

Determinants of Financial Sustainability in Urban Metro Projects: An Empirical Analysis of Delhi Metro's Revenue Structure

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Abstract

The urban metro systems are important in helping to deal with congestion, environmental stress, and mobility issues in fast-growing megalopolises such as Delhi, but their long-term economic viability is a critical issue. Delhi Metro Rail Corporation (DMRC) has been practicing diverse revenue approaches such as fare revenue, advertising, property development, retail leasing, and engaging the private bodies, but the functionality of those approaches needed to be evaluated systematically with empirical analysis. This paper evaluates the determinants of financial sustainability at Delhi Metro by evaluating the correlation between revenue collection means and the financial performance. A mixed-method research design was utilized in this study, which comprised a questionnaire survey of 421 metro users through snowball sampling and a structured questionnaire and secondary data of the DMRC financial reports and other relevant scholarly materials. Descriptive statistics, correlation, regression, and hypothesis testing as quantitative analysis tools were integrated in SPSS to assess the role played by various revenue sources in enhancing financial sustainability. The results indicate that the diversification of revenue and financial sustainability are positively associated and their correlation is statistically significant with property development, advertising revenues, retail income, and partnership with other individuals turning out to be the most important factors. The research also attests to the fact that the use of fare revenue is not enough to support the large-scale metro operations. Although financial management practices had a positive effect, the government subsidies and financial transparency had a relatively low direct statistical impact. Altogether, the findings have highlighted that the necessity of diversified non-fare sources of revenue and strategic commercial use of metro resources is necessary in enhancing financial resilience and long-term sustainability of urban transport financing.

Keywords: urban metro systems, environmental stress, mobility, DMRC, fare revenue, property development, private bodies, financial sustainability, financial resilience and long-term sustainability

1. Introduction

The Delhi Metro has become an important aspect of urban redevelopment of the National Capital Region. Being one of the largest and most advanced urban metro networks in the globe, it has had a great impact on the city infrastructure and movement environment. Having been designed as an efficient and environmentally friendly substitute to road transport, the metro has been a critical solution to the traffic jam and air pollution in Delhi. One of the most vivid examples of the functioning of the mass rapid transit in stimulating the urban development and ensuring the sustainable mobility is the development of the Delhi Metro that is able to make the cities more habitable and connected (Begam et al., 2024). With the ever-increasing urban population, the metro has become a part of the mobility requirements in a rising megacity that has not only environmental but also socio-economic advantages (Rahman, 2017).

Although it has made a significant contribution, there is still the issue of guaranteeing the financial sustainability of the Delhi Metro. The system is based on the mix of fare collection, government subsidies and non-fare sources of revenue, such as advertising and property development. They are crucial in covering operational expenses and expansion costs but there is a balance between making it affordable to the commuters and ensuring that the business is profitable. Due to the large capital and operation cost of operating a system of urban rail, revenue maximization plans and reduction of reliance on subsidies are paramount. One of the aspects that should be explored to guarantee long-term sustainability of the metro system is the exploration of the various sources of non-fare revenue and the practice of better financial management (Singh & Gupta, 2020). Therefore, it is critical to analyze the dynamics of the revenue mechanism of Delhi Metro to come up with sustainable urban transport solutions that could help the city evolve in the future.

1.1. **Background of Urban Metro Systems :** The Delhi Metro, one of the largest and most advanced urban transit systems in the world, has been a cornerstone in transforming the urban mobility landscape of Delhi. It has been in operation since its inception and offers a safe, sustainable alternative to road transport, which has helped to reduce the number of vehicles on the road, as well as, aiding in air pollution mitigation in the city. The metro is an important component of the Delhi public transportation system and has fulfilled and met the urban mobility needs of the city and also provided urban development by enhancing transportation of different sections of the city (Begam et al., 2024). Another aspect that indicates the success of the Delhi Metro is that it serves as an example to other cities in India and the world that consider the integration of a mass rapid transit system (MRTS) into its city planning models. It has played a significant role in dealing with the challenge of the fast rate of urban growth in such a megacity as Delhi where the population is growing (Rahman, 2017). But the sustainability of a such a large scale metro system is doubtful. Fare revenue is frequently not enough to meet the operating and expansion demands, so the metro should consider other non-fare sources of revenue, including advertising and property development (Singh & Gupta, 2020). This reiterates the need to maximize the revenue structure in the long-time financial sustainability of the Delhi Metro.

