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Assessment of Shared Mobility Acceptability for Sustainable Transportation in Amman

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Abstract: Shared mobility services furnish convenient transportation alternatives for individuals without vehicle ownership or a preference against driving. Shared mobility could benefit developing countries by providing a cost-effective alternative, enhancing accessibility, reducing congestion, and creating multiple job opportunities. In this study, a comprehensive analysis to assess shared mobility options as an avenue to sustainable transportation in Amman, Jordan, is presented. The study employs a multifaceted methodology, including a survey questionnaire, preliminary analysis, Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis, and Structural Equation Model (SEM). The data were collected from a diverse group of Amman residents using a survey composed of 29 questions. The survey included demographic information, travel behavior, willingness to adopt shared mobility, perceived benefits, and possible barriers. These data were analyzed using Structural Equation Modeling (SEM), providing an in-depth understanding of the interrelationships among the variables studied. This study concludes by contributing to the ongoing discussion on sustainable urban transportation in Jordan and providing a road map for policymakers, urban planners, and transportation service providers. The presented findings provide an empirical basis for guiding future strategies and interventions toward sustainable urban development in Amman and potentially other urban contexts with comparable characteristics. Key findings reveal a significant potential for shared mobility to enhance urban transportation sustainability. Specifically, a notable positive perception among Amman residents was observed, with an average willingness to switch to shared mobility for daily commuting scoring 4.68 on a 7-point Likert scale. Moreover, a statistical analysis indicates that factors such as reduced costs, improved service reliability, and better environmental sustainability, notably influence the adoption of shared mobility services.

Keywords: shared mobility; public acceptability; structural equation model; exploratory factor analysis; confirmatory factor analysis (CFA)

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1. Introduction

Faced with swiftly urbanizing cities, ever-increasing populations, and imperative environmental concerns, sustainable urban mobility is now acknowledged as a crucial component of effective transportation planning and policy [1]. Sustainable transportation is a key priority for numerous cities around the globe, and that is because it can improve air quality, lower vehicle traffic, and enhance the public's general well-being. Therefore, to ensure that the transportation system is sustainable, equitable, and conducive to a high quality of life, there is a need to increase the global and local recognition of the contemporary urban mobility situation.

To address the growing challenges of urban transportation in rapidly developing cities, particularly in the context of Amman, Jordan, this study zeroes in on shared mobility as a pivotal solution. Shared mobility, encompassing services like ridesharing, bike-sharing, and car-sharing, stands at the forefront of transforming urban mobility landscapes by offering sustainable, equitable, and efficient transportation alternatives. This pivot to shared mobility is driven by its potential to mitigate the adverse impacts of private vehicle ownership, such as escalating traffic congestion, environmental pollution, and the strain on urban infrastructure [2].

Despite the acknowledged benefits, the adoption of shared mobility in Middle Eastern urban contexts, like Amman, remains underexplored. This gap in research underscores the urgency of understanding shared mobility's role in promoting sustainable urban development, the barriers to its adoption, and its social acceptability among different demographic groups in such unique urban settings.

Amidst these global trends, in Jordan's capital, Amman, the need for environmentally friendly transportation options is especially urgent as the city's transportation infrastructure encounters a wide variety of hurdles. These hurdles consist of the rapid growth of private vehicle ownership, which has contributed to escalated traffic congestion and air pollution, the dearth of reliable public transit options, and a public transportation network that requires repair and maintenance due to an aging road network.

Recently, shared mobility, which comprises a variety of shared transportation services, has been recognized as a promising solution to several key issues related to the cities' urbanization [3]. Shared mobility options, which might include several options such as vehicle sharing, bike-sharing, and ride-hailing, can provide a wide range of benefits to the city of Amman. Some of these benefits involve lowering the number of privately owned vehicles, which could contribute to alleviating traffic congestion as well as reducing air pollution levels, thereby contributing to the development of sustainable and effective urban mobility infrastructure [4]. Additionally, providing individuals with more affordable and readily available modes of transportation would contribute to a more equitable society. Moreover, shared mobility options can encourage other active modes of transportation, such as biking and walking, which would benefit the health of Amman's residents.

The absence of such research initiatives impedes not only the ability to comprehend shared mobility in the context of the city of Amman but also the ability to inform and direct relevant policies and initiatives. For instance, in many Western cities, shared mobility has been demonstrated to have significant potential to reduce vehicle traffic and minimize the impact on the environment. However, it is unclear how these benefits translate to rapidly urbanizing cities in the Middle East, such as Amman, Jordan. In addition, the literature has understudied the role of shared mobility in promoting equitable and affordable transportation options. Against this backdrop, this study offers a robust framework for comprehending the shared mobility landscape in Amman and its prospective impact on sustainable urban development. This study's findings and recommendations can act as a roadmap to steer Amman's transport policy toward more sustainable, shared, and efficient systems. The insights gleaned from this study will promote informed decision-making and policy design, not only in Amman but also in other comparable urban contexts that seek to leverage shared mobility for sustainable urban transport. Accordingly, the primary objective of this study is to assess the acceptability of shared mobility services as a cornerstone for sustainable transportation in Amman. Specifically, we aim to (1) identify the factors influencing the adoption of shared mobility services among Amman residents; (2) evaluate the perceived benefits and barriers to using shared mobility; and (3) propose actionable strategies to enhance the adoption of shared mobility, thereby contributing to the sustainable development of urban transportation systems.

2. Background

The evolution of shared mobility has emerged as a transformative force in the realm of urban transportation, heralding a shift towards more sustainable and inclusive mobility solutions. This transition is underpinned by a rich body of research that explores various facets of shared mobility, from its environmental benefits to its role in fostering community-based models and enhancing digital infrastructure.

Recent research underscores the growing significance of shared mobility as a linchpin for sustainable urban transportation systems. A research team provided a comprehensive review, highlighting the multifaceted impacts of shared mobility on enhancing the sustainability of transportation systems, emphasizing the need for integrated policies and technological advancements [5]. Concurrently, another research team introduced an innovative decentralized community of practice-based models for on-demand electric car-pooling, projecting a pathway towards achieving sustainable shared mobility by leveraging communal resources and technologies [6]. Furthermore, the exploration of shared transport services' acceptability among vulnerable groups reveals critical insights into the social dimensions of shared mobility, advocating for inclusive policies that ensure broader acceptance and utilization [7]. Additionally, one study delved into the digital ecosystems facilitating sustainable shared electric mobility-as-a-service in smart cities, proposing a novel business model that could catalyze the transition to more sustainable, efficient urban mobility solutions [8]. These works collectively contribute to a nuanced understanding of shared mobility's potential to revolutionize urban transportation, underscoring the importance of inclusive, technology-driven approaches for fostering sustainability.

