Pilot Study on Scale Reliability and Model Validity for Human and Technological Factors Influencing Smart Transportation Service Performance

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Abstract: - This pilot study is to test the reliability of measurement scales and the validity of the research model used to study human and technological factors that impact smart transportation service performance. A quantitative method was used in which a structured questionnaire was used to gather data from a population of 30 participants relevant to the smart transportation context in Amman, Jordan. The study aims to evaluate the internal consistency of the measurement items in each of the three internal dimensions of the study, of which the three dimensions of the human factor (Smart Transportation Awareness, Perceived Safety, Social Influence) and three dimensions of the technological factor (Performance Expectancy, Effort Expectancy, Facilitating Condition, System Integration, and Data Privacy) are examined, and to confirm the correctness of the relations of constructs in the model, namely Smart Transportation Service Performance. The findings show satisfactory reliability of all the measurement scales and acceptable validity of the model, which allows us to use the model in further large-scale empirical studies. The result of this pilot study is considered to be a methodological foundation for further research and the strength of the developed research instrument for the study of the performance of smart transportation services.

Key-Words: - Smart transportation service performance, Human factors, Technological factors, Pilot study, Scale reliability, Model validity

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1 Introduction

Smart transportation nowadays in urban environments leverages technology, data, and innovative solutions to improve the quality of life for residents, enhance sustainability, and optimize the operation and management of transportation between places [1]. Smart transportation utilizes various interconnected digital systems and sensors to gather real-time data, enabling efficient resource utilization, informed decision-making, and enhanced citizen engagement. The concept of smart transportation revolves around the integration of information and communication technologies (ICT) into different sectors of urban life. This integration enables transportation operators to collect and analyze data from diverse sources, such as transportation systems, energy grids, public services, and citizen interactions. By harnessing the power of data analytics, Smart transportation aims to address

urban challenges, improve transportation service delivery, promote sustainability, and create a more livable and resilient environment [2].

An ad hoc strategy cannot maintain the development of smart mobility. Rather, a comprehensive vision is needed to direct decision-making and action plans toward putting into practice workable solutions that produce observable outcomes that may improve the experience of all city commuters. Jordan's capital, Amman, and the logistics hub of Aqaba recently announced plans to include smart mobility and began developing comprehensive projects with outside specialists [3]. In order to effectively manage Amman's limited infrastructure resources and assets, the Greater Amman Municipality and the European Bank for Reconstruction and Development (EBRD) have been supporting the "Smart City Amman" concept since 2017. A number of immediate and long-term investments are being undertaken with the help of the EBRD in order to improve services for Amman residents and lessen the strain of traffic congestion in Amman City [4].

The development of smart transport systems is a complicated phenomena that calls both novel top-down and bottom-up ICT-enabled governance approaches in order to effectively manage cities. Cities are a significant source of environmental, socioeconomic, and urban data that serve as the foundation for creating and evaluating smart mobility solutions. In the last ten years, the idea of smart transport has grown significantly [5]. In order to ensure efficacy and efficiency in service planning, decision-making, and governance, transportation administrators have recognised the potential of ICT to gather and analyse municipal data and provide fresh knowledge about the operation of a transportation system. This intelligence cannot be produced without urban data and ICT usage, or it demands significant resources (financial, human, etc.). Innovative domain-specific applications that might provide new information or knowledge are highlighted in recent papers in the field of smart transportation. Transportation administrations, residents, and private sector organisations may utilise this new information to manage their daily operations and/or commercial processes, as well as the decision-making processes that support municipal government, in an effective and efficient manner. There is little discussion of the holistic view of cross-thematic transport data, which necessitates Big Data management techniques and high-performance computing paradigms like cloud computing. The transportation data is generated from various thematic domains (e.g., transport, land-use, energy, economic, climate, etc.) [6].

The development of smart transportation requires a comprehensive approach to guide decision-making and action plans towards realistic solutions that improve the quality of services for all commuters. The city of Amman in Jordan has recently announced plans to provide Bus Rapid Transit as a smart transportation service and is collaborating with external experts to create detailed projects [7]. The Bus Rapid Transit as a smart transportation service in Amman, supported by the Greater Amman Municipality for Reconstruction and Development, has been promoting efficient management of scarce infrastructure resources and reducing traffic congestion [8].

