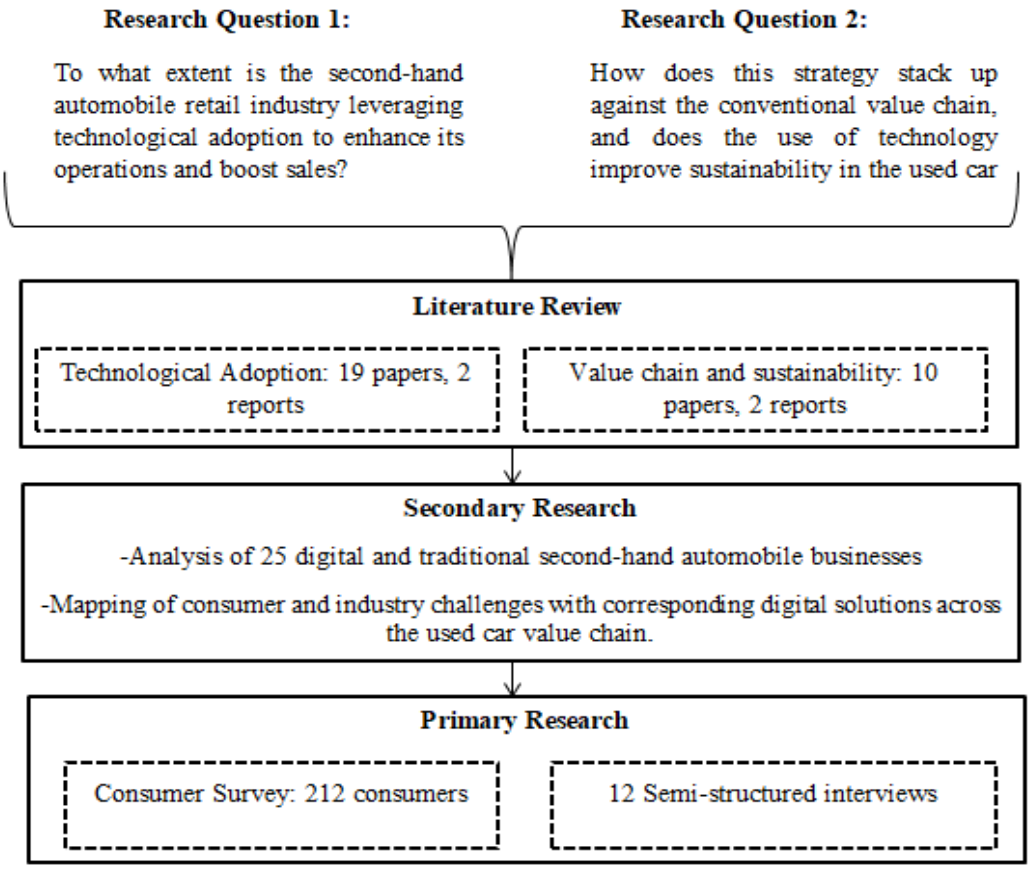

Figure 2: Overview of research methodology

Systematic Literature Review

A thorough literature review covering 29 peer-reviewed academic and industry sources was conducted to develop a strong theoretical framework for this investigation. The review sought to determine the extent and use of new digital solutions throughout the vehicle resale value chain and the obstacles that still exist in conventional used car markets. To guarantee thorough coverage of the subject, pertinent literature was retrieved using specific keyword combinations from four significant academic databases: Scopus, ScienceDirect, IEEE Xplore, and Google Scholar (Table 1).

Using keywords like *"used car value chain"* and *"blockchain automotive,"* 12 sources from Scopus were found, highlighting information asymmetry, transparency, and traceability in conventional resale models. Nine articles from ScienceDirect that addressed *"Circular economy cars"* and *"AI in vehicle resale"* highlighted sustainability-

driven models and the function of AI in automating valuations and enhancing consumer confidence. Using the terms *"IoT vehicle tracking"* and *"digital twins auto,"* IEEE Xplore produced four important publications that discussed Industry 4.0 technologies for innovative diagnostics, real-time data tracking, and digitization of vehicle histories. Finally, four more sources that provide information on consumer behavior, ethical issues, and platform-mediated trust mechanisms in second-hand car markets were taken from Google Scholar using keywords like *"Odometer fraud tech"* and *"second-hand auto platforms."*

This systematic review provides a basis for examining how digital innovations are changing the retail ecosystem for used cars and resolving persistent issues like fraud, opaqueness, and inefficiencies in documentation and valuation.