1.2. **Financial Sustainability in Public Transportation :** The financial sustainability of the individual transportation systems is more critical of guaranteeing the long term success, especially in the urban metro projects such as the Delhi Metro. Such systems rely on the financial health of the financial systems not only on the basis of fare revenues but also on the management of other revenue sources including government subsidies, non-fare revenues through advertising, property development and retail outlets. It is important to ensure that these varied income streams are maximized which ensures that the services are affordable as well as the operation and expansion costs. With the ever-increasing cities, there is a greater need to have a design of the public transport systems that are economically viable and capable of meeting the demands in the future. The problem in Delhi has been the inability to balance affordability and financial sustainability of fares, and more so the demand to counter the rising operational cost (Chaudhari, Singari, and Bhandarkar, 2025). Metro systems worldwide have embraced the best practices in their operations, management as well as revenue diversification in order to be financially sustainable. Effective models focus on effective operational practices, cost control and strategic collaborations with private organizations to get extra funding. The example of Delhi Metro is based on a mix of fare collection and property development in addition to advertising revenues, yet more investigation into these types of non-fare sources of revenue is required to decrease dependency on subsidies and provide financial stability. Relying on global experience in metro management and operation can give information about the cost-effective solutions that can help to ensure financial sustainability and provide high-quality and accessible service to commuters (Sharma, Jain, and Devendra, 2022). This all-inclusive strategy is required to construct strong systems of the metro that enable sustainable urban mobility in the long run.

1.3. **Key Determinants of Financial Sustainability in Metro Projects:** The most vital financial sustainability factor in the metro projects is complex and requires different sources of revenue and practices. Four important factors are:

- **Advertising Revenue:** Non-fare revenue that is particularly generated through advertisement has a substantial role in financing the financial sustainability of the metro systems. Metro systems can earn a lot of income by using the best places in the metro stations and trains.

Advertising revenue is an important part of the financial model since, so far, Delhi Metro has used it appropriately to complement the revenue from fares (Jha & Bhatia, 2026).

- **Fare Revenue Alone Is Insufficient:** Fare revenue is sometimes a major source of metro systems income, but it does not usually suffice to meet the costs of operation and capital. Most metro systems have been struggling with the issue of affordability of fares and at the same time, the need to make ends meet. This brings about the essence of considering other sources of revenue like development of properties and collaboration with private companies (Arora, 2019).
- **Property Development:** Financial viability is the development of metro-nearby properties. By bringing together real estate development and transit infrastructure, metro systems can create huge non-fare revenues. The property development strategy of Delhi Metro has become one of the primary reasons why it has less dependence on the revenue of fares and greater financial autonomy (Jha & Bhatia, 2026).
- **Partnerships with Private Entities:** Strategic partnerships with private enable metro systems to diversify the sources of revenue. Such partnerships may involve joint venturing in property development, the retail outlets and other business activities that are revenue generating. Engaging the private players would also enable the metro systems to tap into more capital and experience, which is part of their financial sustainability (Jha and Bhatia, 2026).

1.4. **Challenges in Revenue Generation for Urban Metro Projects:** There are various challenges encountered in the generation of revenues in the urban metro projects, which may affect their financial sustainability in the long-term. Among the major challenges is the lack of adequate fare revenue that in most cases is not enough to meet operation and maintenance expenses not to mention capital expenditures. Though fare collection is one of the main sources of revenue, it is not usually sufficient to maintain the financial demands of the growing metro, particularly in large population cities with low fare systems. With the rise in the number of people in the urban areas as well as the number of commuter needs, the metro systems have to depend on other sources of income to achieve their financial objectives. Such sources of income like non-fare revenues through advertisement, property development and retail outlets are very important but may prove tricky to maximise in well urbanised regions where the land space is very limited and there is high competition in the advertising space. Moreover, most of the metro systems such as the Delhi Metro also rely on government subsidies to close the revenue gap which poses long term difficulties associated with funding stability and sustainability. Besides financial constraints, growing ridership is both an opportunity and challenge to the metro systems. As the ridership increases, both the infrastructure and capacity requirements also increase and the operation and maintenance costs increase. This further strains the metro systems to not only generate more revenue but also enhance the operation efficiency. Financial transparency is one of the challenges facing many urban metro projects because it may be difficult to effectively trace and use revenue streams as provided by various sources. In addition, complex regulations, project delays, and uncertainties within the financial sector tend to impede partnership with private organizations and even the public- private collaboration. Consequently, the metro systems have to seek new revenue sources, cost control, and quality provision without burdening the financial system (Huang, Zhang, and Li, 2020; Yadav and Gupta, 2021).

