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DIAGNOSTIC EVALUATION OF URBAN METRO TRANSIT SYSTEM POST-COVID-19

Summary. Public transportation usage in Delhi has declined, with the Delhi Metro having a significant share. However, due to fare hikes and COVID-19 restrictions, the DM's share has been decreasing further. To improve ridership, a study is being conducted to evaluate the DM's performance and identify areas for improvement in passenger convenience and comfort. The Magenta line is investigated through an on-board survey to collect primary data. The survey covers commuter perceptions of safety & security, financial & economic factors, infrastructure & comfort and functional & operational features. The Relative Importance Index approach is used to analyse the data and evaluate DM performance. An ANN model is also presented to determine the factors influencing the choice to travel on the DM, with the “metro fare per trip” factor being a key consideration. Based on the analysis results, recommendations are made to improve the DM's performance. The study found that safety and security had the highest RII, followed by efficiency and viability, functional and operational features, infrastructure and comfort, and financial and economic factors. The subway fare had the lowest RII. The ANN model is adapted to understand the reasons behind low metro ridership.

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1. INTRODUCTION

The Delhi Metro (DM) is one of the world's largest and extensive metro networks. The DM is a major means of Public Transportation (PT), making commutes accessible to millions. The DM has a distance-based fare system and infrastructure with future network expansion (FE Online, 2017). The DM saw decreased ridership due to an increase in fare (Sanjana Agnihotri, 2018). To mitigate the influence of COVID-19, the DM set limits and social distancing tactics. The DM's ridership was curtailed due to the travel guidelines during COVID-19 (Jasjeev Gandhiok, 2022). Even when the limitations were lifted, the DM suffered losses due to decreased ridership (Atul Mathur, 2023).

The inability to fully utilise DM as a PT and the lack of Last Mile Connectivity (LMC) are other factors in the drop in usage (Mittal, 2023). The author suggests that the attractiveness of PT relies on safety, cost, time, comfort, and convenience. Transit planning often neglects first and last-mile connectivity (Board et al., 1973). The rationale for the fall in ridership of DM must be determined. This can be comprehended using the Performance Evaluation (PE) of DM (Khursheed & Kidwai, 2022). The Magenta (Line 8), of DM has a total length of 37.46 km and consisting of 25 metro stations from Janakpuri West to the Botanical Garden (DMRC, 2022). A performance evaluation on the magenta line is essential given its length and the decline in ridership in DM.

The paper explores a comprehensive analysis of various methodologies used to assess the performance of the Magenta Line and provides a thorough investigation of the multifaceted issues related to ridership, providing valuable insights and recommendations for future enhancements.

2. LITERATURE REVIEW

A robust, inexpensive, and safe PT infrastructure is crucial. It is to ensure everyone has equal access to opportunities in work, education, healthcare, and recreation, especially for those who are socially and economically disadvantaged. The PT is a vital facility that must be provided equitably (Ghosh et al., 2022). Currently, the majority of riders are middle-class office workers and students of all age groups, rather than the fair distribution of riders that the DM had envisioned. The cause for this is an increase in metro fares in quick succession that is no longer affordable to the poor/middle class of the society (Saraswat & Girish, 2020). The PT provided by the metro has a high possibility of usage if it is easily accessible by the users in terms of time, distance, safety, and convenience (Bhandari et al., 2014). Long total travel time and high cost lowers the probability of using the PT. The increase in access-egress distance to the transfer location reduces the chances of using the PT (Keijer and Rietveld 2004; Loutzenheiser 1997; O'Sullivan and Morral 1996). The metro projects in India are implemented in isolation without concern for access and egress connectivity (Geetam Tiwari, 2013). There is growing recognition of the importance of LMC to mass transit systems. The authors recommend that walking as an LMC choice needs to be promoted through enhanced user experience, in the absence of which a significant amount of last-mile travel will happen through unsustainable mechanized modes. (Kanuri et al., 2019). Service quality characteristics, notably safety, and security, have the greatest influence on passenger adoption behaviour, favourably impacting DM as a PT. (Yogendra Pal Bharadwaj, Mukesh Singh, 2020). The methods for evaluation of a transport project now draw indicators accounting for accessibility, safety, and environmental effects (Lake and Ferrari 2002, Zhu and Ziu 2004). Factors such as fares, quality of service, and ownership of vehicles also influence the use of PT (Neil Paulley.et.al, 2006).