Table 1: Keywords and Sources Used in Literature Review

Database	Keywords Used	No. of Sources
Scopus	"Used car value chain", "Blockchain automotive"	12
Science Direct	"Circular economy cars", "AI in vehicle resale"	9
IEEE Xplore	"IoT vehicle tracking", "Digital twins auto"	4
Google Scholar	"Second-hand auto platforms", "Odometer fraud tech"	4

Secondary Research

The literature review highlighted a critical research gap at the intersection of digital technologies and circular value chains in the second-hand automobile sector. The way sustainability and digital transformation intersect in the used car market has received little scholarly attention, despite the growing conversation about these topics in automotive markets. Because of this disparity, a thorough desk-based study was required to methodically examine the scope and type of technology integration to improve sustainability in this area.

Secondary data collection involved a comprehensive review of industry reports, academic journal articles, and white papers. To facilitate an in-depth desk-

based investigation, a purposive sampling approach was employed to identify 25 automobile retailers encompassing both digital-native platforms and traditional dealerships exhibiting diverse technological adoption levels. The selection criteria included:

- Operational transparency (e.g., vehicle history disclosure, inspection reports, emissions tracking)
- Utilization of advanced technologies such as artificial intelligence for pricing and diagnostics, blockchain for provenance and transaction integrity, and digital platforms enabling seamless C2C and B2C transactions
- Commitment to sustainability practices, including vehicle refurbishing, recycling initiatives, and efforts to extend product life cycles.

The desk research aimed at:

- Classify the business models based on value chain integration.
- Identify Industry 4.0 technologies for enhancing trust, traceability, and operational efficiency.
- Map the consumer-facing digital tools (e.g., vehicle history apps, digital inspection reports, online financing) across the second-hand car customer journey.
- Align technological implementations with key sustainability pillars: economic efficiency, environmental impact, and consumer trust.

The findings were validated by a panel of five academic and industry experts and summarized in Table 2, which maps technological solutions to pain points across the second-hand automobile value chain.

Table 2. Consumer and industry challenges are mapped with corresponding digital solutions across the used car value chain.

Value Chain Stage	Pain Points	Technological Solutions	Sustainability Pillars
Sourcing & Inspection	-Lack of transparency -Inaccurate car condition assessment	-Vehicle history apps -Vehicle inspection reports	-Economic efficiency -Environmental impact -Customer trust
Pricing & Purchase	-Pricing uncertainty -Financing difficulties	- AI-based valuation tools	

		-Online financing platforms	
Ownership Transfer	-Concerns over fraud -Cumbersome paperwork	- Blockchain	
Sales & Marketing	-Inefficiencies -Limited market reach	-Digital marketplaces -C2C platforms	

Various digital tools and consumer-facing touchpoints are being used more by online platforms in the used car market to address common friction points during the purchasing process. The secondary research identified key technological solutions that address consumer pain points along the used car value chain. These solutions included peer-to-peer digital marketplaces, digital inspection reports, AI-based valuation tools, online financing platforms, blockchain-enabled ownership systems, and vehicle history applications. These pain points included transparency issues during sourcing, uncertainty in pricing and financing, risk of fraud during ownership transfer, and limited reach in marketing and sales. Every digital solution was carefully mapped to a particular stage of the customer journey, such as sourcing and inspection, pricing and purchase, ownership transfer, and sales and marketing, to assess its contribution to enhancing operational effectiveness, environmental performance, and customer trust. All authors critically reviewed this mapping exercise to confirm sectoral significance and analytical consistency.

This detailed desk-based analysis was used to plan the next research phase, which included a consumer survey and a series of semi-structured interviews with digital technology providers, used car retailers, and industry experts. In addition to separating the outcomes of secondary data and the literature, these primary research activities aimed to empirically measure the effectiveness of identified digital tools in removing consumer barriers. The objective was to learn more about how these technologies contribute to a more transparent, efficient, and sustainable used automobile purchasing process.

Primary Research

Consumer Survey

A structured survey was conducted to discuss the study goals and capture consumer insights related to technological integration in the second-hand automobile

retail sector. The main goal was to estimate the degree of digital adoption, relate traditional and technology-enabled retail experiences, assess sustainability effects, and identify key tasks and best practices from the consumer's perspective.

The survey, *"Buying a Used Car: Digital vs. Traditional Experience",* was shared through digital automotive communities, including Facebook groups focused on vehicle resale, online car buying forums, and Reddit threads such as r/cars and r/used cars. Two categories of respondents were targeted:

- Consumers who purchase a second-hand vehicle through a digital platform.
- Consumers who had engaged with or purchased from traditional offline dealerships.