2.1. Benefits of Shared Mobility

It has been demonstrated that shared mobility provides numerous advantages, such as reduced traffic congestion and carbon footprints, as well as enhanced accessibility. Research studies carried out in American cities have shown, for instance, that ridesharing services can substantially reduce the number of privately owned cars on the road, resulting in less traffic congestion and reduced carbon emissions [9]. Likewise, a 2011 study by Firnkorn and Müller found that car-sharing services in Berlin lead to a substantial drop in private car ownership among users [10].

The ability of shared mobility to offer enhanced service efficiency and flexible access compared to conventional ownership models holds great promise for transforming transportation systems [11]. The success story of ride-sourcing services like Uber and Lyft illustrates how shared mobility can outperform conventional transportation services with respect to waiting time, travel time, and overall expenditure [12]. Ridesharing has been linked with a variety of potential advantages, including reduced emission levels, traffic congestion, and overall transportation costs [13]. Nevertheless, the scale of these advantages is contingent on user adoption patterns and the specific implementation of shared mobility systems [13]. The recently developed notion of Mobility as a Service (MaaS)—the combination of a variety of transport services into a single accessibility system—offers a viable approach to managing travel patterns, which could lead to reduced car ownership and promote sustainable transportation modes [14].

2.2. Implementation Challenges

Nonetheless, implementing shared mobility solutions does not come without challenges. According to some studies, several potential challenges exist, including rules and regulations, a lack of user trust, and technological obstacles. For example, a study conducted in Shanghai found that regulatory uncertainty was a significant barrier to the development of bike-sharing services [15]. Other research efforts has emphasized the significance of establishing user trust, both in terms of the safety of shared mobility services and the preservation of user data [3].

Utilizing solutions for shared mobility offers numerous technical and strategic challenges. The efficient redistribution of service vehicles to match fluctuating demand is a crucial technical challenge requiring complicated algorithms [16]. Additionally, the implementation of electric taxi transportation systems requires meticulous planning and vehicle-to-station assignments to reduce costs associated with their operation [17]. Strategically, the disruption induced by competitors such as Uber poses traditional transportation services with competitive challenges and necessitates innovative responses [18]. Intriguingly, the growing use of ridesharing services can result in an increase in total vehicle miles traveled, which can worsen traffic congestion and environmental issues [19]. In addition, free-floating car-sharing services confront the operational challenge of balancing supply and demand, necessitating functional vehicle relocation strategies [20]. The aforementioned challenges emphasize the need for comprehensive planning and the effective administration of shared mobility services.

2.3. User Behavior

Knowledge of user behavior is essential for the successful utilization of shared mobility. Cost, convenience, and service quality are considered integral parts when it comes to user adoption of shared mobility [21]. Additionally, demographic factors such as age and income impact utilization patterns [22]. These research results emphasize the significance of customizing shared mobility services to suit the specific requirements and preferences of various user groups.

Understanding user behavior is crucial for the execution of effective shared mobility services. The lifecycle periods of urban households, for example, have a major effect on their mobility behaviors and patterns as well as preferred modes of transportation [23]. Additionally, the correlation between lifecycle events and variations in vehicle ownership is considered supporting evidence for this matter. Therefore, successful Mobility as a Service (MaaS) applications require a comprehensive comprehension of users' behaviors and their needs [24,25]. This is especially important in the context of ridesharing services such as Uber, where user acceptability is influenced by a multitude of complex factors [26]. Therefore, user behavior is crucial in promoting the acceptance and efficient use of shared mobility services, which requires comprehensive behavioral studies and user-centric design approaches.

2.4. Environmental, Economic, and Social Impacts

Shared mobility has the potential to have a substantial effect on the environmental, economic, and social landscapes of communities and cities. On the aspect of the environment, shared mobility can aid in the reduction in carbon emissions and the improvement in air quality [27]. In terms of economics, shared mobility can lead to cost savings for users and yields to create new jobs and opportunities for companies [28]. On a social level, while shared mobility can enhance access for marginalized communities, there are several possible downsides such as employment displacement and traffic congestion [29].

In general, shared mobility has profound impacts on numerous facets of urban life, including social, economic, and environmental variables. For example, integrating public transit and car-sharing has the potential to generate beneficial environmental impacts as well as cost reductions [30]. Various household structures can affect transport demand and, consequently, the urban economy as a whole [31]. The creation and widespread implementation of Bus Rapid Transit (BRT) systems can bring substantial changes in the provision of public transit and their related impacts [32]. In the future, the widespread use of autonomous vehicles could significantly improve access to mobility, with significant financial, environmental, and social repercussions [33]. Nonetheless, it is essential to consider the potential gaps in urban accessibility, as they may result in social inequality [34]. Consequently, a comprehensive comprehension of the multifaceted effects of shared mobility is essential for policy formulation and system design.

2.5. Impacts of Increased Shared Transportation Use

This study underscores shared mobility's promise to enhance urban transportation sustainability. However, it is crucial to consider the broader impacts of escalating shared transportation use. Increased shared mobility can significantly influence urban landscapes, including reducing private vehicle ownership, which in turn mitigates traffic congestion and decreases greenhouse gas emissions, contributing positively to environmental sustainability [4].

Economically, shared mobility presents cost-saving opportunities for users and generates new employment opportunities within the shared mobility services sector [28]. Socially, it promotes accessibility and mobility for diverse urban populations, particularly those without access to private vehicles, though it may also pose challenges such as potential job displacement within traditional transportation sectors [29].

Furthermore, while shared mobility has the potential to enhance urban mobility, its widespread adoption requires the careful consideration of potential downsides, such as increased total vehicle miles traveled, which could negate some of the expected traffic congestion and environmental benefits. Therefore, future research should delve into these impacts more deeply, exploring strategies to maximize shared mobility's positive effects while mitigating any negative outcomes.

3. Methodology

This study's methodology functions as the structured blueprint for investigating shared mobility in Amman, Jordan. This section has been developed methodically to ensure the robustness, reliability, and validity of the research findings. This section presents an in-depth explanation of the study's design, including the survey design and implementation, sampling methodology, data acquisition method, and the utilized analysis approaches. This exhaustive methodology will be used to analyze the different aspects of shared mobility in Amman, yielding valuable insights that can shape the future of transportation strategies in Amman, Jordan. The subsequent subsections elaborate on each component of the research methodology.

3.1. Shared Mobility Options in Amman, Jordan

In Amman, Jordan, shared mobility is becoming increasingly common. For instance, app-based platforms that offer user-friendly services have established a significant foothold in the local Jordanian market. This is part of a global trend in which the term "Mobility as a Service" is gathering traction significantly due to its ability to offer reliable and affordable transportation options that minimize the environmental impact by lowering the overall number of vehicles that are privately owned.