Before COVID-19, these investigations were carried out by researchers from various regions and timelines. The PIs from the preceding macro-level studies are incorporated in the present DM micro-study. As a result, based on the scope of the research indicated above, this post-COVID micro-level study is undertaken on the MAGENTA line. The study considers infrastructure and comfort, security and safety, functional and operational, efficiency and viability, and financial PID to assess the performance of the MAGENTA line. An Artificial Neural Network (ANN)-based performance model considering private car ownership, major haul distance, DM parking facilities, frequency of DM travel, and number of station interchanges per trip. The time for access and egress is proposed. The model's goal is to determine the PI factors influencing the Magenta line performance.

3. RESEARCH METHODOLOGY

Understanding commuter preferences within the DM demands a nuanced approach that combines the use of both qualitative and quantitative approaches. This study involves an in-depth analysis of multifaceted factors that influence commuters' mode choices. To facilitate these strategies, a significant number of passengers' travel data is required. A preliminary survey was conducted among a small cohort to refine and enhance the survey questionnaire before a wider distribution. Feedback from this preliminary phase is used to redesign the questionnaire and make it more holistic, to encompass the operational, financial, safety and comfort considerations within the DM framework.

The parameters were examined, and a logical analysis was applied to ensure the reliability and accuracy of the data used. The check was conducted on board with an aggregate of 742 passengers from which 630 passengers' answers were anatomized for keeping in mind the considerable size to understand the commuter preferences comprehensively. Post-data collection, a statistical interpretation was done leveraging the various software. This method facilitates a structured organization of extensive questionnaire data, providing an overview of the commuter inclinations.

The cross-tabulation analysis is an important statistical tool in enabling the interpretation of several factors, focusing on PIs and the RII. The PI serves a critical role in channelling the variables into distinct channels while encompassing the nuanced perspectives of commuters. Simultaneously, the RII helps in ranking the variables and identifying the factors influencing the metro ridership. The ANN model facilitates the decision-making process by unravelling intricate patterns within these complex data structures. This analysis offers a comprehensive evaluation of the indices dictating the commuter preferences within the DM framework.

The subsequent sections of this research paper provide insights into the analysis and interpretation of the implications drawn from survey outcomes. This provides a base for the decision-making process in the ridership analysis of DM.

4. DESCRIPTIVE AND CROSS-TABULATION ANALYSIS

The Descriptive analysis serves as a precise instrument to methodically organize data, presenting a structured outline of its elements and variables. Conversely, the cross-tabulation analysis details the interdependencies within the dataset components (Widyaningsih. et, al., 2022). The development of transportation networks involves a multitude of factors that influence their utilization and flexibility. It involves demographic aspects such as age, frequency, accessibility, parking provisions, comfort, ticket convenience, and amenities.

Tab. 1

Travel frequency vs age of commuters

Age of Commuters (Years)	Occasional (%)	1-2 times per month (%)	4-5 times per month (%)	2-3 times per month (%)	Daily (%)	Total (%)
Less than 20	4 (5.9)	2 (8.4)	5 (10)	8 (9)	14 (7.2)	33 (7.7)
20-30	32(47.9)	14 (58.3)	31 (62)	42(47.2)	107(55.2)	77(18.1)
30-40	20 (29.4)	4 (16.7)	7(14.0)	21(23.6)	48 (24.7)	100 (23.5)
40-50	6 (8.8)	4 (16.7)	5 (10)	13 (14.6)	17 (8.8)	45 (10.6)
50-60	5 (7.4)	0 (0)	2 (4)	5 (5.6)	5 (2.6)	17 (4)
Above 60	1 (1.5)	0 (0)	0 (0)	0 (0)	3 (1.5)	4 (0.9)
Total	68 (16)	24 (5.6)	50 (11.8)	89 (20.9)	194 (45.6)	425 (100)

Source: [13, 14]

The survey conducted was analysed, and the strategies were applied to explore the correlation between commuters' age and the frequency of utilizing the metro. It is noted that the age group of 20–30 years constitutes a large segment of the daily metro users, followed by the 30-40 age group. It is also observed that the age group above 40 has the lowest number of users. This underscores that DM usage is most prominent among the 30-50 age group who travel using the metro for educational and occupational purposes. The age group above 50 does not prefer the metro. These findings reveal the imperative need to improve the DM services to ensure inclusivity across different age cohorts and to address concerns.