The questionnaire's design reflected the four main research objectives (Figure 3). It investigated consumer preferences for online versus offline transactions, trust in blockchain technology, environmental factors in purchasing decisions, and awareness and use of digital tools (such as AI-based pricing tools and vehicle history reports). Additionally, the survey aimed to identify digital platforms' perceived advantages and drawbacks, particularly regarding operational transparency, convenience, and general trust.

A pilot phase involving 30 participants was conducted to refine the questionnaire, with specific attention given to sections on digital trust and sustainability. Following adjustments, the final survey was live for six weeks and generated 212 complete responses from participants across five major Indian cities, covering both urban and semi-urban regions. The completion rate was 87%, and responses spanned a range of age groups, education levels, and vehicle ownership experiences (Figure 5).

The survey objectives were:

- To examine the extent of technological adoption by identifying how consumers interact with tools such as digital inspection reports, online listings, AI-based valuation, and customer support platforms.
- To compare traditional and technology-enabled value chains, based on perceived efficiency, transparency, and user satisfaction.
- To evaluate how technology contributes to sustainability by measuring consumer awareness of eco-friendly practices (e.g., vehicle

refurbishment, emission tracking) and its influence on purchasing decisions.

- To identify challenges and best practices, particularly those affecting trust, fraud prevention, and transaction convenience in the digital second-hand car buying process.

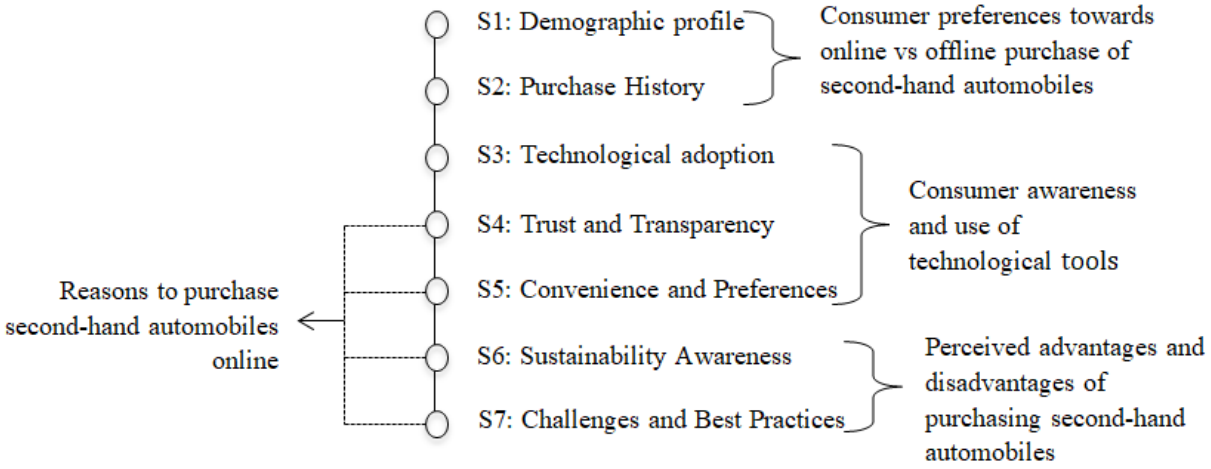

Figure 3. Overview of the survey questions

Quantitative data were analyzed using descriptive statistics and cross-tabulation techniques in SPSS (v23.0) to identify behavioral patterns and trust dynamics Table 3.

Table 3. Key Metrics and Survey Findings

Survey Theme	Indicator	Result Summary
Digital Platform Usage	% using online platforms	68% regularly browse or purchase via digital tools
Trust and Transparency	Belief in blockchain verification	74% found digital records more trustworthy
Convenience Preference	Preferred digital over physical	59% preferred online purchasing
Sustainability Concern	Environmental factors in decisions	41% rated sustainability as highly important