"Careem", a ride-hailing app that originated in the Middle East and is tailored to the requirements and preferences of the local population, is one of Amman's primary shared mobility options. The app-based platform provides users with a convenient method to book transportation, with a variety of service categories to accommodate diverse client requirements. Uber, the global champion in the ride-hailing industry, also has a substantial presence in the metropolis. The operation of Uber in Amman provides local users with the benefits of global technological advancements and service standards. Both Careem and Uber are now ubiquitous names, making ridesharing a common and popular mode of transportation in the city. In addition, Easy Taxi and Jeeny are local app-based services that provide additional ridesharing options in Amman. Easy Taxi collaborates with local taxi drivers to integrate the traditional taxi service with the digital booking convenience of the twenty-first century. Another localized ride-hailing app, Jeeny, provides a platform for booking transportation from any location in the city, at any time. These diverse options for shared mobility contribute to the evolving transportation landscape in Amman by providing alternatives to personal vehicle ownership and conventional public transportation for residents and visitors. This variety of options reflects an ongoing trend toward sustainable and adaptable urban mobility solutions.

3.2. Survey Design and Data Collection

This study employed a targeted yet random sampling approach to gather data from a broad cross-section of Amman residents. In recognizing the importance of capturing diverse perspectives on shared mobility, our sampling strategy was designed to include individuals from various demographic backgrounds, including different ages, professions, and socioeconomic statuses. To evaluate shared mobility options in Jordan's capital city, Amman, a well-structured internet-based survey using "Google Forms" was created and utilized in order to gather information from a sample of the city's population. This method facilitated the collection of input from both users and non-users of shared mobility services, enriching the dataset with varied insights on transportation preferences and behaviors in the urban context of Amman. This empirical approach is essential for comprehending the current dynamics of shared mobility, conveying the perspective of users, as well as pinpointing feasible enhancements. The purpose of the survey was to assess the public's travel habits, attitudes toward shared mobility, propensity to employ these services, and perceptions of their advantages and disadvantages. This approach of data collection enabled input from both users and non-users of shared mobility products and services. The following sections provide a thorough explanation of the study's methodology by outlining the specific elements of the survey's design and data collection procedure.

The survey was meticulously designed to encompass numerous aspects of shared mobility services in Amman, Jordan. A total of 29 multiple-choice and Likert scale questions were included in the survey. The questions were designed based on the Driver Behavior Questionnaire (DBQ) to avoid the common survey biases, such as self, loading, leading, double-barreled, and no-response biases. In contrast, Likert scale items allowed respondents to convey their degree of agreement or disagreement on a symmetrical agree–disagree scale, which was particularly useful for attitude and opinion-based questions. The questionnaire consisted of several sections. The first section collected demographic data, including age, occupation, and vehicle ownership status, establishing the foundation for any demographic correlations. The second section explored the driving behavior habits of respondents, including their primary mode of transportation and frequency of travel. In the third segment, respondents' propensity to utilize shared mobility options under various conditions was evaluated. In the fourth section, the perceived importance of shared mobility was investigated in order to gain insight into public sentiment and potential barriers to the widespread adoption of these services. The fifth section included questions about the potential and perceived barriers to adopting shared mobility options, while the last section included questions about the potential benefits of shared mobility. The objective of this comprehensive survey was to collect exhaustive data to portray a nuanced picture of Amman's shared mobility landscape.

3.3. Participants

This study's primary target population consisted mainly of Amman residents, regardless of their age, profession, or socioeconomic standing. The survey participants were those who use, and are affected by, the transportation system in the city. Therefore, it is essential to comprehend their perceptions, behaviors, and preferences in relation to shared mobility.

Initial calculations determined that a minimum of 246 responses were necessary for a representative sample; this was determined by applying Equation (1) [35]. It is worth mentioning that the utilized equation to calculate the sample size is well known and well accepted to calculate the required sample sizes [36–38]. The employed equation calculated the sample size for proportions with a correction for a finite population. The population proportion is the proportion of participants who will accept/confirm the shared mobility options' benefits. Utilizing prior knowledge of the population proportion (p), the optimal sample size was calculated. Due to the documented benefits of shared mobility, it was anticipated that 80% of the participants would concur with the benefits of shared mobility and that only 20% might disagree. In the calculation procedure, a 95% confidence interval with a z-score of 1.96 and a 5% margin of error were utilized. A total of 246 responses were required to obtain a representative sample size. The total received responses were 270 valid responses.

$$\text{Sample Size} = \frac{\frac{z^2 \times p \times (1-p)}{e^2}}{1 + \left(\frac{z^2 \times p \times (1-p)}{e^2 \times N}\right)} \quad (1)$$

where:

Z = z-score for a defined confidence level;
p = population proportion;
e = margin of error;
N = population size.

In addition, the demographic diversity of those surveyed, spanning various age groups, professions, and socioeconomic statuses, enhanced the potential for the generalization and representativeness of the findings. Consequently, it can be affirmed with a high degree of certainty that the survey findings provide a robust and comprehensive understanding of shared mobility options and attitudes among Amman's residents.

In detailing the selection of survey participants, this study targeted a representative sample of Amman's population to understand shared mobility's potential impact comprehensively. Utilizing a combination of convenience and stratified random sampling, we ensured that the survey reached a wide audience while also targeting specific groups within the population for more nuanced insights. The stratification criteria were based on demographic factors such as age, gender, occupation, and vehicle ownership status, which are pertinent to transportation habits and preferences. The survey participants were selected using a random sampling method. This strategy was selected to assure a broad representation of viewpoints, consequently diminishing bias in sampling and improving the applicability of the study's findings. Considering the technology-driven character of Amman's contemporary society and the pervasive use of social media in Amman, the data collection process was conducted online. The survey was distributed via a variety of online platforms, including social media and email.

4. Data Analysis

Table 1 provides a detailed description of the survey questionnaire design. The questions included in the survey, their measurement scale, and their categories are detailed in Table 1. Furthermore, the mean, mode, median, and standard deviation are provided for the questions to provide insights about the obtained responses.

The initial phase of our data analysis consisted of a thorough descriptive analysis of the survey results. This step enables us to comprehend the basic patterns and trends within the survey results, providing an overview of the data distribution and establishing the groundwork for further inference analysis. This preliminary analysis is an integral part of the study, as it lays the groundwork to perform the subsequent, more complex Structural Equation Modeling analysis. Table 1 shows the basic descriptive statistics for the 29 questions.

The majority of participants are between the ages of 18–24, are male, and are students. Also, more respondents own a vehicle than those who do not. The travel behavior of the respondents is that most respondents travel twice a day and primarily use a private car (either as a driver or passenger) for daily commuting. The most common commute time is between 15 and 29 min. The average frequency of public transportation use is relatively low, suggesting that most respondents do not frequently use public transportation.