5. PERCEPTION INDEX BASED ON PERFORMANCE INDICATORS (PID)

The PI assesses the transit performance to ensure a continuous increase in the quality of the transit services and to allocate resources using PIDs (Khursheed & Kidwai, 2023). Evaluating transit service quality involves both subjective measures of passengers' perceptions and metrics. They are compared to gauge the quality of transit services and detect opportunities for enhancement. (Hounsell, Mathew, 2023). The PID from the European standards are considered to interpret the survey and understand the limitations. The PT quality determinants have been studied extensively, and services are mainly characterized by several aspects such as service availability, reliability, comfort, cleanliness, safety and security, fare, information, and customer care. These aspects can be measured in various ways by considering different indicators (Eboli, L. and Mazzulla, G., 2012). The following subsections will provide a detailed description of some of these indicators, along with suggested target values.

The PI is composed of multiple evaluations that assess different aspects of the transportation network. These evaluations include the fairness of metro fares compared to other modes of public transport, satisfaction with station parking facilities, frequency of the DM, overall satisfaction with DM services, and the effectiveness of nighttime security measures. A study has shown that the total duration of DM trips compared to other transportation options, as well as the higher expenses associated with the metro, has been correlated with a significant number of dissatisfied PI ratings. Many DM customers, especially those travelling shorter distances, are requesting fare adjustments to align them with other modes of transportation. Furthermore, the data suggests that there is room for improvement in various aspects of the PI ratings, particularly regarding the LMC.

Table 2 examines the perceptions regarding different performance indicators that impact DM usage. These evaluations were conducted to gauge the quality or effectiveness of each specific indicator in influencing usage patterns. This analysis aims to understand how various factors contribute to the overall assessment of DM, providing insights into which indicators are deemed significant in shaping users' decisions to utilize this mode of transportation. The quality assessment of these indicators helps in comprehending their respective impacts on the usage patterns of DM services.

Tab. 2

Perception index based on performance indicators

S. No.	Performance parameters	Yes	No	Perception Index
A	**Infrastructure and Comfort Performance Indicators**			
1	Are parking facilities offered by Delhi Metro enough and affordable?	69.17%	30.83%	**6.29**
2	Are there sufficient vending machines and easy to use?	81.70%	18.30%	
3	Is there sufficient standing space for passengers?	61.54%	38.46%	
4	Is there sufficient seating space for passengers?	39.25%	60.75%	
B	**Security and Safety Performance Indicators**			
1	Do you think Security measures like CCTV cameras at stations and metro coaches are effective for safety at night?	96.28%	3.72%	**8.80**
2	Do you think that frisking and X-ray checking of luggage's at stations are effective for security measures?	91.44%	8.56%	
3	Do you think metro train services are required after 11:30 PM as well?	76.35%	23.65%	
C	**Functional and Operational Performance Indicators**			
1	Are you a frequent traveller by metro?	60.77%	39.23%	**5.77**
2	Are you satisfied with the operating frequency of Delhi Metro services at office hours?	65.58%	34.42%	

3	Does travelling by metro increases your time?	83.91%	16.09%	
4	Do you think breakdowns in Metro cause hindrance in your working routine?	22.73%	77.27%	
5	Do you consider other transportation means due to delays and breakdown of Metro trains in your daily working routine?	28.44%	71.56%	
6	Does it create any trouble while using interchange?	84.78%	15.22%	
D	**Financial and Economic Performance Indicators**			
1	Do you think that Metro fares are costlier comparing other public transport systems in Delhi?	63.16%	36.84%	**2.76**
2	Do you think that there should be reduction in fare in metro?	81.70%	18.30%	
E	**Efficiency and Viability Performance Indicators**			
1	Are you satisfied with the services provided by Delhi Metro Rail Corporation?	90.16%	9.84%	**6.21**
2	Do you think Delhi Metro Rail Corporation is efficient?	81.14%	18.86%	
3	Do you think there is a need to improve Last Mile Connectivity?	41.03%	58.97%	
4	Do you think there is a need to increase the number of trains?	35.20%	64.80%	
5	Do you find metro network simple?	63.19%	36.81%	