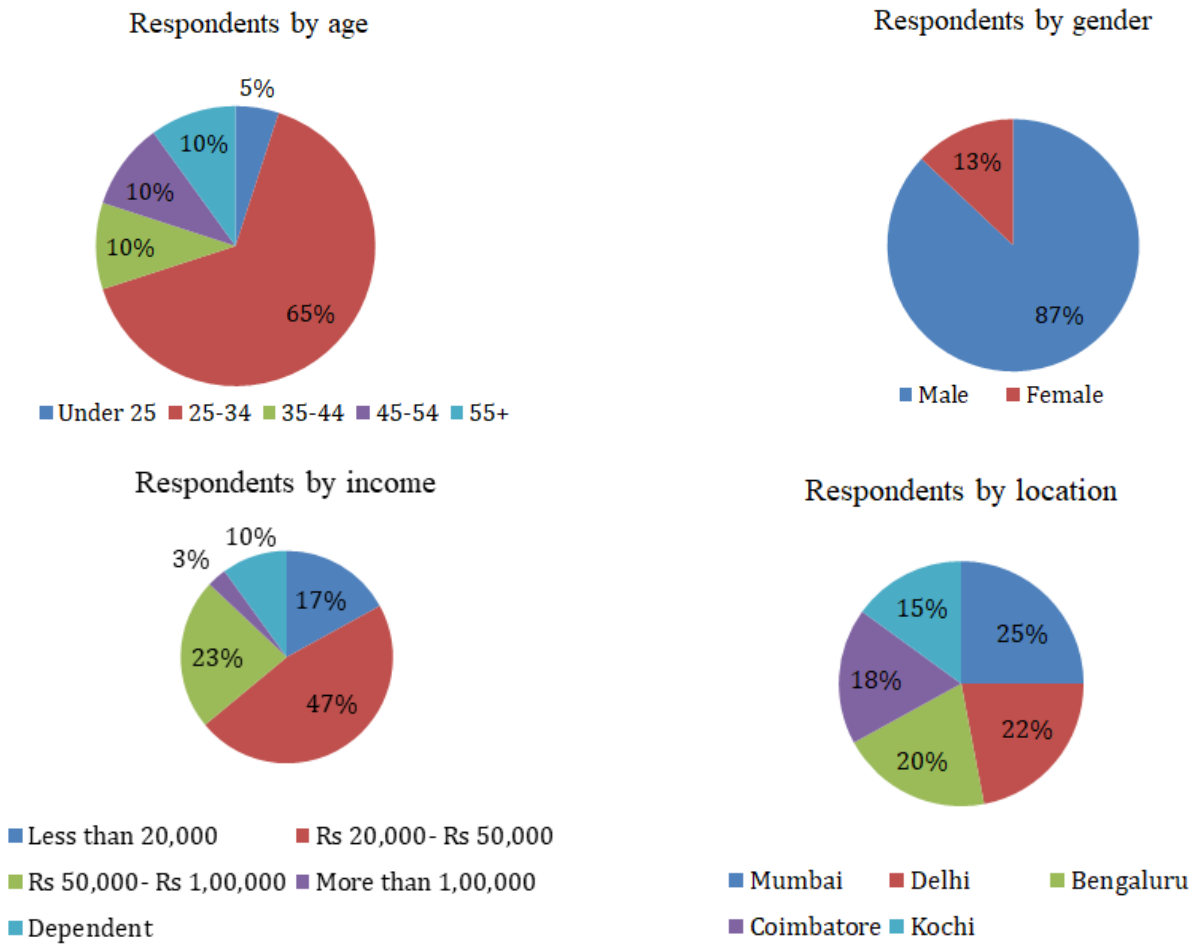

Figure 5. Overview of the statistics of the respondents

Interviews

In-depth 12 semi-structured interviews were conducted with stakeholders involved in the used automobile value chain, such as online platform operators, certified resale dealers, blockchain consultants, and sustainability officers (Table 4).

Table 4. Overview of interviews

Business Model	Stakeholder Type	Number of Interviews	Key Insight Theme
Digital Platform	Online Platform Operators	4	Platform scalability, user retention
Traditional Dealership	Certified Resale Dealers	3	Digital adoption barriers

Technology service model	Blockchain Consultants	2	Tech-stack integration challenges
Sustainability Strategy	Sustainability Officers	3	Post-pandemic CE strategy alignment

Each interview lasted 45–60 minutes and was guided by a structured script (Appendix C) to minimize bias and enable detailed qualitative analysis. Phone calls or video conferences were used to conduct semi-structured interviews. The semi-structured interviews covered a wide range of themes, including:

1. Digital tools are adopted across the key stages of the value chain: sourcing, inspection, sales, and post-sale service.
2. Efficiency and transparency shift in the value chain due to digitization, comparing pre- and post-digital models.
3. Environmental and sustainability benefits were achieved, such as vehicle lifespan extension and reduced emissions from optimized logistics.
4. Consumer challenges include price distrust, concerns over a lack of physical inspection, and how digital tools help mediate these concerns.
5. Organizational priorities and perceived internal and external barriers to further technology adoption, especially for SMEs and legacy players.