Smart transportation around the world has solved many problems. Amsterdam focuses on sustainability and has implemented smart transportation systems, including electric vehicle charging infrastructure and smart parking. The city also uses data analytics for energy management and waste reduction [9]. In Asian countries, Singapore is one of the leading Asian smart cities, where technologies have been deployed in its cities. It has adopted smart traffic management systems, effective public transportation, smart lighting and sensors for monitoring air and water quality [10]. Tokyo is a city with cutting-edge infrastructure and smart projects. It involves innovative technologies such as smart grids, IoT sensors, and real-time data analysis to enhance energy usage, transportation networks, and waste management [11]. Moreover, New York City uses data analytics for better traffic management and to enhance public safety. The City of San Francisco is a city that is known for its focus on sustainability and innovation. The city has implemented smart transportation systems, electric vehicle infrastructure, and intelligent parking solutions. Data analytics also helps it to track air quality and optimise energy consumption [12].

Big data is an important enabler and is vital to the development of Smart transportation. It is the term used for data, in this case large volumes of data, both structured and unstructured, generated from a variety of sources within a system [13]. The focus of Big Data in Smart transportation is on collecting, analysing, and leveraging data in order to extract meaningful information for decision-making, management of resources and services, etc. For example, Big data analytics can support city authorities and decision-makers to make decisions based on real-time and historical data [14]. City planners can use the information from these various sources, including data from sensors, social media, and government records, to learn about patterns, trends, and correlations, and then respond to transportation issues.

The use of big data makes it possible to optimise infrastructure and services in a Smart transportation project. It can, for example, support intelligent traffic management systems that use real-time traffic data to help manage congestion and improve transportation efficiency. Furthermore, it helps to optimise resource use, including water and energy usage, by tracking consumption patterns and suggesting areas for improvement [15].

This study is based on several theories that collectively explain the acceptance and performance of smart transportation services. Using the Unified Theory of Acceptance and Use of Technology (UTAUT), constructs of performance expectancy, effort expectancy and facilitating conditions are employed to measure the users' evaluation of the utility, ease of use and support offered for involvement with the BRT system. Theory of Reasoned Action (TRA) also contributes to explaining the findings, which focus on attitude and social norms, represented by constructs such as system integration, data privacy, smart transportation awareness, perceived safety, and social influence. The TAM is integrated with big data analytics' perceived usefulness, which acts as a mediator between users' perceptions and overall service outcomes. Finally, the dependent variable (smart transportation service performance) is based on Goal-Setting Theory, which highlights the importance of performance factors, including reliability, accessibility, and user satisfaction, as important goals that can be achieved through the alignment of human and technological factors with user goals. Based on these theories, Figure 1 presents the proposed research framework, in which three human factors (Smart Transportation Awareness, Perceived Safety and Social Influence) and five technological factors (Performance Expectancy, Effort Expectancy, Facilitating Condition, System Integration and Data Privacy) are linked to Smart Transportation Service Performance as the dependent variable.

The purpose of this pilot is to test the instruments of the research model and its measurement scales in order to obtain the reliability and validity of the research model before conducting the main empirical study. Specifically, the study aims to determine the internal consistency of the measurement items by using the Cronbach alpha coefficient in order to assess scale reliability, and to determine construct validity using Pearson bivariate correlation analysis to find the appropriateness and coherence of the relationships between the study variables. This study aims to highlight the preliminary testing of the measurement instrument, which is both statistically sound and conceptually consistent and methodologically robust. Results from this pilot study offer crucial data for use in future hypothesis testing and large-scale data collection with the scales and model.

2 Smart Transportation Issues

Today's transportation faces several challenges, including safety hazards, congestion, pollution, and excessive energy consumption. Traffic accidents have become a significant concern, with over 1.2 million deaths and around 50 million injuries occurring globally each year due to road crashes [16]. Despite the implementation of improved road infrastructures and stricter regulations, the rate of road trauma continues to rise in many countries. If no immediate action is taken, traffic-related injuries could become the fifth leading cause of death by 2030 [17].