1.5. **The Role of Non-Fare Revenue in Metro Sustainability :** The non-fare revenue forms a very important part of the financial sustainability of the metro systems, especially in the city such as Delhi where metro costs are not always adequately provided by the fare revenue. Other sources of non-fare income, which include advertising, property development and retail outlets, assist the metro systems in diversification of their income streams. As suggested by Kuriakose (2025), the development of land around metro stations to commercial and residential purposes brings a substantial level of revenue, which makes it less reliant on government subsidies and fare collection. Moreover, Patil and Gaur (2026) also highlight that metro systems that have a variety of revenue streams operate more efficiently regarding their financial standing since they cannot be affected by changes in the number of people using the services or alterations in fares. The non- fare revenue can be reinvested into infrastructure, service enhancement and expansion of the system. Through research on the possibilities of partnership with the populace and other business opportunities, the metro systems will be able to maintain financial stability in the long-term and at the same time contribute to the development of the city. This balanced revenue model makes metro systems resistant to the economic challenges.

1.6. **Impact of Government Subsidies on Metro Financial Health:** The subsidies provided by the government have a central role in the financial performance of the metro systems especially in the developing world such as India. Metro systems such as the Delhi Metro are faced with a lot of financial difficulties in meeting expenses of expansion, operation and maintenance. Although a part of those costs is the fare revenues, they are often not enough to ensure that the whole financial load is covered. According to Ghosh, Ghosh and Sinha (2026), government subsidies can play a very important role in bridging such a financial gap so that the metro systems can build their infrastructure, enhance the quality of services without overwhelming the commuters with high fares. The government subsidies can be used to make sure that the metro systems are affordable, accessible, and operational particularly in the initial years development where the number of riders is yet to stabilize. Nonetheless, there is also a reliance on subsidies which brings about a challenge in the aspects of long-term sustainability. When the metro systems reach maturity, there is a risk of overstraining the available government resources and this is why there is a need to diversify the source of funding. Negi and Gupta (2022) emphasize that despite the necessity of the subsidies, alternative financing methods, including the public-private partnerships (PPP), should be utilized to provide the further financial sustainability of the metro systems. Such alternative funding models assist in minimizing the reliance on government funding and at the same time present the capital to support the further growth and enhancement. Agarwal et al. (2025) also note that the mix of the use of government subsidies and other sources of revenue is one of the main aspects of ensuring the financial sustainability of metro systems. This strategy allows the success of the long-term life of metro projects and sustaining the important mobility solutions to the urban areas.

2. Systematic Literature Review

Rahman (2017) places the Delhi Metro in the context of the bigger processes of urban growth and spatial restructuring in the National Capital Region. Studies have shown that the mass rapid transit development improves accessibility and land-use change along the metro lines and, therefore, the economic and financial feasibility in the long term. Nonetheless, uncontrolled growth of stations can put strain on infrastructures and financial pressure unless controlled by planning. There is empirical evidence that the metro accessibility is also associated with the housing markets and car reliance, which interacts with transport decisions and revenue potential (Agarwal et al., 2025). Literature on urban transformation goes further to reinforce the claim that transit-oriented development in the area of Delhi Metro has triggered a spur in commercial activities and heightened mobility demand (Begam et al., 2024). The literature collectively demonstrates that metro-led development can be financially advantageous with the help of a consistent land-use policy and institutional coordination.

Arora (2019) critically analyses the negative transit ridership patterns and brings out implications that they have on the farebox sustainability of the Delhi Metro. The existing studies indicate that inappropriate first and last-mile connectivity and interference with other modes of transportation suppresses steady increases in passenger numbers, which has a direct effect on revenues. The service quality and commuter satisfaction are determined to be considerable factors of repeat usage and readiness to pay (Bharadwaj and Singh, 2020). Other studies that focus on accessibility further pinpoint that affordability, inclusive design, and multimodal integration are critical in maintaining the level of ridership in Indian metro systems (Kuriakose, 2025). All in all, the literature indicates that financial sustainability is tightly linked with high ridership with efficiency of the services, accessibility and customer-based operations.