Transcriptions were analyzed using thematic analysis to draw out patterns relevant to the research objectives (Figure 6).

Additionally, the interview questions were designed to explore topics such as:

- Implementation barriers of digital platforms in traditional retail ecosystems.
- Integration of blockchain with legacy systems
- Return on investment (ROI) and evolving consumer responses post-pandemic, particularly around digital trust and remote vehicle transactions.
- Circular business model innovations, such as buy-back schemes and vehicle-as-a-service (Vaas) models, are being piloted by progressive firms.

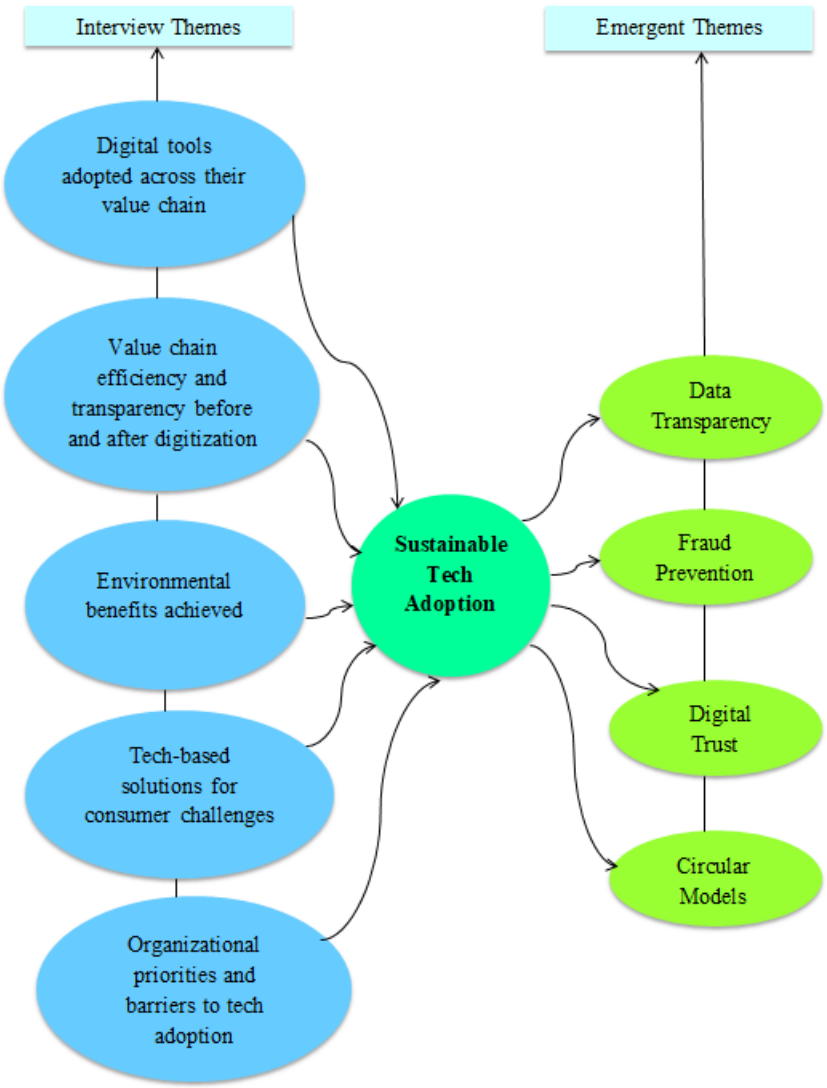

Figure 6: Themes Emerged from Expert Interviews

These interviews provided critical insights into the opportunities and constraints surrounding technological adoption in second-hand automobile retailing and its contribution to circular economic objectives.

Results

Survey results

Extent of Technological Adoption in the Second-Hand Automobile Retail Sector

Survey findings indicate a growing adoption of digital technologies within the second-hand automobile (SHA) retail sector. Approximately 45% of respondents, mainly from the 25–34 age range (62%), said that the emergence of specialized online marketplaces and vehicle history apps has increased their likelihood of buying a used automobile (Figure 7).

Respondents identified several valuable digital tools:

- AI-driven vehicle recommendations and pricing tools
- Virtual inspection, mobile-first platforms
- 360° vehicle inspection videos and digital documentation
- Online financing and secure payment systems

Digital tools were particularly appreciated by younger buyers, with 87% of respondents aged 18–34 emphasizing their importance in the decision-making process. Online platform operators also emphasized the quick adoption of digital technology to increase scalability and user retention. Start-ups were commended for their quick integration of automated verification, real-time customer service, and mobile-first interfaces. Some conventional certified dealerships, on the other hand, pointed to training requirements and integration costs as obstacles.