High Traffic Density: Urbanisation has contributed significantly to increased vehicle congestion. According to the United Nations' World Urbanisation Prospects report, in 2014, 54% of the global population lived in cities. The number of private vehicles has increased dramatically, with the U.S. Department of Transportation reporting that vehicle miles travelled rose by 15% between 2000 and 2016 [18]. This high vehicle density results in longer travel times, increased pollution, and greater fuel consumption.

Limited Transportation Times and High Costs: Poor traffic management systems result in transportation delays and high costs. According to the Lessons Learned Report from the Smart City Challenge, 10% of urban road congestion is due to inadequate traffic management systems and 30% of congestion is caused by vehicles looking for a parking spot. In metros, the average time spent driving a private vehicle is 56 minutes a day, or 42 hours per year per commuter. The inefficiency results in a total yearly delay of 6.9 billion hours and 3.1 billion gallons of wasted fuel that cost the economy about $160 billion annually [19].

Transportation Inefficiencies: Inefficiencies extend to the logistics and supply chain sector. There were 3.63 million Class 8 trucks in use in the U.S. in 2015, carrying 70.1% of domestic freight tonnage and generating $726.4 billion in gross freight revenue. But congestion and stop-and-go traffic resulted in wasted fuel and high operating costs -- a total of $28 million per year. The railway industry also has its problems, with Class I Rail Tonnage totaling 1,700 million tons, and the need to find smarter ways to transport goods and people to increase efficiency [20]. The challenges underscore the need for innovative solutions to address these challenges, including the implementation of Intelligent Transportation Systems

(ITS) to enhance traffic management, reduce congestion, and increase road safety.

A major challenge is ensuring that benefits of smart transportation projects are achieved for all segments of the population. Smart transportation measures may inadvertently further reinforce social and economic inequalities if not all groups have access to digital services and technologies. A smart transportation project was implemented in the city of Rio de Janeiro, Brazil, with the aim of offering digital services and smart infrastructure in areas with higher income, while areas with lower income were not benefiting from these technological advances [21].

The adoption of smart transportation solutions can be associated with considerable upgrades of the existing infrastructure. Cities can encounter problems if older infrastructure systems need to be retrofitted, or if there are compatibility issues between the various technology platforms. A smart transportation project in London, UK, encountered challenges because of the integration of intelligent traffic management systems with the various types of legacy traffic infrastructure in the city [21], [22], [23].

Economic sustainability is crucial for smart transportation projects, as it ensures their long-term sustainability and continuous improvement. Now cities need to look at how to sustain and further develop their smart projects after initial implementation. Although many smart transportation initiatives have been successfully implemented in Singapore, the city still has to deal with several challenges related to funding for the long-term maintenance and upgrading of smart transportation infrastructure [1], [5], [10], [13], [15].

Key to smart transportation project success is public acceptance and awareness. Resistance or restricted citizen participation can be the result of a lack of awareness or understanding of the benefits of smart initiatives. A problem in Dubai, United Arab Emirates, was gaining public trust and acceptance of this new technology, autonomous vehicles, in a smart transportation project [24], [25].

Flexible and adaptive regulatory and policy frameworks are frequently essential to support innovative solutions and emerging technologies in smart transportation. Striking a balance between enabling innovation and safeguarding public interests can be complex. Seoul, South Korea, encountered challenges with regulations that made it difficult to implement drone delivery services for smart transportation [10].

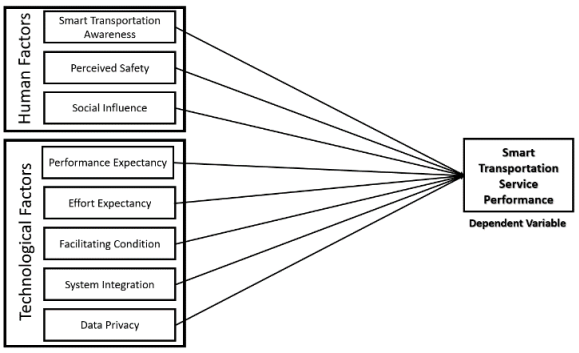


Fig. 1: Proposed Research Framework
Source: created by the authors

3 Research Methodology

During this research, a quantitative research method was used, with the use of structured questionnaires as the main data collection technique. The attention was directed towards the users and stakeholders of smart transportation services in Amman, Jordan, who were approached through questionnaires to collect the relevant information regarding the performance of smart transportation services.

