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An Empirical Study on Acceptance of Carpooling Service in Mirpur DOHS, Dhaka

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Abstract

Building a multivariate statistical model is the aim of this research for identifying the aspects that impact carpooling and acquisition in a residential area. Based on the stated attitudes and perceived risk of the users, a structured questionnaire is created with 152 feedbacks in total are gathered from residents of Mirpur DOHS. The research hypotheses are validated by means of structural equation modeling (SEM). The best SEM is chosen using statistical criteria and multiple trials. To validate the selected SEM, the feedbacks are further examined using the Relative Importance Index (RII) approach. The study shows that the "Safety & Security" latent variable has more influence on the acceptance of the carpooling system among the two latent variables. Among the six observed variables underneath the "safety & Security" latent variable, 'Sharing Personal Information (y7)' has the most significance. The service providers and policymakers will be able to execute the carpooling system in the Mirpur DOHS area with the aid of the identification of the significant factors in this.
Keywords: Carpooling, Mirpur DOHS, Structural Equation Modeling, Relative Importance Index.

1. Introduction

A dependable transportation network is essential in every community. The city will be intolerable and uninhabitable without a safe, reasonable, and effective mode of transportation infrastructure (Rahman et al., 2020). As a result of the country's growing economy and high levels of travel, Dhaka, Bangladesh's capital, is exhibiting a densely packed land use pattern. Studies estimate that there are about 75 million vehicles on Dhaka's roads, with a road density of 65 kilometers per 100 square kilometers. In situations where the same amount of space is used by both motorized and non-motorized vehicles (NMV), the peculiar pattern of modes makes the scenario more dangerous (Sourav et al., 2023).

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The absence of reliable public bus service and rapid mass transit significantly increases travel time. Also, the 10% annual increase in new vehicles that crowd them onto the same street space demonstrates an absence of effective planning techniques (Rahman and Nahrin, 2012).
A kind of transportation called carpooling relies on using private vehicles in groups (Bruglieri et al., 2011). In carpooling, the crews are typically created on the spot, and the driver decides whether to pick up passengers so that they may use the high occupancy vehicle lane or so that they can share the cost of the trip. These offerings serve as an advanced place a post-it note that everyone can review or incorporate details regarding travel routes, origins, and destinations rather than suggesting a match between users. Thus, solitary users are responsible for finding their travel partner (Burris and Winn, 2006). Most recently, the use of carpooling systems has exponentially tumid. Due to the availability of cellular mobile phones, tiny electrical devices, and the Internet of Things, carpooling systems have become more popular. Individuals use the carpooling system by utilizing digital, simple, and automatic payment systems (Farin et al., 2016).

Many research projects have been carried out on the carpooling system in recent years. A study by Burris & Winn (2006) identified carpooling as a reliable and safe mode of transportation. Another study by Farin et al. (2016) stated that carpooling isn't limited to any particular vehicle. As a result, the proposed system allows for pooling any vehicle, including cars, buses, and even lorries. They also stated that a secure payment system could make carpooling more acceptable. A study by Wolfler Calvo et al. (2004) has shown that carpooling systems are simpler to design and implement when everyone has a shared arrival/departure location. To overcome traffic, parking problems, and fuel combustion carpooling system is more efficient (Hasan et al., 2016). A study by Tahmasseby et al. (2016) identified that occupation, earnings, marital status, and hours worked flexibility, etc., influences carpooling system use. Hernández et al. (2018) identified via Nash Equilibrium that operational costs should be kept low in carpooling. A study by Friginal et al. in 2014 identified passenger privacy issues as a concern for carpooling system. Manzini and Pareschi, (2012) study identified carpooling as a cost-effective transportation system. Correia & Viegas (2011) have stated that carpooling system needs to gain trust among the users. Another study by Rey-Merchán et al. (2022) identified that carpooling isn't feasible for a short distance. Ni et al. (2016) stated that passengers' information should be secured in the carpooling system.