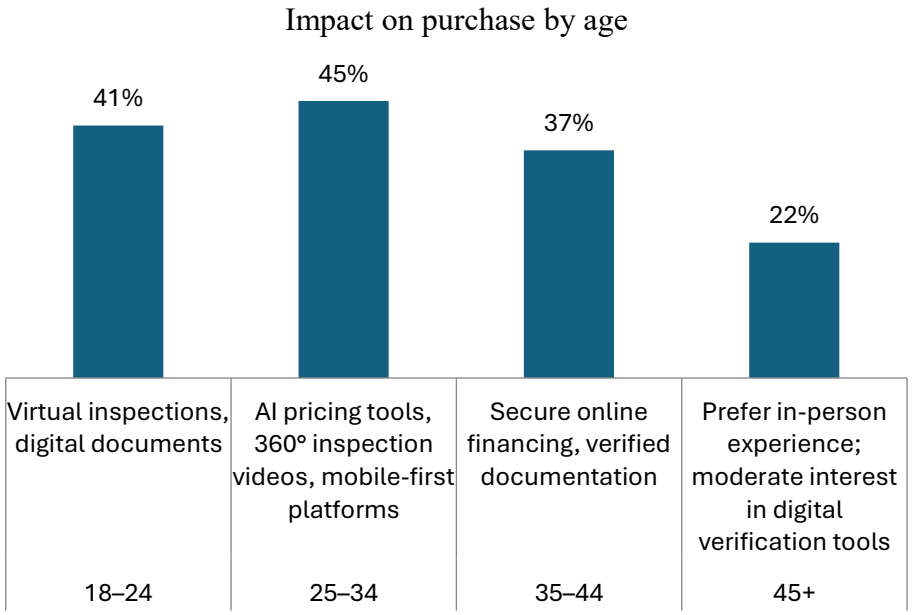

Figure 7. Overview of technological adoption in second-hand automobile retail

Influence on Consumer Behavior and Platform Preferences

Consumer responses revealed key behavioral shifts:

- 72% reported finding a suitable vehicle was easier online than through physical dealerships.
- 68% appreciated the broader choice and price comparison features on digital platforms.
- 38% believed in-person pricing was more reliable, whereas 27% preferred online pricing filters and benchmarks.

However, trust remains a concern:

- 48% feared fraud or misrepresentation during online transactions.
- Only 12% trusted online vehicle condition claims, compared to 61% for certified offline dealers.
- 53% flagged maintenance history and repair transparency as major deterrents.
- Hygiene concerns were minimal, but cleanliness and accident history were critical.

Overall, the results support earlier research showing that people who have bought things online are more likely to trust and find it easy to use. In contrast, people who have never bought anything online are more skeptical, especially regarding documentation and after-sales service. (Figure 8) shows the relationship map of the influence of digital tools on consumer behavior, in which the "+" sign shows positive influence, and the "-" sign shows negative influence.