The structured questionnaire aimed to generate specific and measurable responses to produce reliable data which could be analysed systematically. The chosen participant group was deemed suitable because they have firsthand knowledge of the use of smart transportation services and related technologies. The research aimed to obtain a full picture of user perceptions, experiences and evaluations of human and technological aspects affecting the use of smart transportation services, which was achieved by distributing questionnaires.

In accordance with established research protocols, the researcher ensured the confidentiality and integrity of all collected data, with careful attention given to ethical considerations and methodological rigour throughout the data collection process. Overall, this study, grounded in a quantitative research paradigm, employs structured questionnaires and a targeted participant group to examine key variables affecting smart transportation service performance in Amman. The adopted approach provides valuable insights into current practices and challenges while supporting evidence-based recommendations for improving smart transportation initiatives.

4 Measurement of the variables

The tools were developed with great care to represent the nature of the research. Because of this, a 36-item questionnaire was created, and the variables were assessed using a five-point Likert scale, where five represents "strongly agree" and one represents

"strongly disagree" [26]. Additionally, to assess the variables of this study, the validated instruments listed in Table 1 were taken from relevant prior research.

Table 1. Questionnaire Development

Variable	No. of items	Reference
Smart Transportation Awareness	4	[27]
Perceived Safety	4	[28]
Social Influence	4	[29], [30]
Performance Expectancy	4	[31], [32]
Effort Expectancy	4	[33]
Facilitating Condition	4	[31], [32]
System Integration	4	[34]
Data Privacy	4	[35]
Smart Transportation Service Performance	4	[36]
Total	36	

Source: created by the authors

5 Findings

The pilot research is always carried out prior to data collection. Additionally, [37] guarantees the value of doing a pilot study prior to data collection. By providing the researcher with an index to address any shortcomings in the study instrument prior to data collection, it is of considerable assistance [37], [38]. The reliability and validity tests for the pilot study came after the researcher presented the respondents' descriptive data (respondent profile).

6 Reliability of the scale

The questions in this research were derived from a previous literature review, which assessed the instrument's dependability. Simultaneously, a sample of thirty individuals underwent Cronbach alpha testing to ensure the validity and reliability of the instrument. Furthermore, [39] emphasised that a cut-off point of 0.6 is necessary during the pilot test level to determine whether the research instrument is reliable and has a valid internal consistency; any value below 0.6 is deemed poor and unacceptable, while Cronbach Alpha values above 0.6 are deemed merely acceptable, above 0.7 are good, above 0.8 are excellent, and above 0.9 are perfect [39]. The dependability of the scale used in this investigation is shown in Table 2 (Appendix).

7 Validity of the Research Model

Criterion-related validity demonstrates the effectiveness of measurements employed in the estimation or prediction process. To verify the validity of the study model, the investigator used the Pearson Bivariate Correlation model in SPSS 28.0 [40]. One common way to assess covariance is via the Pearson correlation coefficient. It is not feasible to directly compare the strength of association for scales with various conceivable values since covariance coefficients preserve information about the absolute scale ranges. Because they may analyse two correlations without taking into account the degree of variation shown by each variable independently, researchers find the correlation coefficient to be helpful [41]. The correlation test's Sig. value, which is less than 0.05, indicates a link between the two variables and statistically demonstrates a substantial unique contribution to the equation, according to [42]. The value of the Pearson Bivariate Correlation and the significance of the correlation between the variables are shown in Table 3, both of which highlight the validity of the research model used in this study.