Negi and Gupta (2022) situate the issue of financial sustainability of Delhi Metro in the context of the financial sustainability of urban metro systems in India. Research stresses the fact that high levels of dependency on state funding and state debt require developing new methods of financing like land value capture, commercial development based on transport, and collaborative work with the commercial sphere. The studies of co-branding and commercial cooperation in DMRC prove that advertising and corporate partnership are important instruments to enhance the level of non-fare revenue collection (Rao et al., 2020). Other studies have indicated that the acquisition of urban rail freight and logistics services would have the potential to generate secondary sources of income and enhance the use of assets (Singh & Gupta, 2020). It is continually stated in the literature that diversified structures of revenue are the key to reducing fiscal risks and the sustainability of the project in the long term. Jha and Bhatia (2026) examine the main factors that determine sustainability in urban metro systems with a focus on operational efficiency, cost management and governance capacity. Evaluations in terms of productivity indicate that the increased technical efficiency and optimal usage of resources have a positive impact on the financial outcomes of Indian metro systems (Patil and Gaur, 2026). Infrastructure-related scholarship also observes that the fast growth of the metro network in India necessitates powerful institutionalized structures and strategic thinking to keep the fiscal self-restraint and service quality (Ghosh et al., 2026). Combined, the literature introduces financial sustainability in Delhi Metro as a multidimensional construct that is determined by the strength of governance, the operational productivity, the diversified nature of revenues and the integrated urban policy alignment.

3. Problem Statement

DMRC has a lot of problems with its financial sustainability in the long term. Although the fare revenue continues to be a major source of income, it is rarely enough to support operation expenses and hence over-dependence on government subsidies. As the number of people using its services grows, its revenues swell and fall, and its operational costs increase, DMRC will need to seek additional sources of revenue and streamline its financial management strategies. This paper will seek to establish the contributing factors to the financial sustainability of the Delhi Metro, where the means of revenue generation will be analyzed and include advertising, property development, and collaboration with the private organizations.

4. Significance of the Study

This research is crucial in the insight into the financial viability of urban metro systems, especially Delhi Metro, which operates with millions of commuters on a daily basis. The research will provide the perspectives on how metro systems can be less dependent on government funding by assessing the streams of revenue and financial practices. The results can guide policymakers, DMRC people, and urban transport planners in terms of enhancing financial management practices and introducing more sustainable revenue models. Furthermore, the given research paper is a contribution to the wider discussion of sustainable urban mobility and the importance of financial management of the urban transportation systems.

5. Objective

To evaluate the revenue generation and financial sustainability of the Delhi Metro

6. Hypothesis

- H0: Revenue generation has no significant relationship with the financial sustainability of the Delhi Metro.
- H1: Revenue generation has a significant relationship with the financial sustainability of the Delhi Metro.

7. Methodology

The information in the financial dimension and perception of the stakeholders were collected using a multi-method strategy. Quantitative data was obtained through the financial reports of DMRC that is, the significant sources of revenues Advertising Revenue, Fare Revenue, Property Development and Revenue, outlets of Retail. Analysis of data was made in order to establish the contribution of these sources to financial sustainability of the Delhi Metro. Besides, the perception of the main stakeholders (commuters, policy makers, DMRC officials, etc.) regarding the Financial Management, Partnerships with Private Entities, and the Focus on Non-Fare Revenue approaches was also influenced with the help of the structured survey. The questionnaire was based on the five-point Likert scale (Strongly Disagree, Strongly Agree) when gauging the attitudes towards such questions as Sufficiency of Fare Revenue Alone, Financial Transparency, and the role of Government Subsidies in the financial well-being of the metro.

7.1. Research Method: The data on the financial aspect and the stakeholder perception were gathered through a multi-method approach. The financial reports of DMRC were used to obtain quantitative data, particularly the major sources of revenue like Advertising Revenue, Fare Revenue, Property Development and Revenue, outlets of Retail. Data analysis was done to determine the contribution of these sources to the financial sustainability of the Delhi Metro. Moreover, the structured survey was also used to influence the perception of key stakeholders (commuters, policymakers, DMRC officials) about the Financial Management, Partnerships with Private Entities, and the Focus on Non-Fare Revenue strategies. "The questionnaire used a five-point Likert scale (Strongly Disagree, Strongly Agree)" in assessing the attitudes towards such questions like Sufficiency of Fare Revenue Alone, Financial Transparency, and the role of Government Subsidies in the financial well-being of the metro.