Over the past few years, some research on carpooling has been conducted in Bangladesh. To ascertain the present status of carpooling services in Bangladesh, Islam et al., (2019) employed 164 responses and basic descriptive statistics. According to their research, the majority of carpooling service users are younger generations. Sakib and Mia, (2019) carried out a second study to employ descriptive analysis to ascertain the current situation, potential for the future, and challenges associated with carpooling systems. According to their research, the younger generation has a high level of acceptance for carpooling services. However, the main challenges facing this industry are a lack of funding, poor logistical support, ignorance, unfavourable government regulations, and intense competition. The users' intention to share cars is justified by a SEM study conducted by

Karim et al., (2020). A total of 250 responses were integrated into five latent variables: Behavioural Intention (BI), Perceived Usefulness (PU), Perceived Usability (PUS), Perceived Trust (PT), and Satisfaction (SAT). Perceived Usefulness (PU) has a significant impact on sharing behaviour, according to their studies. Binte Shahid et al., (2020) carried out a second study by SEM to evaluate the level of service provided by carpooling services in Bangladesh. They gathered 582 responses and combined them with two latent variables—Service Performance and Service Feature—to support their hypothesis. According to their research, the most important factor influencing carpooling services' overall service quality is service performance.

Development of Mirpur DOHS was done under the Bangladeshi Government's Defence Officers Housing Society Project. The DOHS Council is responsible for overseeing this area. The majority of defence officers, whether retired or still serving, reside. Compared to other areas, this one differs slightly. Security concern exists here. There is no access for public transport here. Which a lot of individuals set up their own vehicles for. Long-distance travelling is also challenging for people without a car. Carpooling is a good idea in this situation for this community. Carpooling has been studied in the past in Bangladesh, but not in DOHS, particularly in the Mirpur DOHS area. The results of this study will help the Mirpur DOHS area authorities to implement a sustainable transport system.

This study aims to introduce the carpooling system in the Mirpur DOHS residential area of Dhaka city through SEM and RII analysis.

2. Methodology

The study was carried out using a two-step process. Data from the respondents are gathered in the first step using a questionnaire survey. And in the second step, the proposed hypothesis framework is estimated by SEM analysis. For this study, SEM and RII methods are adopted. The process of Structural Equation Model (SEM) estimation is recurrent and ultimately produces the best-fitted model, which supports the hypothesis. Numerous methods, including maximum likelihood (ML), weighted least squares (WLS), and generalised least squares (GLS), can be used to estimate structural equation models. The most widely used of these three approaches is machine learning. The complexity of the SEM, the sample size, the scale properties of the parameters, and various probability distribution assumptions all play a role in choosing the optimal SEM (Golob, 2003). The model's goodness of fit must be described using multiple steps in order to navigate the complexity of the SEM (Hooper et al., 2008). Any relationship between variables is not just an empirical association; rather, it is an informal connection. SEM is a highly adaptable technique that can be applied to a wide range of relationships, including direct (A→B), indirect (A→C→B), and interactive (A→C→B and D→C→E). To explain the connections between latent and observed variables, SEM employs path analysis (Sourav et al., 2022a). The term "relative importance index" describes how well a variable predicts a result when used alone or with other variables in combination (Johnson and Lebreton, 2004). When the predictors are interrelated, indices frequently obtained by several regression analyses, the variance is not efficiently partitioned (Darlington, 1968). RII analyses aim to divide explained variation among numerous predictors to understand better each predictor's involvement in a regression equation (Tonidandel and LeBreton,

2011). In essence, RII describes the contribution of each predictor to the explanation of the variance in the criterion (Darlington, 1968). In some cases, a variable may only account for a very small portion of the predictably observed variance but still be extremely important, and in other cases, it may account for a larger portion of the variance but only have limited practical applicability (Martell et al., 1996). Importantly, RII analyses are more effective at showing the true impact of a given predictor than simple correlations or normalized regression coefficients (Tonidandel and LeBreton, 2011).