Source: Authors

The data suggests that safety and security are paramount to DM users, as reflected in the highest rating given to these aspects. Additionally, the survey highlights a willingness among commuters to utilize the metro service beyond 11:30 pm, indicating a demand for extended operational hours. The survey revealed that financial considerations, particularly fare costs, received the least attention. This insight implies that fare pricing might significantly influence commuters' choices, leading them to opt for alternative transportation modes over the metro.

In essence, the priority given to safety and the desire for extended service hours demonstrates the positive aspects of the metro. However, addressing fare concerns could be pivotal in retaining and attracting more commuters to the metro system.

6. RELATIVE IMPORTANCE INDEX OF PERFORMANCE INDICATORS

The RII serves as a useful means of assessing metro performance indicators. It assigns a numerical value to the importance or relevance of various indicators, enabling the prioritization of elements based on their perceived significance in the realm of DM services. Through the analysis of survey data or opinions about metro performance indicators, the RII provides valuable insights into the factors that hold the greatest sway over overall metro performance, facilitating targeted enhancements and strategic decision-making within metro systems (Kurniawati, et.al. 2023).

$$RII = \frac{\Sigma W}{A*N} \quad (0 \leq RII \leq 1) \tag{1}$$

Here RII is the relative importance index, W is the weighting assigned to each element by respondents (ranging from 1 to 5), A is the greatest weight (in this example, 5), and N is the total number of respondents. The RII value ranges from 0 to 1 (0 inclusive); the greater the RII, the more significant the indication. Table 3 displays the RIIs of PID as well as the findings.

Understanding the intricacies and nuances of PID within transit systems offers a profound glimpse into the facets shaping passenger experience. The evaluation, rooted in user feedback and satisfaction rankings, unveils both commendable aspects and critical areas necessitating attention. At the pinnacle of satisfaction rankings lies the Security and Safety PID, a testament to meeting and potentially surpassing passenger expectations. This vital aspect, foundational to trust and comfort, stands as an exemplar within transit systems. Following closely are the Efficiency & Viability indices, marking significant contributions to positive passenger experiences. However, RII exposes focal points for improvement. Concerns over LMCs, limited seating space within coaches, and inadequate designated parking facilities emerge as pivotal areas warranting attention. Addressing these concerns is crucial for enhancing overall passenger experiences and boosting ridership.

A striking disparity surfaces when comparing the highest-rated DM efficiency PID against the lowest-rated metro fare in terms of RII and satisfaction rank. This incongruity highlights the impact of fare structures on passenger contentment and ridership trends, particularly in the context of the COVID-19 epidemic. The correlation underscores the need for a nuanced reassessment of fare strategies that prioritize accessibility and passenger satisfaction while aligning with economic imperatives. LMC assumes paramount importance in transit systems. Optimizing this aspect through seamless integration and accessibility can significantly elevate the overall transit experience, addressing concerns and fostering inclusivity and efficiency. The limitation of seating space within coaches poses a tangible challenge. Striking a balance between capacity and comfort becomes imperative to accommodate increasing passenger demands. Innovative design interventions or operational strategies can optimize space utilization without compromising passenger comfort. In conclusion, the comprehensive evaluation of PID within transit systems outlines a transformative trajectory. Strategic interventions in fare structures, last-mile connectivity, seating space optimization and parking facilities are pivotal in sculpting transit systems that prioritize passenger satisfaction and accessibility. This holistic reimagining, underscored by innovation and collaboration, fosters systems that harmonize efficacy, accessibility, and passenger-centricity. Table 3 shows the ranking index from each indicator and gives an overall rank for the subcategories.