Most significantly, respondents' usage of shared mobility services and their willingness to adopt these services in the future is shown in Figure 1. In terms of the "Willingness to use bike-sharing service for daily commute" prompt, the responses are distributed across a scale from 1 to 7. However, the most frequent response is 1, indicating a low willingness among a large number of respondents. Moreover, for the "Willingness to use ride-sharing service for daily commute" prompt, the responses are also distributed across the scale from 1 to 7, with the most frequent response being 1.

Table 1. Designed Survey Questionnaire and Descriptive Statistics.

Q#	Description	Code: Category or Level	Mean	Mode	Median	SD
		Demographics				
Q1	Age	1: (<18), 2: (18–24), 3: (25–34), 4: (35–44), 5: (45–54), 6: (55–64), 7: (≥65)	2.92	2.00	2.00	1.41
Q2	Gender	1: (Male) and 2: (Female)	1.39	1.00	1.00	0.49
Q3	Occupation	Student/Unemployed/Agriculture/ Manufacturing/Wholesale and Retail Trade/Information and Communication Technology, etc.	NA	NA	NA	NA
Q4	Do you own a vehicle?	0: (No) and 1: (Yes)	0.63	1.00	1.00	0.48
		Travel Behavior for Participants				
Q5	How often do you travel a day?	0: (No daily travel), 1: (Once a day), 2: (Twice a day), 3: (Three–four times a day), 4: (Five or more times a day)	1.81	2.00	2.00	1.11
Q6	What is your primary mode of transport for daily commuting?	1: (Vulnerable Road User), 2: (Public transport), 3: (Private car) 4: (Rideshare)	2.64	3.00	3.00	0.80
Q7	How long is your average commute (in minutes)?	1: (<15 min.), 2: (15–29 min.), 3: (30–44 min.), 4: (45–59 min.), 5: (60–74 min.), 6: (≥75 min.)	2.60	2.00	2.00	1.29
Q8	How frequently do you use public transportation?	Seven-point Likert scale (Never to All the time)	2.52	1.00	2.00	1.94
Q9	In your opinion, how reliable public transportation is?	Seven-point Likert scale (Not reliable to Very reliable)	2.67	1.00	2.00	1.61
Q10	Have you used any shared mobility services in the past? (Bike sharing, car sharing, ride-sharing, etc.)	0: (No) and 1: (Yes)	0.58	1.00	1.00	0.49
		Willingness to Use Shared Mobility				
Q11	If available, would you consider using a bike-sharing service for your daily commute?	Seven-point Likert scale (Never to All the time)	2.88	1.00	2.00	2.17
Q12	If available, would you consider using a car-sharing service for your daily commute?	Seven-point Likert scale (Never to All the time)	3.72	1.00	4.00	2.21
Q13	If available, would you consider using a ride-sharing service for your daily commute?	Seven-point Likert scale (Never to All the time)	3.70	1.00	4.00	2.18
		Perceived Importance of Shared Mobility				
		How would you rate the importance of shared mobility in:				
Q14	Reducing traffic congestion.	Seven-point Likert scale (Not important at all to Extremely important)	4.79	7.00	5.00	2.05
Q15	Reducing transportation costs.	Seven-point Likert scale (Not important at all to Extremely important)	4.82	7.00	5.00	1.98
Q16	Reducing environmental impact.	Seven-point Likert scale (Not important at all to Extremely important)	4.85	7.00	5.00	2.03
Q17	Enhancing convenience.	Seven-point Likert scale (Not important at all to Extremely important)	4.60	7.00	5.00	2.05

Table 1. *Cont.*

Q#	Description	Code: Category or Level	Mean	Mode	Median	SD
Perceived Barriers to Using Shared Mobility						
Are you concerned about the following being a potential barrier to using shared mobility?						
Q18	Safety.	Seven-point Likert scale (Not a concern at all to A major Concern)	4.45	4.00	4.00	1.96
Q19	Privacy.	Seven-point Likert scale (Not a concern at all to A major Concern)	4.41	7.00	4.00	2.01
Q20	Reliability.	Seven-point Likert scale (Not a concern at all to A major Concern)	4.37	4.00	4.00	1.94
Q21	Accessibility.	Seven-point Likert scale (Not a concern at all to A major Concern)	4.43	4.00	4.00	1.89
Q22	Cost.	Seven-point Likert scale (Not a concern at all to A major Concern)	4.37	7.00	4.00	2.04
Perceived Benefits of Shared Mobility						
How would you rate the following to make you more likely to use shared mobility options for your daily commute?						
Q23	Lower cost compared to the current mode of transport.	Seven-point Likert scale (Not important at all to Extremely important)	4.50	7.00	5.00	2.09
Q24	Availability of service near my home/work.	Seven-point Likert scale (Not important at all to Extremely important)	4.63	7.00	5.00	2.05
Q25	Faster travel time compared to the current mode of transport.	Seven-point Likert scale (Not important at all to Extremely important)	4.60	7.00	5.00	2.05
Q26	More reliable service.	Seven-point Likert scale (Not important at all to Extremely important)	4.68	7.00	5.00	1.95
Q27	Better environmental sustainability.	Seven-point Likert scale (Not important at all to Extremely important)	4.67	7.00	5.00	1.97
Q28	Improved comfort and cleanliness of vehicles & better safety measures.	Seven-point Likert scale (Not important at all to Extremely important)	4.76	7.00	5.00	2.01
Q29	Convenient booking and payment options.	Seven-point Likert scale (Not important at all to Extremely important)	4.88	7.00	5.00	2.03

For the "Average willingness to switch to shared mobility for daily commuting" prompt, the average was calculated based on the following factors:

1. Lower cost compared to the current mode of transport;
2. Availability of service near my home/work;
3. Faster travel time compared to the current mode of transport;
4. More reliable service;
5. Better environmental sustainability;
6. Improved comfort and cleanliness of vehicles and better safety measures;
7. Convenient booking and payment options.

The average score for willingness to switch to shared mobility for daily commuting is approximately 4.68 on a scale of 1 to 7. This proximate measure implies that each of these variables contributes equally to the decision to transition to shared mobility.

While a good number of respondents have used shared mobility services in the past, their willingness to use such services for daily commuting, specifically bike-sharing, car-sharing, and ridesharing services, varies widely. However, the average willingness to switch to shared mobility, considering various factors, is relatively high at around 4.68.

The perceived barriers and benefits of shared mobility according to the respondents are explored. With an average score between 4.60 and 4.85, respondents view shared mobility as advantageous for reducing traffic congestion, transportation costs, and environmental impact and enhancing convenience. On the other hand, respondents also voiced concerns regarding safety, privacy, reliability, accessibility, and cost, with an average score between

4.37 and 4.44. These are potential obstacles that could prevent individuals from employing solutions for shared mobility.