Data Collection and Demographics of the Respondents

The target respondents were residents of the Mirpur DOHS area. Defence Officers Housing Society, or Mirpur DOHS, is a wealthy neighbourhood overseen by Mirpur DOHS Housing Porishod and located under the Bangladesh Armed Forces cantonment board. Out of all the DOHS, Mirpur DOHS is the biggest, with 1,290 plots designated for defence officers and 138.81 acres of land. By the time building and land development are finished, this residential area is expected to house over 9000 households. Online platforms and direct distribution in person were used to gather a total of 152 data. A biased sample can result from participants who voluntarily choose to participate in online surveys or studies being systematically different from those who do not. Personal information is gathered and stored as part of online data collection. Data breaches and privacy violations could occur if the situation is not handled securely. Intentionally or inadvertently, online respondents may provide false or incomplete information, which could compromise the accuracy of the data that is gathered. There is less control over the online survey environment for researchers, which increases the possibility of interruptions or distractions that could compromise the quality of the data. The generalizability of results may be limited by the characteristics of respondents to an online survey being unrepresentative of the general population (Barabino et al., 2012). For assessing acceptance of carpooling system following steps are followed shown in Figure 1.

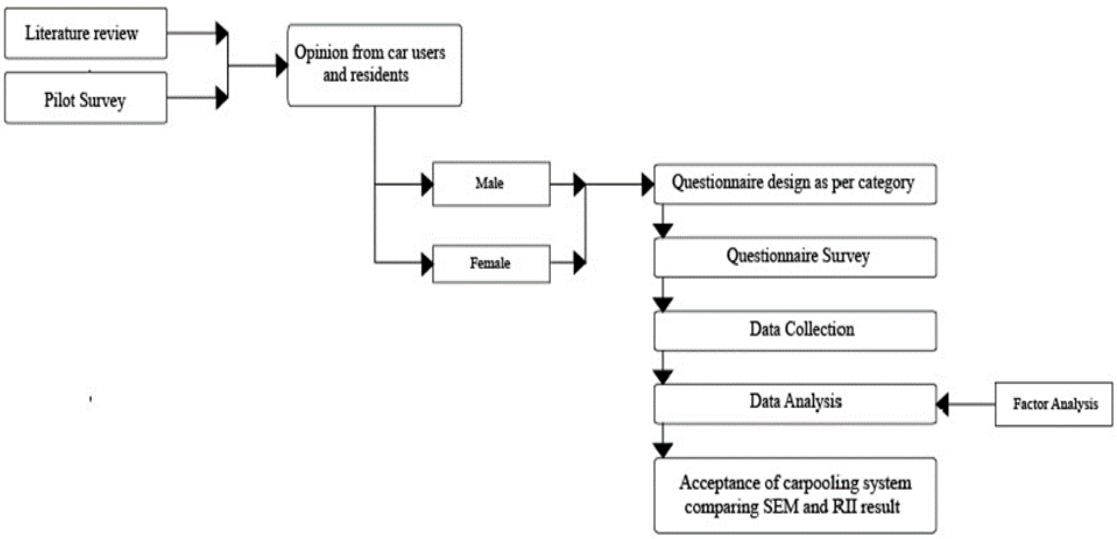
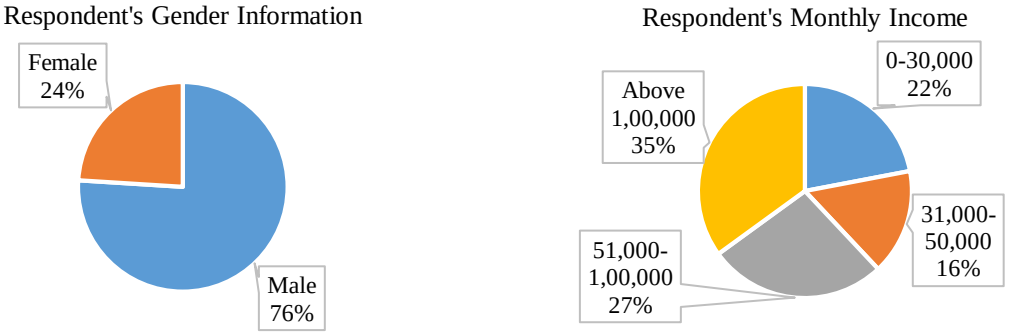