Table 3 assesses perceptions concerning various PIs influencing DM usage. The evaluations aim to determine the quality or effectiveness of each indicator in influencing the patterns of usage. The indicators are ranked from 1 to 19, reflecting their importance in terms of performance. Within the infrastructure and comfort category, the ease of using vending machines received the highest rank, while seating spaces were rated the lowest. This suggests that commuters found vending machine accessibility more satisfactory compared to seating availability. In terms of safety and security, the overall index received the highest ranking, indicating that users highly prioritize safety measures. However, the dissatisfaction with the availability of metro services after 11:30 pm resulted in this specific sub-indicator receiving the lowest ranking within this category.

Tab. 3

RII ranking of performance indicators based on users' perception

S. No.	Performance parameters	RII	Overall RII	Rank	Overall Rank
A	**Infrastructure and Comfort Performance Indicators**				
1	Are parking facilities offered by Delhi Metro enough and affordable?	0.605	0.609	3	13
2	Are there sufficient vending machines and easy to use	0.695		1	8
3	Is there sufficient standing space for passengers?	0.650		2	12
4	Is there sufficient seating space for passengers	0.486		4	19
B	**Security and Safety Performance Indicators**				
1	Do you think security measures like CCTV cameras at stations and metro coaches are effective for safety at night?	0.855	0.792	1	1
2	Do you think that frisking and X-ray checking of luggage's at stations are effective for security measures?	0.850		2	2
3	Do you think metro train services are required after 11:30 PM as well?	0.673		3	10
C	**Functional and Operational Performance Indicators**				
1	Are you a frequent traveller by metro?	0.591	0.652	4	14
2	Are you satisfied with the operating frequency of Delhi Metro services at office hours?	0.700		3	7
3	Does travelling by metro increase your time?	0.791		2	6
4	Do you think a breakdown in the Metro cause hindrance in your working routine?	0.500		5	17
5	Do you consider other transportation means due to delays and breakdown of the Metro trains in your daily working routine?	0.495		6	18
6	Does it create any trouble while using interchanges?	0.836		1	3
D	**Financial and Economic Performance Indicators**				
1	Do you think that the Metro fares are costlier than other Delhi public transport systems?	0.691	0.693	2	9
2	Do you think that there should be a reduction in fares in the metro?	0.695		1	8
E	**Efficiency and Viability Performance Indicators**				
1	Are you satisfied with the services provided by the Delhi Metro Rail Corporation?	0.832	0.676	1	4

2	Do you think the Delhi Metro Rail Corporation is efficient?	0.795		2	5
3	Do you think there is a need to improve Last Mile Connectivity?	0.532		5	16
4	Do you think there is a need to increase the number of trains?	0.568		4	15
5	Do you find the metro network simple?	0.655		3	11

Source: Authors

The indicator with the lowest overall RII was seating space, mainly due to its limited availability. This suggests that the provision of adequate seating is a crucial factor affecting commuter satisfaction and usage patterns. This analysis aims to understand how various factors contribute to the overall assessment of DM, providing insights into which indicators are deemed significant in shaping users' decisions to utilize this mode of transportation. The quality assessment of these indicators helps in comprehending their respective impacts on the usage patterns of DM services.

7. PERFORMANCE EVALUATION MODEL USING ARTIFICIAL NEURAL ANALYSIS (ANN)

Artificial Neural Networks (ANNs) are widely recognized as valuable and resilient computational models for both prediction and classification tasks. To enhance the accuracy and reliability of the processed data, these architectures are frequently constructed using a well-suited amalgamation of artificial neurons and activation functions (Nandal et al., 2020). ANNs, specifically Multilayer Perceptron (MLP) models, are highly effective tools in modern transportation research. They offer a sophisticated approach to evaluating performance indicators and measuring passenger satisfaction in transit systems. The implementation of an MLP-based ANN model involves a complex network of interconnected nodes that enables the system to learn from input data, recognize patterns, and make predictions (Qu & Chen, 2008). In the context of the DM, utilizing an MLP-based ANN model is crucial as it allows for a comprehensive analysis of various performance metrics, including travel time, service frequency, and passenger sentiments. This approach provides a holistic understanding of the system's functionality.