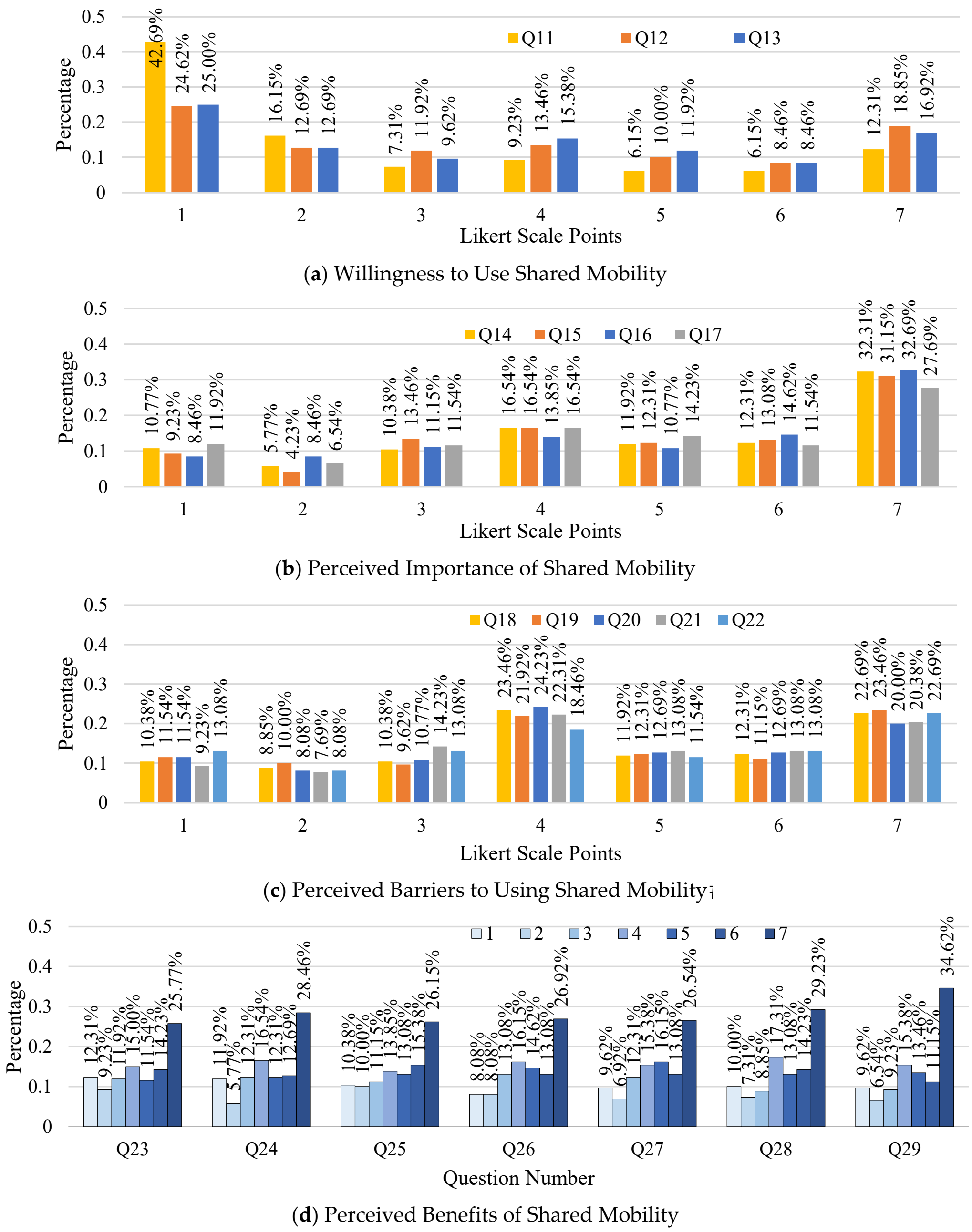

Figure 1. Percentages of the participants' responses distributed on the 7-point Likert scale.

These findings provide valuable insights into the acceptability of shared mobility for sustainable transportation in Amman. It seems there is an overall positive perception of the benefits of shared mobility. However, to increase its adoption, it would be important to address the perceived barriers related to safety, privacy, reliability, accessibility, and cost.

5. Exploratory and Confirmatory Factor Analysis

An Exploratory Factor Analysis (EFA) was employed to determine the exogenous and endogenous latent variables. EFA was utilized to uncover the latent structure of the shared mobility survey questionnaire, evaluate its reliability, and validate the survey instrument. EFA enabled the identification of unobserved latent factors (constructs) that accounted for the variability observed in the collected survey data. Multicollinearity was checked by developing a multicollinearity matrix, where the r-squared was less than 0.8 [39,40], in which three questions were removed from the analysis due to multicollinearity with other variables. Notably, EFA was conducted on a randomly selected 30% subset of the data (78 observations) to avoid biased patterns in subsequent Confirmatory Factor Analysis (CFA) [41]. To ensure convergence, a minimum of three indicator variables were chosen to measure each latent variable. Multiple iterations were performed to obtain the final factors. The generalized Least Squares (GLS) extraction method was employed in conjunction with Varimax orthogonal rotation, using a factor loading cutoff value of 0.4 [40]. A Kaiser–Meyer–Olkin value (KMO) of 0.884 was obtained, indicating the presence of robust factors [42,43].

Compared to EFA, CFA offers a more concise solution by accounting for the error variances that arise from the interdependencies among the indicator variables [39]. CFA was employed to establish the measurement models utilized for conducting the path analysis within the SEM framework.

The assessment of indicator variable reliability was conducted by evaluating their contribution to the measurement model. The reliability indices (R^2), which represent the percentage of variance explained by the corresponding latent variable, were used as a measure of item reliability [40]. Indicator variables with an R^2 index exceeding 0.4 are considered optimal. Table 2 displays the results of the CFA, which were in line with the EFA results. Table 2 includes the obtained values for the R^2, along with the corresponding latent variables and factorized indicator variables. The obtained factors effectively elucidated the key aspects of the survey and provided insights into the five underlying factors addressed in the study.

Table 2. Item Reliability Index for the Investigated Indicator Variables.