7.2. Research Strategy: The adopted research strategy was cross-sectional involving the collection of data at a given point in time to determine the financial sustainability of the Delhi Metro system at the given time. This design could facilitate the evaluation of the existing sustainability performance with regard to various revenue generation approaches. "The statistical methods, such as correlation analysis and regression analysis, were used to analyze the interrelations between different sources of revenues (such as advertising, retail outlets, and fare revenue)" and the general financial sustainability. It also analyzed how the metro will meet its financial sustainability as the number of riders increases and how effective government subsidies are.

7.3. Questionnaire Design : The questionnaire was created in accordance with the objectives of the study and financial sustainability indicators reported in the literature. Some of the key parameters that were taken into consideration were to get a feel of what the stakeholders think of these non-fare revenue sources, some of which were Advertising Revenue, Property Development and Revenue in the form of retail outlets among others. The questions were phrased in a way that was not difficult to grasp. A pilot review was done to check the content validity and clarity after which the final distribution was done. The responses to the survey were on Financial Transparency, the Sufficiency of Fare Alone and the Effect of Government Subsidies on DMRC financial status.

7.4. Sampling Design: The survey used snowball sampling to recruit the participants. First, some of the active commuters of the Delhi Metro were picked and they were persuaded to distribute the survey to other regular users. The approach enabled wider and more varied group of participants to be accessed. Four hundred and twenty-one valid responses were obtained. Besides, semi-structured interviews will be done with DMRC officials, transport economists, and financial experts to collect qualitative information on the financial sustenance practice of the Delhi Metro, and in this case, the attention is given to the practice of Private Entity Partnerships, Non-Fare Revenue Streams, and Financial Management Practices.

7.5. Data Collection: A mixed methodology was used to gather primary data, as it involved the use of online surveys (with Google Forms) and face-to-face interviews with commuters, DMRC officials, and other interested parties. It has been collected in "Delhi and National Capital Region (NCR), which comprised of Delhi, Gurugram, Noida, Faridabad, Ghaziabad, Bahadurgarh, and Ballabhgarh." Secondary data were collected on annual financial reports of DMRC, government publications, and academic research on the subject of financial sustainability of urban metro, and such issues were considered as Advertising Revenue, Property Development, and Fare Revenue Strategies.

7.6. Type of Study: This research adopted the cross-sectional design, where data was gathered at one time. The questionnaire was designed in such a manner that it gathered information on different financial sustainability issues of the Delhi Metro, but especially on the

revenue generation strategies and how the same work towards keeping the whole institution financially alive. The paper also examined the views on financial adequacy of fares income, the effect of collaboration with private organizations and government subsidies.

7.7. Data Analysis: Data were to be handled using the SPSS software. The demographic data and the patterns of the survey responses were summarized by means of descriptive statistics. The correlation analysis was used to investigate the links between various sources of revenues (e.g., Advertising Revenue, Fare Revenue, Revenue from Retail Outlets) and financial sustainability outcomes. The influence of the financial management practices, the partnerships between the privates and the government subsidies to the overall financial sustainability of the Delhi Metro were evaluated with the help of regression analysis. Thematic analysis was also used to the data of the qualitative interviews to determine the main trends in the opinions of the stakeholders about non-fare revenue and financial transparency.

7.8. Results

Table 1: Demography

Category	Parameters	Frequency	Percent	Category	Parameters	Frequency	Percent
Gender	Male	228	54.2	Marital status	Married	287	68.2
	Female	193	45.8		Unmarried	134	31.8
	Total	421	100.0		Total	421	100.0
Qualification	High School	78	18.5	Area	Delhi	195	46.3
	Diploma	65	15.4		Gurugram	83	19.7
	Graduation	159	37.8		Noida	56	13.3
	Master	97	23.0		Faridabad	25	5.9
	PhD	22	5.2		Ghaziabad	28	6.7
	Total	421	100.0		Bahadurgarh	18	4.3
					Ballabhgarh	16	3.8
			Total	421	100.0		
Number of metro line use	Single line	82	19.5	Reach metro station	Walk	54	12.8
	Double line	187	44.4		Own Vehicle	60	14.3
	Triple line	117	27.8		Public Transport	237	56.3
	More than triple line	35	8.3		Ola/Uber Cab	70	16.6
	Total	421	100.0		Total	421	100.0