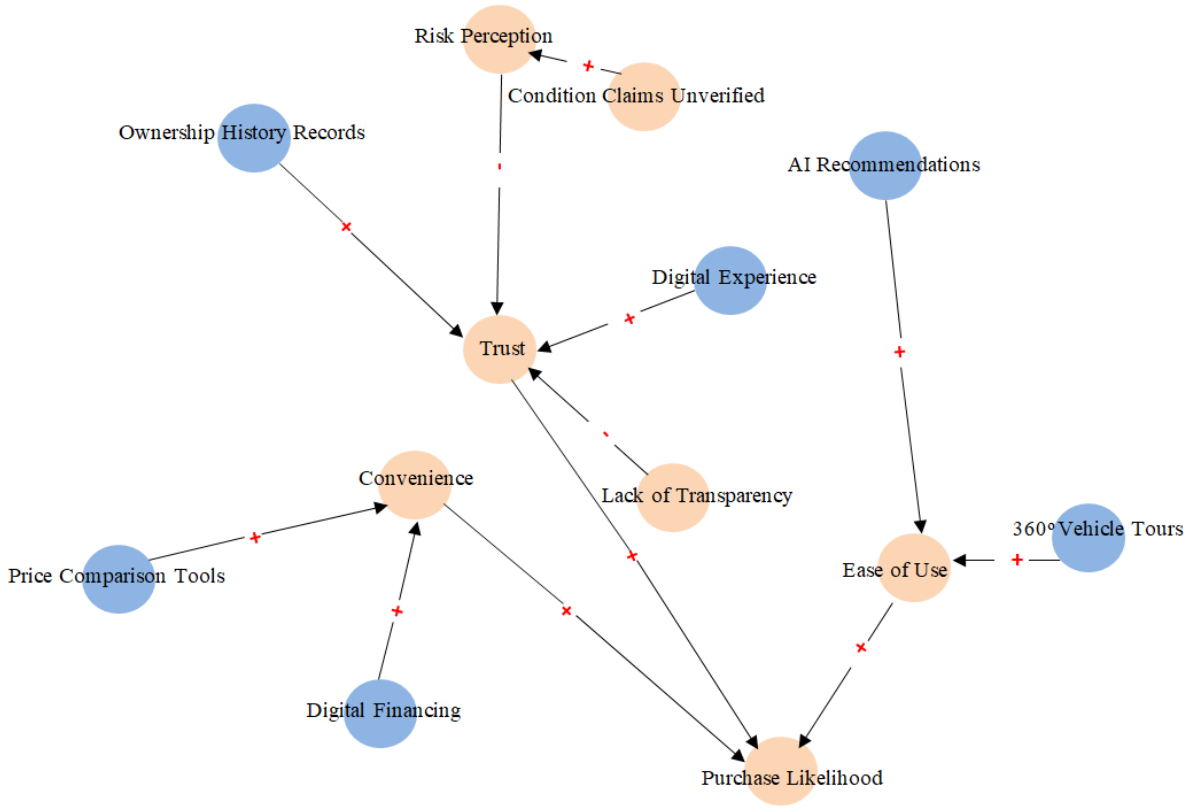

Figure 8. Overview of the relationship map of the influence of digital tools on consumer behavior

Sustainability and Circularity Perceptions among Consumers

The survey also suggested an increasing consumer preference for sustainability and circular economy (CE)-oriented platforms:

- Many valued transparencies in emissions, quality assurance, and low-carbon logistics.
- Platforms that included refurbishment options, resale models, and predictive diagnostics to extend vehicle lifespan were rated favorably.
- Start-ups leveraging CE as a core principle reported greater consumer alignment.

Interview Results

Circular Economy Business Models

Stakeholder interviews showed that scaling circular models is still more possible for start-ups than legacy players. Certified dealerships said that buy-back, refurbish, and reuse models are sustainable, but they also said that these models only make up a small part of their business because of cost and marketing issues.

In contrast, start-ups were found to build their operations around sustainability from the beginning:

"We are not just reselling vehicles, we are extending their lifespan through diagnostics, refurbishments, and lifetime service partnerships." – Platform Founder (C1)

Interviewees also noted emerging models like Vehicle-as-a-Service (VaaS) and shared ownership, inspired by platforms like Uber and Airbnb.

Consumer Trust and Transparency Barriers

Consistent barriers to digital SHA adoption include:

- Lack of a standardized grading system
- Limited vehicle history transparency
- Interoperability issues between blockchain-based tools and legacy systems

One blockchain consultant (C3) noted that the absence of secure verification systems and fragmented data contributed significantly to trust deficits.

Efforts to address these include:

- QR-coded maintenance records
- Blockchain-based service and ownership histories
- Digital vehicle passports using VIN tracking

Digital Inconvenience and Process Complexity

Manual processes also discouraged dealer participation. Certified dealer C2 highlighted:

"It takes 30–40 minutes to list one vehicle properly, and even then, buyers call to verify every detail."

Lack of automation, time-consuming uploads, and consumer demands for confirmation created friction in platform scalability.

Consumer Experience and Education Gaps

Stakeholders noted that many consumers still lack familiarity with digital SHA platforms. One blockchain expert (C3) stated:

"We realized people do not even know trustworthy platforms exist."

Companies responded by implementing interactive tutorials, virtual test drives, and in-app educational hubs to combat this. To replicate in-person purchasing experiences digitally, features like 360° interior scans, emotion-driven testimonials, and live chat support were also implemented.

Pricing Tools and Affordability Innovations

Interviewees highlighted AI-powered pricing engines, transaction history dashboards, and Rent Now, Pay Later models as important tools to build affordability and trust. One start-up (C5) shared:

"We show past prices for similar vehicles, which helps customers understand the fair value, like a stock ticker for cars."