Q#	Description	Obtained Factors and Item Reliability Index (R^2)				
		F1	**F2**	**F3**	**F4**	**F5**
Q4	Do you own a vehicle?	na	−0.711	na	na	na
Q5	How often do you travel in a day?	0.778	na	na	na	na
Q6	What is your primary/daily mode of transport?	0.601	na	na	na	na
Q7	How long is your average commute?	na	na	−0.474	na	na
Q8	How frequent do you use public transportation?	na	0.668	na	na	na
Q9	How reliable public transportation is?	na	0.718	na	na	na
Q10	Have you used shared mobility services in the past?	−0.588	na	na	na	na
Q11	Would you consider using a bike-sharing service?	na	na	0.803	na	na
Q12	Would you consider using a car-sharing service?	na	na	0.675	na	na
Q14	Perception of ridesharing to reduce traffic congestion	na	na	na	na	0.803
Q16	Perception of ridesharing to reduce environmental impact	na	na	na	na	0.804
Q17	Perception of ridesharing to enhance commute convenience	na	na	na	na	0.780
Q23	Rate of ridesharing for lower commuting cost	na	na	na	0.836	na
Q25	Rate of ridesharing for faster travel time	na	na	na	0.830	na
Q26	Rate of ridesharing for more reliable service	na	na	na	0.888	na
Q27	Rate of ridesharing for better environmental sustainability	na	na	na	0.829	na
Q28	Rate of ridesharing for better safety measures	na	na	na	0.861	na
Q29	Rate of ridesharing for convenient booking and payment options	na	na	na	0.855	na
Factor	**Construct**					
F1	Dependency on Private Vehicle					
F2	Limited Annual Income					
F3	Public Acceptability of Rideshare					
F4	Perceived Usage of Rideshare					
F5	Reliability of Rideshare					

Note: na = not applicable.

The constructs obtained from the CFA succeeded in further explaining the context of the survey. The first factor was determined to express the public dependency on private vehicles, in which three observed questions formed this factor. This factor showed that those who travel often in a day are more likely to depend on a private vehicle. Additionally, it showed that participants who have used shared mobility services in the past are less likely to depend on private vehicles. Limited annual income was found to be the second obtained factor. The second factor clarified that respondents who have limited annual income are less likely to own a vehicle, use public transportation frequently, and perceive public transportation as reliable. According to the third factor, the public acceptability of rideshare, participants would consider using rideshare options for short commuting distances. Six observed questions were factored in to form the fourth construct, expressing the perceived usage of rideshare. The high factor loadings indicate that those who rate cost, travel time, reliability, environmental sustainability, safety, and convenient booking and payment options as important factors are more likely to depend on rideshare services.

6. Structural Equation Model

A Structural Equation Model (SEM) is a statistical technique widely utilized for analyzing datasets obtained from survey questionnaires [39–44]. SEM offers several advantages, including its ability to handle complex relationships (such as indirect, multiple, and reverse relationships) between exogenous and endogenous variables [45]. It accomplishes this by quantifying unmeasurable variables through the creation of latent variables using observed variables. Furthermore, SEM simultaneously estimates the path coefficients representing the relationships between the latent variables within the framework of a comprehensive model. The Structural Equation Model (SEM) comprises two primary components. Firstly, there is the measurement model, which is developed in the CFA phase and identifies the essential variables capable of measuring each latent variable through an exogenous model and an endogenous model. Secondly, there is the structural model, which determines the significant direction of prediction between the exogenous model and the endogenous model. The measurement models can be expressed as shown in Equation (2) and the structural model is given in Equation (3) [46,47].

$$\begin{bmatrix} y \\ x \end{bmatrix} = \begin{bmatrix} \lambda_y & 0 \\ 0 & \lambda_x \end{bmatrix} \begin{bmatrix} \eta \\ \xi \end{bmatrix} + \begin{bmatrix} \varepsilon \\ \delta \end{bmatrix} \tag{2}$$

$$\eta = \beta\eta + \Gamma\xi + \zeta \tag{3}$$

where x is the vector of observed exogenous variables, y is the vector of observed exogenous variables, ξ is the vector of latent exogenous variables, η is the vector of latent endogenous variables, δ is the vector of measurement error terms for observed variables x, ε is the vector of measurement error terms for observed variables y, λ_x is the structural coefficients for latent exogenous variables to the observed variables, λ_y is the structural coefficients for latent endogenous variables to the observed variables, γ is the regression effects for exogenous latent variables to endogenous latent variables, and δ and ε are the error terms.

The goodness-of-fit indices were used to determine the best-fit path model for the SEM, in which multiple iterations were conducted. Figure 2 shows the developed path model that clarifies the perceived public usage of ridesharing options in Amman. Latent variables are represented by oval shapes, while indicator variables are depicted by rectangular shapes. The arrows within the model indicate the direction of relationships for the path model. The path coefficients (estimates) are displayed on top of the arrows, while the corresponding t-value and *p*-value are presented below each arrow. The analysis of the constructed models revealed the presence of statistically significant direct and indirect relationships. A direct relationship is characterized by a direct linkage between the exogenous variable and the endogenous latent variable. Meanwhile, the indirect relationship involves an intermediate exogenous latent variable. The provided path coefficients demonstrate the estimates for the linear equations, in which all the provided coefficients were significant at a 95% confidence level.

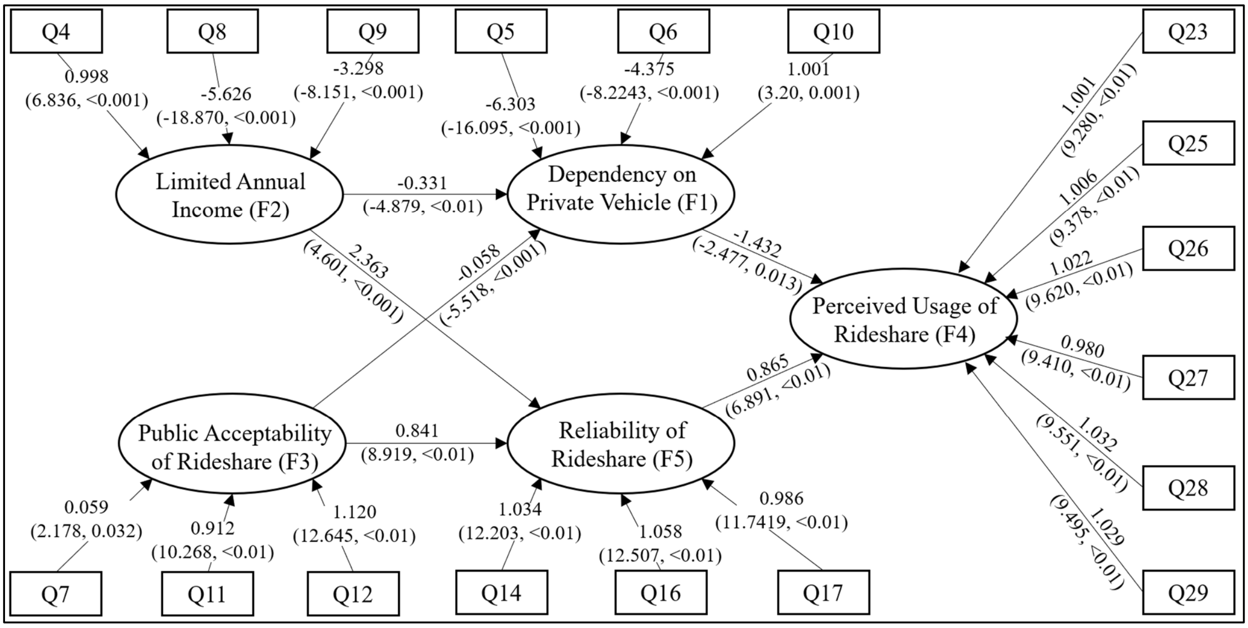

Figure 2. Structural Equation Model (Path Model) for the Perceived Usage of Rideshare.