Figure 1: Flowchart illustrating the process followed to conduct the research

First, we reviewed previous studies and conducted a pilot survey of some variables. In the survey we took the opinion of car owners and residents. Based on the survey feedback,

we have formulated the full questionnaire. After that we collected data both online and manually. After collecting the data we reviewed it. And, verified the acceptance of carpooling system using SEM & RII method.
To create the intended SE model, a total of 27 Service Quality variables were employed. Of them, 24 were latent variables that were not observed, and the remaining 24 were observed variables. The following sections discuss the variables that were chosen after a thorough review of the literature and focus group discussions (FGDs) with experts, academics, and policy makers. A study suggest that for more than 150 samples fit indices can be considered for a better hypothesis (Z., 2012).

Among the respondents, most of the respondents are male (76%), and rest of them are female (24%) as shown in Figure 2. Maximum respondent's monthly income is above 31,000 BDT, which means the respondents are financially solvent Figure 2.



(a) Respondent's Gender Information (b) Respondent's Monthly Income

Figure 2: Demographics of the respondents

2.1 Independent Variables

In total, twenty-four (24) variables have been used in this study. Variables have been identified from previous studies on carpooling systems. Twenty-four variables have been incorporated into two latent variables; "Service Performance(η1)" and "Safety & Security(η2)". The variables are demonstrated in Table 1.

Table 1: Variables related to carpooling

Variable Name	*Variable Annotations*	*Variable Type*	*Numerical Scale*	*Qualitative Scale*
Knowledge on Carpooling	y_1	Exogenous	1-5	Strongly Disagree to strongly Agree
Convenience	y_2	Exogenous	1-5	Strongly Disagree to strongly Agree
Accessibility	y_3	Exogenous	1-5	Strongly Disagree to strongly Agree
Willingness to Share Car	y_4	Exogenous	1-5	Strongly Disagree to strongly Agree

Behavior of Car Owner	y_5	Exogenous	1-5	Strongly Disagree to strongly Agree
Congestion reduction	y_6	Exogenous	1-5	Strongly Disagree to strongly Agree
Sharing Personal Information	y_7	Exogenous	1-5	Strongly Disagree to strongly Agree
Safety	y_8	Exogenous	1-5	Strongly Disagree to strongly Agree
Reduction of Accidents	y_9	Exogenous	1-5	Strongly Disagree to strongly Agree
Security	y_{10}	Exogenous	1-5	Strongly Disagree to strongly Agree
Willingness to wait	y_{11}	Exogenous	1-5	Strongly Disagree to strongly Agree
Comfort	y_{12}	Exogenous	1-5	Strongly Disagree to strongly Agree
Saving Time	y_{13}	Exogenous	1-5	Strongly Disagree to strongly Agree
Cost Reduction	y_{14}	Exogenous	1-5	Strongly Disagree to strongly Agree
Pollution Reduction	y_{15}	Exogenous	1-5	Strongly Disagree to strongly Agree
Willingness to Share Accident Expenses	y_{16}	Exogenous	1-5	Strongly Disagree to strongly Agree
Comfort With Opposite Gender	y_{17}	Exogenous	1-5	Strongly Disagree to strongly Agree
Conflict While Sharing Expenses	y_{18}	Exogenous	1-5	Strongly Disagree to strongly Agree
Fitness of Vehicle	y_{19}	Exogenous	1-5	Strongly Disagree to strongly Agree
Behavior of Peers	y_{20}	Exogenous	1-5	Strongly Disagree to strongly Agree
Cleanliness of Vehicle	y_{21}	Exogenous	1-5	Strongly Disagree to strongly Agree
Reliability	y_{22}	Exogenous	1-5	Strongly Disagree to strongly Agree
Maintenance of Vehicle	y_{23}	Exogenous	1-5	Strongly Disagree to strongly Agree
Performance of Carpooling	y_{24}	Exogenous	1-5	Strongly Disagree to strongly Agree