Table 1 presents the demographic profile of 421 respondents included in the study. The gender distribution indicates that 54.2% (228) are male and 45.8% (193) are female. A majority of respondents are married (68.2%), while 31.8% are unmarried. In terms of educational qualifications, most respondents are graduates (37.8%), followed by postgraduates (23.0%), high school (18.5%), diploma holders (15.4%), and PhD holders (5.2%), indicating a relatively well-educated sample. Area-wise, 46.3% reside in Delhi, “followed by Gurugram (19.7%), Noida (13.3%), Ghaziabad (6.7%), Faridabad (5.9%), Bahadurgarh (4.3%), and Ballabhgarh (3.8%). Regarding metro usage, 44.4% use double lines, 27.8% use triple lines, 19.5% use a single line, and 8.3% use more than three lines, reflecting substantial route connectivity.” Concerning accessibility, 56.3% reach metro stations via public transport, 16.6% use Ola/Uber cabs, 14.3% use their own vehicles, and 12.8% walk, highlighting strong reliance on integrated transportation systems.

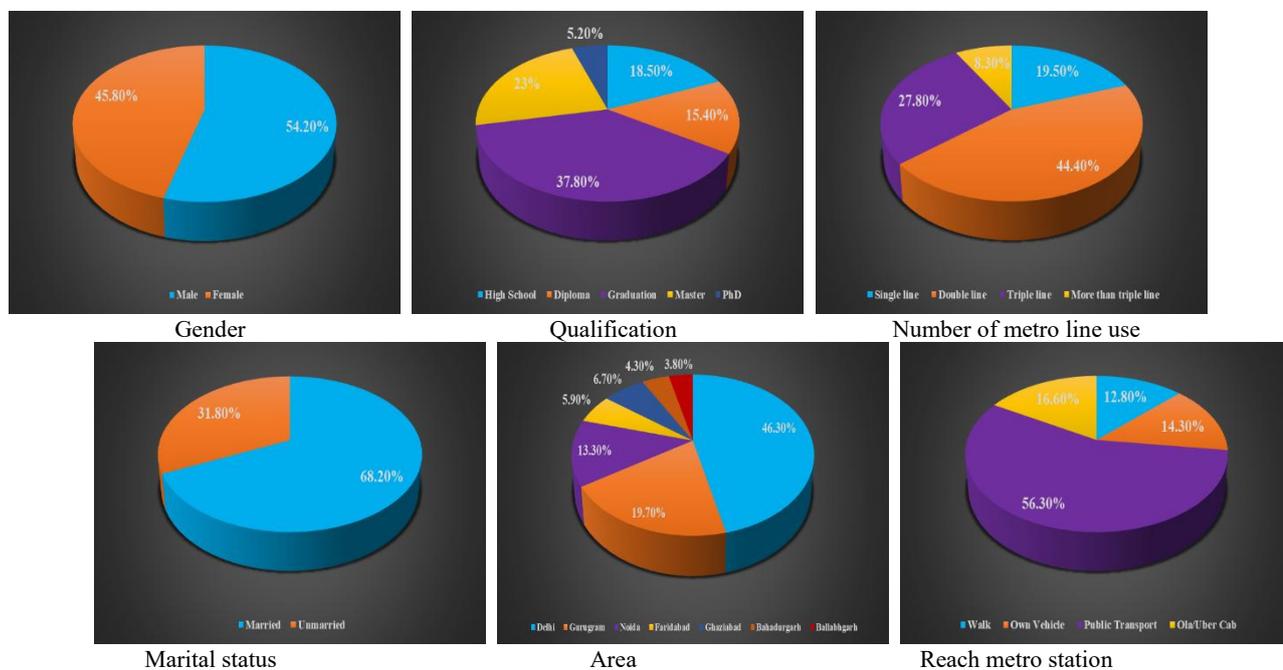


Figure 1: Demography

Table 2: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.457 ^a	.209	.190	1.183

a. Predictors: (Constant), Partnerships with Private Entities, Focus on Non-Fare, Property Development, Financial Transparency, Government Subsidies, Financial Management, Increasing Ridership, Advertising Revenue, Fare Revenue Alone Is Insufficient, Revenue from Retail Outlets