Table 3. Pearson Bivariate Correlation Results

	AW	**PS**	**SI**	**PE**	**EE**	**FC**	**INT**	**DP**	**BDA**	**ST**
AW	1	.717**	.606**	.782**	.818**	.661**	.843**	.425**	.461**	.619**
PS	.717**	1	.825**	.760**	.696**	.409**	.774**	.437**	.569**	.905**
SI	.606**	.825**	1	.626**	.644**	.559**	.791**	.405**	.510**	.741**
PE	.782**	.760**	.626**	1	.855**	.701**	.761**	.638**	.706**	.723**
EE	.818**	.696**	.644**	.855**	1	.781**	.866**	.710**	.766**	.769**
FC	.661**	.409**	.559**	.701**	.781**	1	.725**	.576**	.558**	.441**
INT	.843**	.774**	.791**	.761**	.866**	.725**	1	.543**	.665**	.751**
DP	.425**	.437**	.405**	.638**	.710**	.576**	.543**	1	.921**	.587**
BDA	.461**	.569**	.510**	.706**	.766**	.558**	.665**	.921**	1	.712**
ST	.619**	.905**	.741**	.723**	.769**	.441**	.751**	.587**	.712**	1

Source: created by the authors

8 Discussion

This study aimed to examine the validity of the research model to investigate the impact of human and technological factors on the performance of smart transportation services and to check the reliability of the measurement scales of the proposed research model. The study concentrated on the following aspects: measurement of the constructs (human factors: Smart Transportation Awareness, Perceived Safety, Social Influence; technological factors: Performance Expectancy, Effort Expectancy, Facilitating Condition, System Integration, Data Privacy) with uniformity, and the fact that the total

model is conceptually coherent. This base is crucial because future full-scale empirical studies are dependent upon the reliability and validity of these measures.

The reliability analysis indicated that all constructs have good internal consistency, which means the items within each scale are closely related and have a good set of items to represent the constructs. Specifically, the human factors, Smart Transportation Awareness, Perceived Safety and Social Influence revealed stable perceptions and attitudes of the participants regarding the smart transportation services items both within and across the scales. Similarly, technological factors, Performance Expectancy, Effort Expectancy, Facilitating Condition, System Integration and Data Privacy had high item-to-total correlations, which means that participants could have a high level of confidence that they could measure similar expectations and conditions for the system. The results suggest that the instrument is clear, structured and methodologically correct, which will minimise measurement errors in future research.

The Pearson bivariate correlation analysis was conducted to confirm the model, thus providing further support for the model. The conceptual meaning and theoretical expectations about the relationship between human factors and the technological factors towards Smart Transportation Service Performance were meaningful. Perceived safety and social influence were directly related to service performance, with awareness being the other human factor that positively affected service performance, thus underscoring the importance of user perception and social context in transportation outcomes. Technological factors, such as performance expectancy, effort expectancy, facilitating conditions and system integration, were also significantly correlated with service performance, suggesting that the capabilities, ease of use and supporting infrastructure of a system play an important role in the success of smart transportation services. Despite being less correlated in the pilot, Data Privacy is still deemed a critical factor in full-scale testing because of its importance in user trust and in system acceptance.

This pilot study has important theoretical implications. They demonstrate that the conceptual structure is well founded and the workings of each construct are appropriate for empirical research. This step increases the methodological rigour, minimises risks of bias, and guarantees the reliability and interpretability of the results of the hypothesis testing that follows. Moreover, the results of the study indicate that the human and technological dimensions are independent but related and support the theoretical foundations that both dimensions contribute to the performance of smart transportation services.

The validated instrument is seen as a meaningful instrument for researchers and practitioners to practically assess the most relevant factors impacting smart transportation services. Knowing what factors, like awareness, safety perception, and social influences, affect the human factors can help inform communication strategies and user engagement efforts. Similarly, knowledge of the factors related to technology (infrastructure, usability of the system, supporting conditions and integration) can be applied to planning for infrastructure, designing the system and implementing policies to enhance the effectiveness of the system and user satisfaction. The purpose of this pilot study was to assess the reliability and validity of the model and additional data collection and analysis would produce meaningful results that would inform research and practice in the area of smart transportation.

From the above, it can be concluded that the main objective of this pilot study was achieved by establishing the validity of the model and the reliability of the measurement scales for human and technological factors that influence the performance of smart transportation services. The findings demonstrate that the instrument is methodologically sound, theoretically consistent and can be used for a broader empirical study. By overcoming the limitations of previous studies, this paper sets the groundwork for the credibility, interpretability and practicability of future research that seeks to improve the performance of smart transportation services. This paper tries to overcome the weaknesses of previous works and to provide a solid basis to increase the credibility, interpretability and usefulness of potential future research efforts to improve the performance of smart transportation services.