2.2 Factor Analysis

Factor analysis is used for data reduction. Utilizing a minor factor to condense or summarize, a sizable number of variables must be considered (Sourav et al., 2022b). In this study, the Kaiser-Meyer-Olkin test is used to assess the extent of scale unidimensionality in the collected data (Mathur and Dhulla, 2014). To ensure that the data were sufficient for factor analysis, the Kaiser-Meyer-Olkin and Bartlett test was used (Napitupulu, Abdel Kadar, and Kartika Jati, 2017). The statistics are appropriate for factor analysis as shown by the KMO and Bartlett tests in Table 2.

Table 2: KMO and Bartlett's test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.851
Bartlett's Test of Sphericity	Approx. Chi-Square	1349.470
	df	300
	Sig.	0.000

By determining Cronbach's alpha test in Table 3, a further reliability test is conducted.

Table 3 : Cronbach's alpha test

Cronbach's alpha	*Cronbach alpha based on the standardized item*	*No. of item*
0.896	0.896	25

The Kaiser-Meyer-Olkin Measure of Sampling's adequacy score of 0.851 shows that the built model is suitable for factor analysis.

In light of model fitness, the model illustrates how the variables are related to one another. An approach for computing model fit indices was presented by Hooper et al. (2008). Absolute fit indices quantify how fit a given model matches the sample data. Table 4 displays the CFI, NFI, RMSEA, and x2/df values.

Table 4: Fit Indices of SE Model

Fit Indices	*SE Model*	*Acceptable limit (Hooper et al., 2008)*
Root Mean Squared Error of Approximation (RMSEA)	0.057	0.00-0.08
Standardized root Mean Square Residual (SRMR)	0.045	SRMR< 0.10
Comparative Fit Index (CFI)	0.889	Closer to 1.00
Normed Fit Index (NFI)	0.729	Closer to 1.00
X^2/df	1.483	X^2/df<3.00

The fit indices in Table 4 demonstrate the model's excellent fit as well as compliance with all fit requirements.

3. Results and Discussions

3.1 Hypothesis Testing Results for SE Model.

The two latent variables "service performance(1)" and "safety & security(2)" are used to introduce our structural model in Figure 3. Six exogenous factors are employed to calibrate the "safety & security(2)" latent variable and 18 exogenous variables are employed to calibrate the "service performance(1)" latent variable. The latent variable "safety & security (η2)" has the highest impact on the acceptance of the carpooling system (Z) in the Mirpur DOHS area. Any carpooling system must prioritise safety & security for a number of reasons, including passenger well-being, risk mitigation, trust-building, legal compliance, etc. Carpooling systems must prioritise safety & security in order to provide a dependable and trustworthy service. This helps to ensure the long-term viability and success of the carpooling platform in addition to safeguarding users. The reader would note that the interestingly latent variable "service performance(η1)" positively influences another latent variable, "safety & security(η2)". Table 5 displays the results of the respected path's hypothesis testing.