6.1. Results of the Measurement Models

In Structural Equation Modeling (SEM), a measurement model specifies the relationships between latent variables and their corresponding observed indicators. Measurement models with a confidence level of 95% were considered in this study, which resulted in a total of five measurement models. The perceived usage of rideshare was constructed using five indicator variables (Q23 to Q29). The results showed that the convenience of booking and payment options (Q29) had the highest impact on participants' perceived usage of rideshare. It was found that a 1-unit increase in the convenience of booking and payment options increased the perceived usage of rideshare by 1.029 units. On the other hand, better environmental sustainability (Q27) had the lowest relative importance compared to the other indicators. A 1-unit increase in better environmental sustainability increased the perceived usage of rideshare by 0.980 units. Dependency on private vehicles was found to have three indicator variables. The results showed that the greater the travel frequency per day (Q5) the fewer participants would depend on private vehicles, in which a 1-unit decrease in daily travel was associated with an increase of 6.303 units in the dependency on private vehicles. Likewise, a one-unit decrease in the reliability of public transportation increased the limited annual income by one unit. Public acceptability of rideshare was factored in using three indicators. Considering the use of a car-sharing service had the highest impact on the public acceptability of rideshare, while the travel distance had the lowest impact.

6.2. Results of the Structural Models

The structural model for the SEM specifies the relationships between the latent variables themselves, which could be referred to as the path model. For the developed SEM, including one endogenous latent variable (the perceived usage of rideshare) and four exogenous latent variables, two of these variables are considered intermediate variables (dependency on private vehicles and reliability of rideshare). The developed model includes direct and indirect relationships between the exogenous and endogenous latent variables. The relationship is considered indirect when an intermediate variable is presented between the exogenous and endogenous latent variables. Table 3 concludes the direct, indirect, and total effect of the exogenous latent variables on the perceived usage of rideshare as the endogenous latent variable.

Table 3. Direct, Indirect, and Total Effects of the Perceived Usage of Rideshare in Amman.

Latent Variable	Direct Effect/Estimate	Indirect Effect/Estimate	Cumulative Effect/Estimate
Dependency on Private Vehicle	−1.432	NA	−1.432 *
Reliability of Rideshare	0.865	NA	0.865 *
Limited Annual Income	NA	2.518	2.518 **
Public Acceptability of Rideshare	NA	0.811	0.811 **

* The total expresses the direct effect only (no indirect effect is presented). ** The total expresses the indirect effect only (no direct effect is presented).

In order to assess the indirect influence of a latent variable on the endogenous latent variable in the SEM, the coefficient estimates along the respective paths should be multiplied. In cases where multiple indirect paths exist, the final indirect coefficient should be obtained by summing up all the individual indirect coefficients. This final estimate represents the cumulative impact of the latent variable on the endogenous latent variable. As an illustration, let us consider the latent variable of the public acceptability of rideshare, which has two indirect effects on the perceived usage of rideshare. To calculate the first indirect impact, we multiply the estimate coefficients of 0.841 and 0.865, resulting in the value of the indirect impact through the intermediate latent variable of the reliability of rideshare. Similarly, by multiplying the estimates of −0.058 and −1.432, we obtain the product that expresses the direct impact through the intermediate latent variable of dependency on private vehicles. Lastly, to determine the cumulative effect, the two indirect estimates are added, resulting in a cumulative impact of 0.811. This cumulative effect shows that for each 0.811-unit increase in the public acceptability of rideshare, an increase of 1 unit is anticipated for the perceived usage of rideshare. Limited annual income had the highest cumulative impact, in which it is estimated to have a 1-unit increase in perceived usage of rideshare for each 2.518-unit increase in limited annual income.

The latent variable of dependency on private vehicles had a negative direct/cumulative impact on the endogenous variable. It was found that for each 1.432-unit decrease in dependency on private vehicles, an increase of 1 unit was estimated for the perceived usage of rideshare. On the other hand, for each 0.865-unit increase in the reliability of rideshare, the perceived usage of rideshare would increase by 1 unit.

6.3. Goodness of Fit and Statistical Power

Several indices were investigated to assess the adequacy of the developed model as seen in Table 4. Threshold guidelines provided by Hooper et al. (2008) are considered the assessment golden rules for SEM validity [48,49]. They concluded the obtained model fit indices and the threshold for each index. Several path models were developed; however, the model with the lowest Akaike Information Criterion (AIC) was reported in this study.

Table 4. Model Fit Indices and Statistical Power for the SEM of Shared Mobility.

Model Fit Index	Obtained Values	Threshold Values
Standardized Root Mean Square Residual (SRMR)	0.0500	<0.050
Goodness-of-Fit Index (GFI)	0.8956	>0.900
Parsimony Index–Adjusted GFI (AGFI)	0.8832	>0.900
RMSEA Estimate	0.0542	<0.055
Bentler Comparative Fit Index (CFI)	0.9478	>0.900
Akaike Information Criterion (AIC)	519	Lower is better

Although a few of the calculated model fit indices did not reach their respective minimum threshold limits, the overall fit of the developed models can still be considered acceptable, as the deviations from these limits are minor. The obtained GFI and AGFI values were slightly below the threshold of 0.900, with values of 0.8956 and 0.8832, respectively.

However, all other indices fell within the specified threshold ranges. The RMSEA value, which serves as an indicator of the model's statistical power, was below the threshold value, indicating satisfactory statistical power.

7. Summary

This study sheds light on the transformative potential of shared mobility for sustainable urban transportation, with far-reaching social, practical, and research implications. Socially, it underscores shared mobility's capacity to democratize urban transit, offering equitable access and contributing to the reduction in environmental footprints, thus enhancing the quality of urban life. Practically, the findings equip urban planners, policymakers, and service providers with critical insights for optimizing the integration of shared mobility into existing transportation networks, emphasizing the importance of user-centric services, affordability, and environmental benefits to increase adoption rates. On the research front, this study enriches the discourse on sustainable transportation by highlighting the underexplored context of Amman, Jordan, suggesting a fertile ground for future comparative analyses and the exploration of shared mobility's long-term impacts on urban infrastructure, policy development, and societal norms. Collectively, these implications signal a pivotal step towards more sustainable, inclusive, and efficient urban environments, urging a continued scholarly examination of shared mobility's role within the broader urban ecosystem.