The architecture of the MLP-based ANN model for evaluating DM performance incorporates a range of input variables. These variables encompass factors such as travel duration, distance between stations, train frequency, service reliability, station amenities, and passenger feedback. Through meticulous data collection and preprocessing, the model undergoes multiple training iterations to optimize its parameters. This process enhances its ability to identify complex relationships between these variables and predict performance indicators. One of the model's key features is its ability to forecast passenger satisfaction levels based on collected data. By assimilating feedback on station facilities, journey experiences, and perceived service quality, the MLP-based ANN model provides valuable insights into commuters' sentiments. It analyses their preferences and highlights areas that require attention within the DM (Gallo et al., 2019). This predictive capability serves as a guide for transit authorities, enabling them to take proactive measures to address shortcomings and enhance the overall passenger experience while aligning with their needs and expectations.

Tab. 4

SSE and RMSE values

Training			Testing		
SS	**SSE**	**RMSE**	**SS**	**SSE**	**RMSE**
307	12.250	0.199	118	5.087	0.207
288	11.19	0.197	131	4.627	0.187
283	10.789	0.195	142	6.574	0.215
292	9.654	0.181	133	5.454	0.202
306	10.184	0.182	119	4.214	0.188
293	11.594	0.198	132	4.403	0.182
298	11.867	0.199	127	4.217	0.182
300	11.404	0.195	125	5.658	0.212
309	10.627	0.185	116	5.884	0.225
292	10.262	0.187	133	5.602	0.205
Mean	10.982	0.192	Mean	5.172	0.200
SD	0.821	0.0072143	SD	0.795	0.014960

Source: Authors

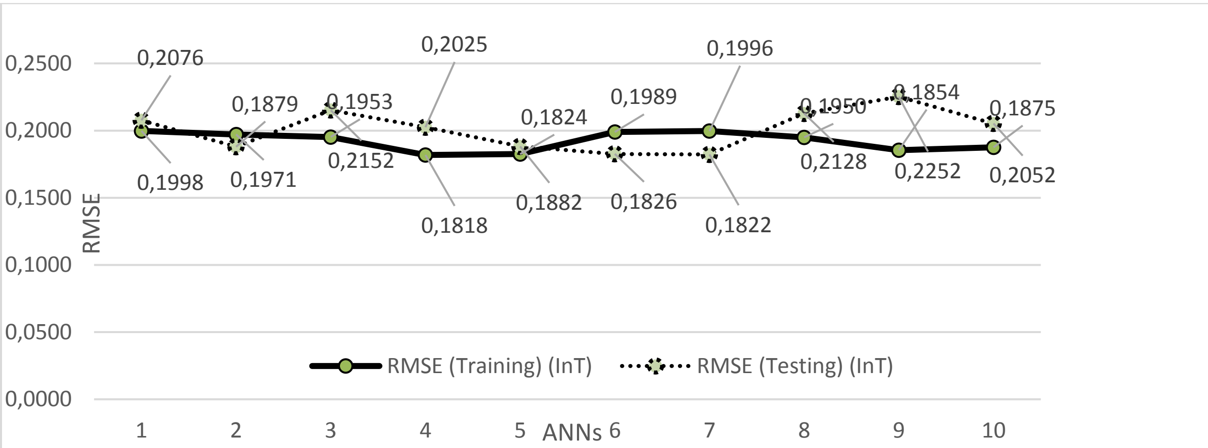

Fig. 1. RMSE training and testing

The MLP structure consists of interconnected nodes organized into layers, encompassing input, hidden, and output layers. The design of the network involves configuring the number of neurons in each layer, defining activation functions, and establishing connections. The ANN model is trained using a dataset split into training and testing subsets (Gallo et al., 2019). During training, the network iteratively adjusts weights and biases to minimize errors, optimizing its ability to predict outcomes. Post-training, the model's performance is assessed by computing the Sum of Squared Errors (SSE) and subsequently deriving the Root Mean Square Error

(RMSE) of given sample size (SS). These metrics quantify the variance between predicted and actual values, determining the model's predictive accuracy.