Table 5: The verdicts of the esteemed path's hypothesis testing

Hypothesis Statement of Path Analysis	*Path Co-efficient*	*P-Value*	*Results on Hypothesis*
H1: Influence of service performance on acceptance of the carpooling system	0.32	***	Supported
H2: Influence of safety & security on acceptance of the carpooling system	0.96	***	Supported
H3: Influence of service performance on safety & security	0.45	***	Supported

From the best-fitted model in Figure 3, it is identified that the observed variable, i.e., the 'Comfort (y12)' variable with path co-efficient 1.08, is the most influencing amongst the eighteen owners' related observed variables. In order to maximise user satisfaction, encourage repeat use, and ensure the platform's overall success, comfort is a critical component of a carpooling system. Carpooling services can gain a competitive edge and expand their user base by emphasising comfortable transportation. In contrast, 'Behavior of Peers (y20)' is the least significant variable with a path coefficient of 0.32. The best-fitted model also identified that 'Sharing Personal Information (y7)' is the utmost influential variable thru a path co-efficient of 2.09 among the six observed variables, whereas 'Safety (y8)' is the least influence with a path co-efficient of 0.75 from the "safety & security(η2)" latent variable. For a variety of reasons, sharing personal information in a carpooling system gives rise to privacy and security concerns. Carpooling platforms need to make user data handling and protection a top priority, prioritise strong security measures, and enforce strict privacy policies.

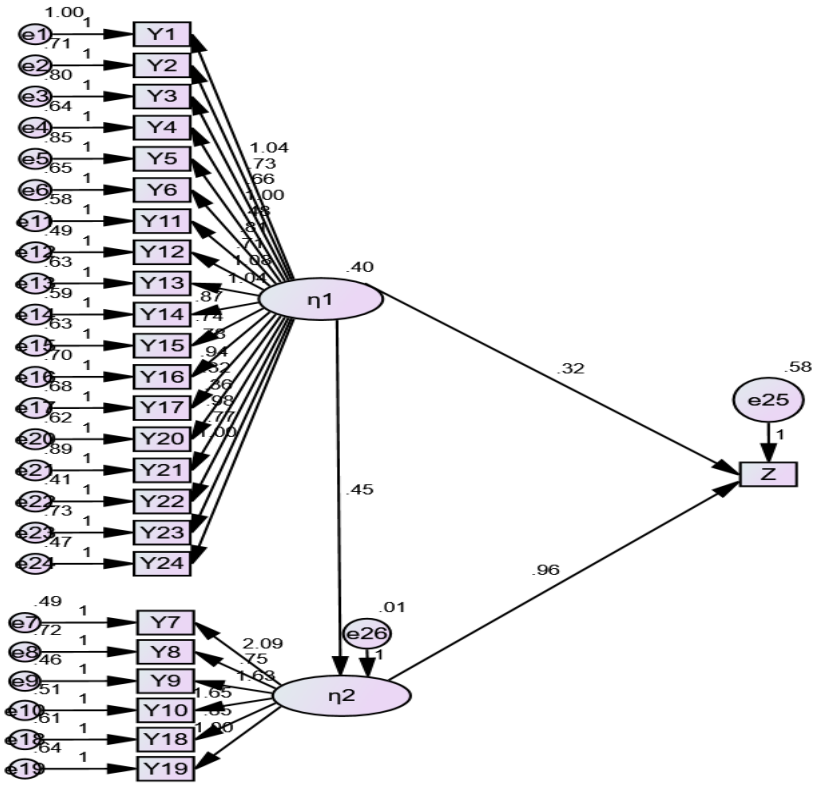


Figure 3: Path co-efficient outcome of structural equation model

The output of the SE model is shown in Table 6, and the values of the path coefficients are all positive. This means that raising a parameter by one unit will have a positive impact on the associated parameter (Z., 2012).

Table 6: Estimated value of different carpooling variables

Factor Group	*Variable Notation*	*P-Value*	*Path co-efficient value*
Service Performance(η1)	y1	***	1.04
	y2	***	0.73
	y3	***	0.66
	y4	***	1.00
	y5	***	0.48
	y6	***	0.81
	y11	***	0.71
	y12	***	1.08
	y13	***	1.04
	y14	***	0.87
	y15	***	0.74
	y16	***	0.78
	y17	***	0.94
	y20	***	0.32
	y21	***	0.36
	y22	***	0.98
	y23	***	0.77
	y24	***	1.00