Hygiene and Condition Verification

Although hygiene concerns were less prominent than in second-hand fashion, cleanliness, accident history, and usage type (e.g., ride-share fleets) were key issues. Companies responded with:

- Certified inspection reports
- Pre-sale detailing
- Warranty-backed listings

Platform Scalability and Local Adaptability

Start-ups focused on P2P models and regional customization to scale efficiently. One operator (C6) described:

"Our app tailors listings based on regional preferences, seasonal demands, and fuel prices."

Discussion and Conclusions

Our study establishes that digital tools are revolutionizing the used car (SHA) market by facilitating scalability, enhancing user experience, and promoting the adoption of circular economy (CE) principles in start-ups and established dealerships. In addition to making transactions easier, online platforms empower buyers to take an active role in car resale ecosystems. The findings also indicate that, despite being able to be addressed through strategic digital interventions, consumer convenience and trust remain significant obstacles. Additionally, digital innovation offers traditional auto dealers a chance to expand while also paving the way for cutting-edge growth paths for start-ups that are digitally native.

Key Consumer Barriers and Digital Solutions

Five dominant consumer engagement barriers were revealed in our study: inconvenience, trust deficits, lack of transparency, digital inexperience, and concerns about hygiene and vehicle condition.

Inconvenience

Digital platforms significantly reduce the friction involved in buying a used car. The process is streamlined by AI-powered suggestions, virtual car inspections, safe online financing, and mobile-first experiences, which are particularly appreciated by younger groups (18–34 years old), according to 87% of respondents. Consumer approval was higher for start-ups that led in automation and real-time support.

Trust and Transparency

Despite technological advancements, trust is still a significant issue, especially regarding vehicle condition and documentation. Compared to 61% of consumers who trusted offline dealers, only 12% of consumers trusted online claims about the condition of vehicles. Digital ownership records, QR-coded maintenance histories, and blockchain-based verification tools were acknowledged as essential innovations; however, interoperability with legacy systems remains challenging.

Digital Inexperience

Additional friction is caused by dealers' and consumers' lack of familiarity with SHA platforms. According to our interviews, users frequently struggle with listing procedures or are unaware of reliable platforms. In response, businesses are bridging this digital literacy gap with educational hubs, virtual test drives, and interactive tutorials.

Pricing Perception

Price transparency is still a problem. Digital features like historical price dashboards and AI pricing engines are helping to normalize fair valuation expectations online, even though 38% of respondents preferred in-person pricing negotiations. In this regard, start-ups that provide vehicle valuations like a "stock ticker" are at the forefront.

Vehicle Condition and Hygiene

In the SHA industry, cleanliness, accident history, and previous use (e.g., ride-share fleet) emerged as concerns. In response, platforms offered pre-sale details, warranties, and certified inspections to reassure purchasers.

Overall, digitalization has done the best job of addressing scalability and inconvenience, but specific solutions are still needed for transparency, pricing perception, and trust.

Opportunities for SHA Platforms and Start-Ups

The model emerging from our consumer and stakeholder research shows that circular, tech-enabled business models represent high-impact opportunities for the SHA sector. The following platform features represent major growth levers:

- Predictive diagnostics and refurbishment models to extend vehicle lifespan
- Vehicle-as-a-Service (VaaS) and shared ownership models
- Local adaptation strategies, including regional pricing and fuel-sensitive recommendations
- Digital vehicle passports to improve cross-platform trust and documentation
- Gamified affordability tools such as "Rent Now, Pay Later"

Start-ups embedding CE principles at the core of their platforms saw greater consumer alignment and flexibility. At the same time, legacy dealerships faced challenges in pivoting their models due to marketing, cost, and internal resistance.

Platforms can use this model to prioritize investments according to opportunities for consumer engagement and barrier mitigation. Furthermore, the used car market can become more scalable and circular with the help of new digital tools, particularly those that allow automated verification, educational features, and real-time diagnostics.

Limitations and Future Research Directions

There is no single SHA digital retailing model that works for everyone. Startup-led circular models and peer-to-peer (P2P) resale seem flexible, but legacy players require unique transformation pathways. While this study captured both consumer and industry perspectives, future research could:

- Develop a quantitative model for trust scoring in digital used car transactions.
- Explore region-specific digital adoption barriers and CE business viability.
- Measure environmental impact metrics of circular vehicle models (e.g., emissions avoided, lifespan extended).
- Investigate user retention and platform loyalty across different digital experience levels.

For a sustainable mobility future, digital platforms must incorporate circularity from the ground up as the SHA sector develops, going beyond resale to include design, diagnostics, and documentation.

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