The RMSE calculations serve as pivotal measures in model evaluation. The RMSE computed on training data gauges the model's fit to the data it was trained on, while the RMSE on testing data assesses the model's ability to generalize to new, unseen data. Lower RMSE values on both training and testing sets indicate superior model performance and stronger generalization capabilities. Additionally, sensitivity analysis is conducted to scrutinize the model's robustness. By systematically varying input variables and observing resultant changes in model output, this analysis elucidates how modifications in inputs influence the model's predictions, offering insights into the model's sensitivity to alterations in specific variables (Buran & Erçek, 2022).

These methodologies collectively contribute to comprehensively assessing and enhancing the ANN with MLP model's performance and reliability. Through training, RMSE computations, and sensitivity analyses, the model's predictive accuracy, generalization capacity, and sensitivity to input variations are systematically evaluated and refined. These processes are fundamental in iteratively improving the model's efficacy, ensuring its applicability in predicting outcomes and informing decision-making processes within the context of the study (Nurhadi et al., 2014).

In sensitivity analysis for each iteration, the normalized significance (NI) of the various neurons is calculated and presented as a percentage of influence in that iteration. The NI is defined as the percentage ratio of each factor's significance over the maximum importance. Furthermore, the normalized value (NV) of each neuron is derived by dividing its average of normalized importance (AvNI) by its maximal significance and is shown as a ratio (Naser et al., 2020).

Tab. 5

Sensitivity analysis

IV	NI (1)	NI (2)	NI (3)	NI (4)	NI (5)	NI (6)	NI (7)	NI (8)	NI (9)	NI (10)	AvNI	NV	Rank
G	10.7	9.1	2.5	6.5	5.5	8.3	5	12.9	18.9	9.7	0.085	0.091	6
OV	14.0	16.7	18.4	33.1	9.2	18.3	10	16.7	33.4	17.6	0.176	0.188	5
PF	27.7	19.3	18.6	13.1	9.9	16.8	27.2	13.8	34.8	50.8	0.222	0.238	4
NS	31.0	46.2	47.4	31.2	49.4	56.7	39.4	34.6	100	48.3	0.453	0.485	2
(A+E) Cost	100	100	100	100	100	100	100	100	80.3	100	0.932	1.000	1
Age	38.1	20.7	22.3	18.8	16.6	12.3	10%	35.7	43.1	14.8	0.226	0.242	3

Source: Authors

In the above table, the dependent variable is considered to be Metro fare per day and the IV = independent variable is G=Gender, OV= Ownership of Vehicle, PF=Parking facility, NS= No. of station interchanges, (A+E) Cost= Access and Egress cost and Age of commuters. The NI are presented in percentage share of the PIs in the respect iterations.

From Table 5 we can understand that the (A+E) Cost, which is the access and egress cost, is the determinant factor. The access and egress cost corresponds to the distance between the metro and the access-egress locations and the cost incurred to cover the same. It involves the last mile connectivity, which governs the access and egress time. The number of station interchanges has a significant impact on the DM ridership. The age as discussed in Table 1 determines the ridership due to factors such as health and other issues that are related to age. On the other hand, ownership of vehicles, parking facilities and gender have the lesser impact on the metro ridership. These findings are in confirmation to the explanation noted in another research authored by (Khursheed & Kidwai, 2022).

8. CONCLUSION AND RECOMMENDATIONS

The age groups of 20-30 years and 30-40 years are the active riders of DM and their concerns are needed to be addressed on priority. The 20-30 year age group contributes to 50% of the ridership every day. The RII gives a ranking based on the perception of metro riders. Safety and security have the highest ranking but the infrastructure and comfort stand at the lowest rank due to less seating space available in the metro. These observations are similar to those (Khursheed & Kidwai, 2022). From the ANN model, it is noted that the access and egress costs are noted to be the most dominating factor. It is inferred that access-egress trip fare plays a major role in metro ridership. From the studies and research, it is concluded that the economic and comfort factors need to be improved/rationalized to have increased metro ridership in the Magenta Line.

9. LIMITATIONS AND FUTURE SCOPE OF WORK

The study is confined to on-board passengers, and subsequent research would require a survey of non-metro commuters. The poll might be affected by how people commute and what they prefer in different weather conditions. As a future study focus, the other PID in terms of financial and economic, functional and operational elements may be investigated. The impact of the aforementioned elements on other cities in the country must be investigated.

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