Safety & Security(η2)	y7	***	2.09
	y8	***	0.75
	y9	***	1.63
	y10	***	1.65
	y18	***	0.85
	y19	***	1.00

Note: *p<0.05; **p<0.01; ***p<0.001 (Joseph et al., 2005; Ulfy, 2020)

3.2 Relative Importance Index (RII) Analysis.

The means and standard deviations of each item, when used to determine the overall rank, are unsatisfactory, according to various research, because they don't take the interactions amid the components into account (Assaf et al., 1995; Chan and Kumaraswamy, 1997; Faridi and El-Sayegh, 2006). The RII approach classifies the variables according to priority and prioritizes the factors that have been discovered (Hoque et al., 2021).

$$RII = \frac{\sum_{i=1}^{5} WiXi}{\sum_{i=1}^{5} Xi} \qquad (1)$$

Where,

Wi = Weight assigned to ith response;

Wi = 4, 3, 2, 1 and 0 for i = 1, 2, 3, 4, and 5

respectively;

Xi = Frequency of the ith response;

i = Response category index = 1, 2, 3, 4 and 5; for Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree respectively.

Accordingly, W1 = Strongly Agree, W2 = Agree, W3 = Neutral, W4 = Disagree, and W5 = Strongly Disagree.

The range of the RII value is 0 to 1. Carpooling system adoption is most strongly influenced by RII values close to 1 (Faridi and El-Sayegh, 2006; Hoque et al., 2021). Table 7 contains the results of the variables' RII analysis.

Table 7: RII Analysis Result and Variable Ranking

Factor Group	*Variable Notation*	*RII value*	*Rank*
Service Performance(η1)	y1	0.621	19
	y2	0.653	18
	y3	0.672	16
	y4	0.667	17
	y5	0.715	4
	y6	0.696	9
	y11	0.690	12
	y12	0.678	14
	y13	0.673	15
	y14	0.705	8
	y15	0.705	8

	y16	0.692	11
	y17	0.681	13
	y20	0.714	5
	y21	0.726	3
	y22	0.693	10
	y23	0.735	2
	y24	0.709	7
Safety & Security(η2)	y7	0.713	6
	y8	0.736	1
	y9	0.709	7
	y10	0.692	11
	y18	0.690	12
	y19	0.678	14

3.3 Comparison between SEM and RII Analysis

SEM determines the salient characteristics by connecting the variables. The qualities are identified as the respondents' feedbacks by RII analysis on the other hand. Rarely do the results of the RII and SEM analyses coincide. But the quality of the carpooling system's service is strongly influenced by those matching variables (Foroutan Mirhosseini et al., 2022; Sourav et al., 2022b).

According to SEM analysis, the ‘Sharing Personal Information (y7)’ variable is found as the utmost weighty variable underneath the “safety & security (η1)” latent variable. Conversely, according to RII analysis, ‘Safety (y8)’ is also found as the most significant variable within the top five variables, as shown in Figure 4. Moreover, among the top five variables in SEM analysis shown in Figure 4, the ‘Sharing Personal Information (y7)’ variable has the most impact on the acceptance of the carpooling system (Z). Users could feel uneasy disclosing personal information like home addresses, phone numbers, or places of employment because they worry that it might be misused or accessed by unauthorised parties. Inappropriate handling of personal data can result in security risks. Identity theft, fraud, and other nefarious activities could result from unauthorised access to sensitive data. If consumers have doubts about a carpooling service's capacity to secure their personal data, they might be reluctant to use it. Any ride-sharing system's ability to function depends on user trust, which can be damaged by worries about data security. Users who disclose personal information run the risk of being harassed or stalked. This is a serious issue, particularly for female travellers who may be more worried about their safety.