The study's findings underscore the critical role of convenience, environmental sustainability, and cost-effectiveness as driving factors behind the adoption of shared mobility services in Amman. The statistical significance of these factors, as demonstrated through Structural Equation Modeling, echoes the sentiments found in recent studies, which highlight the importance of these elements in influencing public acceptance of shared mobility solutions [6]. Specifically, our analysis revealed that convenience in booking and payment options significantly increases the perceived utility of rideshare services among Amman's residents, with a 1-unit increase in convenience leading to a corresponding increase in rideshare usage of 1.029 units (see Figure 2). This aligns with the findings that emphasized the pivotal role of digital ecosystems in enhancing the user experience and adoption of shared electric mobility services [8].

Moreover, our study's insight into the limited but growing interest in environmental sustainability among respondents—where a 1-unit increase in sustainability concerns led to a 0.980 increase in the perceived usage of rideshare services—parallels the discussions by another study [7]. Their research into the acceptability of shared transport services among vulnerable groups further validates our findings, suggesting a broader societal shift towards valuing sustainability in urban mobility choices.

In summary, this study contributes to the growing body of literature on shared mobility by providing empirical evidence from Amman, Jordan, which underscores the multifaceted factors influencing the adoption of shared mobility services. By integrating the study's findings with the established research, the study highlights the nuanced dynamics of shared mobility adoption, which encompasses economic, convenience, and environmental considerations. These discoveries not only enrich the academic discourse on sustainable urban transportation but also offer actionable insights for policymakers and practitioners aiming to foster the adoption of shared mobility solutions.

8. Conclusions

This study conducted a comprehensive evaluation of the prospective impact of shared mobility alternatives on Amman's sustainable transportation system, thereby contributing to the ongoing discussion regarding sustainable urban transport services in Jordan. The study aimed to provide stakeholders, urban planners, and transport service providers with valuable insights to guide future strategies, aligning them with the broader objective of sustainable urban development.

The study's methodology entailed the development and distribution of a comprehensive survey to Amman's residents, which allowed us to collect information regarding their travel habits, perceptions toward shared mobility, and the difficulties and benefits they associate with these services. This data collection was followed by a thorough analysis using the sophisticated statistical technique of Structural Equation Modeling (SEM). The SEM analysis served to create a robust understanding of the relationships and underlying mechanisms influencing shared mobility adoption and its subsequent impacts.

The SEM analysis yielded findings indicating that various factors significantly influence the adoption of shared mobility. These factors encompass the reliability of the service, the acceptability of the service, the dependency on private vehicles, and the limited annual income of individuals. To promote the uptake of rideshare alternatives among road users, the implementation of incentive programs that encourage the utilization of shared bikes, scooters, and cars in place of private vehicles could be beneficial. Furthermore, offering diverse rideshare options for both short- and long-distance trips would enhance the acceptability and reliability of the rideshare service, thereby fostering its adoption. Additionally, the analysis revealed that individuals with limited income are predominantly from younger age groups, suggesting that younger individuals are more inclined to adopt rideshare compared to older age groups. Consequently, targeting campaigns towards older age groups to familiarize them with the advantages of ridesharing could facilitate the increased adoption of rideshare.

In light of this study's findings on the potential and acceptability of shared mobility services in Amman, this study proposes several policy recommendations to foster the development of a sustainable and efficient shared transportation ecosystem. Firstly, it is imperative to create an enabling regulatory framework that supports the growth of shared mobility services while ensuring public safety and data privacy. This includes the formulation of clear guidelines for the operation of shared mobility platforms, as well as incentives for both the users and providers of these services. Secondly, enhancing public awareness and trust in shared mobility solutions through comprehensive information campaigns can significantly impact their adoption rates. These campaigns should highlight the environmental, economic, and social benefits of shared transportation, addressing any misconceptions and emphasizing the role of shared mobility in reducing traffic congestion and pollution. Furthermore, the integration of shared mobility services with existing public transportation networks could provide a seamless and efficient urban mobility experience. Collaborative initiatives between the government, shared mobility providers, and public transport authorities are crucial in creating a unified transportation system that caters to the diverse needs of Amman's residents. Lastly, continuous monitoring and research into the impacts of shared mobility on urban transportation dynamics are vital. This should include the assessment of usage patterns, user satisfaction, and the long-term effects on traffic flow and environmental indicators. Such insights will be invaluable in adjusting policies and strategies to maximize the benefits of shared mobility for Amman's sustainable urban development.

The significance of this study transcends the empirical findings, setting a precedent for urban transportation policy and planning in Amman and potentially similar urban settings. By illuminating the factors that influence the acceptability and adoption of shared mobility, this research not only contributes to the scholarly discourse on sustainable urban mobility but also provides a pragmatic blueprint for policymakers and urban planners. The study underscores the necessity of fostering an enabling environment for shared mobility through regulatory support, public awareness initiatives, and infrastructural integration with existing public transport systems. In doing so, it advocates for a holistic approach to urban mobility planning that prioritizes sustainability, accessibility, and efficiency. Furthermore, by identifying the social, practical, and research implications of shared mobility, this study lays the groundwork for future investigations, encouraging a multi-disciplinary exploration of urban mobility solutions. Ultimately, the study's findings aim to catalyze the transition towards more sustainable, resilient, and inclusive urban transportation ecosystems, underscoring the pivotal role of shared mobility in achieving these objectives.

9. Limitations and Future Directions

While this study offers valuable insights into the acceptability and potential impact of shared mobility services in Amman, Jordan, it acknowledges certain limitations that warrant discussion. Firstly, the study's focus on Amman limits the applicability of its conclusions to other urban contexts with different socioeconomic and cultural dynamics.

This study's methodology, centered around a survey distributed among Amman residents, provided critical insights into shared mobility's potential impact and acceptance. However, it inherently carries the risk of self-selection and response biases, common to survey-based research. Such biases could influence the representativeness of the survey responses, potentially affecting the generalizability of our findings. Additionally, the reliance on self-reported data might not accurately capture all nuances of respondents' behaviors and attitudes toward shared mobility services.

Future research could address such limitations by incorporating a broader geographic scope, including comparative studies across cities with varying characteristics to enhance the robustness and applicability of the findings. Moreover, longitudinal studies examining the long-term effects of shared mobility services on urban transportation systems would provide deeper insights into their sustainability and efficacy. Another promising direction involves exploring the integration of shared mobility services with existing public transportation networks to optimize urban mobility solutions further. Finally, given the rapid technological advancements in transportation, ongoing research is essential to understand the evolving user preferences and the impact of new mobility solutions on urban transportation ecosystems.

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