9 Future Research Recommendations

This pilot study calls for future studies to replicate it with a larger, more diverse sample of students to test the validity of the measurement instrument used. Expanding the sample size of cities and/or regions may help gain insights into the validity and reliability of the model, as well as the representation of the human factor differences, including Smart Transportation Awareness, Perceived Safety, and Social Influence. Moreover, the participation of different demographics and commuting groups might provide more detailed insights into the relationship between perception and social dynamics and the performance of smart transportation services in each context. This would provide the model with greater

external validity and would make the conclusions drawn more valid. Moreover, future studies may use a longitudinal or multi-wave research design to study the changes in the human and technological factors over time, and the influence they have on the performance of smart transportation services. Changes over time allow researchers to infer the effect of the technological infrastructure and system integration, and facilitating conditions, on user perceptions and social influences of service outcomes. These relationships may be influenced by organisational support and policy interventions and should be explored in future studies to better understand the various contextual factors that might reinforce and/or diminish these relationships. These extensions would be useful for both adding theory and for giving guidance to transportation planners and policy makers who seek to maximize the performance of services.

Declaration of Generative AI and AI-assisted Technologies in the Writing Process

During the preparation of this work, the author(s) utilized artificial intelligence (AI) technologies solely for the purpose of linguistic refinement and grammatical correction. Following the application of these tools, the author(s) comprehensively reviewed, verified, and edited the resulting text. The author(s) maintain full accountability and responsibility for the accuracy, integrity, and final content of the publication.

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APPENDIX

Table 2. Results of Scale Reliability

Itesm	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Cronbach's Alpha	N of Items
AW1	10.73	7.168	0.549	0.898	0.871	4
AW2	11.37	5.826	0.776	0.814		
AW3	11.23	4.806	0.862	0.779		
AW4	10.97	6.585	0.764	0.827		
PS1	12.07	6.547	0.648	0.919	0.888	4
PS2	11.70	7.666	0.810	0.844		
PS3	11.63	7.344	0.905	0.813		
PS4	11.80	6.924	0.758	0.855		
SI1	11.83	4.695	0.752	0.755	0.833	4
SI2	12.07	3.720	0.713	0.780		
SI3	11.80	4.372	0.849	0.711		
SI4	11.90	5.679	0.414	0.884		
PE1	11.50	3.983	0.676	0.732	0.805	4
PE2	12.07	3.237	0.554	0.832		
PE3	11.87	3.706	0.796	0.676		
PE4	11.77	4.599	0.569	0.786		
EE1	12.63	2.447	0.610	0.724	0.782	4
EE2	12.43	3.357	0.332	0.848		
EE3	12.53	2.809	0.787	0.649		
EE4	12.40	2.593	0.706	0.666		
FC1	11.80	3.683	0.715	0.790	0.846	4
FC2	12.43	3.357	0.637	0.848		
FC3	11.70	4.286	0.822	0.776		
FC4	11.57	4.185	0.670	0.812		
INT1	12.40	2.524	0.781	0.842	0.886	4
INT2	12.37	2.378	0.838	0.818		
INT3	12.30	2.700	0.763	0.848		
INT4	12.43	3.151	0.639	0.893		
DP1	12.03	3.757	0.880	0.894	0.930	4
DP2	11.83	3.523	0.897	0.889		
DP3	12.03	3.826	0.848	0.905		
DP4	11.80	4.510	0.738	0.940		
BDA1	11.70	6.079	0.905	0.931	0.952	4
BDA2	11.73	5.995	0.901	0.932		
BDA3	11.97	5.413	0.843	0.956		
BDA4	11.70	5.872	0.908	0.929		
ST1	12.13	4.671	0.871	0.912	0.937	4
ST2	12.10	4.162	0.910	0.902		
ST3	12.13	5.016	0.808	0.931		
ST4	11.93	5.375	0.857	0.923		

Source: created by the authors