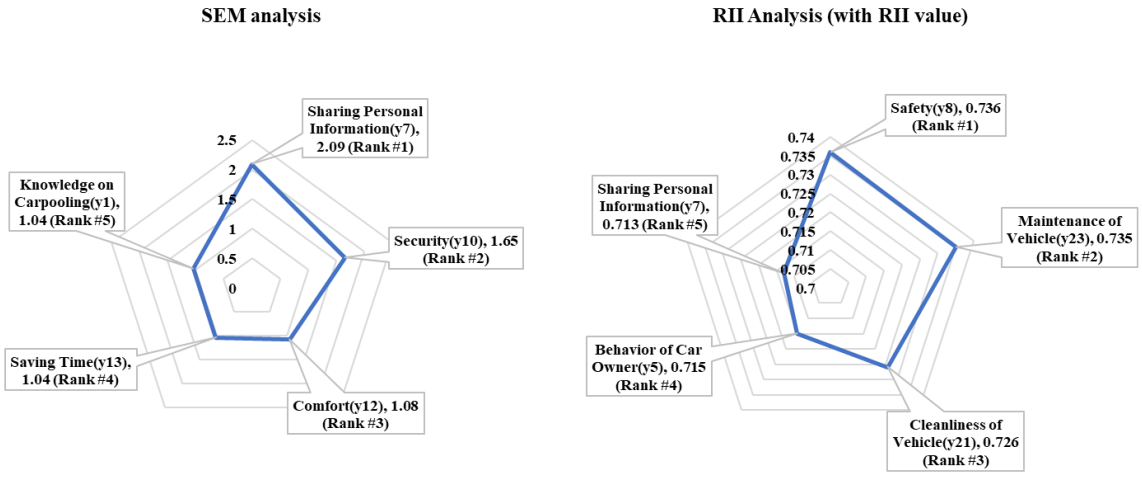


Figure 4: Utmost five momentous variables that sway acceptance of carpooling system according to SEM and RII (Radar Chart)

4. Conclusion

Over traditional travel, carpooling services are becoming more and more popular worldwide. Because of the improved sustainability indicators provided by this new technology, several governments promote it as a means of transportation in urban areas. Similarly, Mirpur DOHS inhabitants selected carpooling as a convenient, comfortable, and time-saving means of transportation. This study examines how users view and accept the carpooling system in the Mirpur DOHS area.

From the SE model, among two latent variables, the "safety & security (η2)" latent variable influences acceptance of carpooling system the most. Among the six observed variables underneath the "safety & security (η2)" latent variable, the 'Sharing Personal Information (y7)' is the most significant one. The main concern about the user is that their personal information, like bank account information, their personal data should be kept with the highest security. Carpooling services have online payment facility. Passengers can pay the fare using their mobile banking account. However, if somehow the mobile banking account information is leaked, then there is a chance for passengers to be cheated.

As the DOHS has limited public transportation options for safety reasons. Residents had to arrange for transportation outside of Mirpur DOHS in order to conduct personal or professional business. A large number of DOHS residents own their own cars. From this study findings, they can sign up for carpooling services. which will benefit the locals for going to work or for any other purpose. Mirpur DOHS authority can use this research finding for implementing carpooling system among the dwellers. This study recommends a sustainable and effective carpooling system in Mirpur DOHS area.

Despite these intriguing results, this study does have some drawbacks. Firstly, 24% of our respondents are female, as their perception of the carpooling system is more important than that of males. The main concern of women using carpooling is their safety. Women are more concerned about security especially at night. If the person carpooling is in bad faith, their safety is in question. Therefore, it is important to understand the carpooling

perception of women than men. Even though we sample the respondents using the normal distribution, the SEM's accuracy will be increased by more exact sampling that makes use of census tract data, gender, and income group.
Further study can be performed using hard data. While taking data online, it is often seen that the respondents answer the questions without reading them. As a result, the desired answer is not found. Which affects the research hypothesis. If the data is taken manually by talking to the respondents, then more accurate results are obtained. Additional studies can be done by addressing heterogeneity among the users. Carpooling services are used by both male and female passengers. It is necessary to verify individual acceptability using men's and women's perspectives independently.

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