Table 3: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	151.574	10	15.157	10.835	.000 ^b
	Residual	573.557	410	1.399		
	Total	725.131	420			

a. Dependent Variable: Delhi Metro is Financially Sustainable

a. Predictors: (Constant), Partnerships with Private Entities, Focus on Non-Fare, Property Development, Financial Transparency, Government Subsidies, Financial Management, Increasing Ridership, Advertising Revenue, Fare Revenue Alone Is Insufficient, Revenue from Retail Outlets

The Model Summary shows a moderate correlation ($R = 0.457$) between financial sustainability and the selected predictors. “The R Square value (0.209) indicates that 20.9% of the variation in Delhi Metro’s financial sustainability is explained by factors such as non-fare revenue, partnerships, ridership growth, and financial management. The ANOVA results reveal the model is statistically significant ($F = 10.835$, $p = .000$)”, confirming that these financial and managerial determinants collectively influence sustainability outcomes.

Table 4: Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients Beta	t	Sig.
	B	Std. Error			
(Constant)	.508	.305		1.665	.097
Advertising Revenue	.134	.048	.134	2.798	.005
Financial Management	.090	.045	.089	1.987	.048
Fare Revenue Alone Is Insufficient	.158	.049	.153	3.194	.002
Property Development	.178	.048	.178	3.722	.000
Financial Transparency	.062	.048	.061	1.275	.203
Partnerships with Private Entities	.109	.050	.105	2.195	.029
Revenue from Retail Outlets	.106	.046	.107	2.311	.021
Increasing Ridership	-.092	.043	-.101	-2.134	.033
Focus on Non-Fare	.096	.047	.095	2.050	.041
Government Subsidies	-.008	.050	-.008	-1.169	.866

b. Dependent Variable: Delhi Metro is Financially Sustainable

Table 4 “presents the regression analysis explaining the influence of selected financial determinants on the financial sustainability of the Delhi Metro Rail Corporation using standardized beta coefficients, t-values, and significance levels. Property Development emerges as the most influential factor with the highest standardized beta ($\beta = 0.178$), a strong t-value ($t = 3.722$), and high statistical significance ($\text{Sig.} = 0.000$), indicating its critical role in strengthening long-term financial stability. Fare Revenue Alone Is Insufficient also demonstrates a strong and statistically significant positive impact ($\beta = 0.153$, $t = 3.194$, $\text{Sig.} = 0.002$), highlighting the necessity of diversifying income sources beyond passenger fares.” Advertising Revenue shows a meaningful positive contribution ($\beta = 0.134$, $t = 2.798$, $\text{Sig.} = 0.005$), emphasizing the importance of commercial utilization of metro assets. Revenue from Retail Outlets ($\beta = 0.107$, $t = 2.311$, $\text{Sig.} = 0.021$) and Partnerships with Private Entities ($\beta = 0.105$, $t = 2.195$, $\text{Sig.} = 0.029$) further exhibit significant positive effects, reflecting the growing relevance of non-fare revenue streams and collaborative financing models in enhancing financial resilience. Financial Management demonstrates a marginal yet statistically significant influence ($\beta = 0.089$, $t = 1.987$, $\text{Sig.} = 0.048$), suggesting that efficient budgeting and cost control support sustainability outcomes. However, Financial Transparency ($\beta = 0.061$, $t = 1.275$, $\text{Sig.} = 0.203$) does not show a statistically significant effect. Interestingly, Increasing Ridership reveals a negative but significant relationship ($\beta = -0.101$, $t = -2.134$, $\text{Sig.} = 0.033$), possibly indicating rising operational costs associated with higher passenger volumes. Overall, diversified non-fare revenue sources emerge as the strongest determinants of financial sustainability.

Table 5: Hypothesis Testing with key variable “DMRC’s Sustainability Initiatives”

Variable	t-value	Sig. (p-value)	Pearson r	Spearman ρ	χ^2 Value	Remark H_1
Advertising Revenue	2.798	0.005	0.261	0.267	55.363	Accepted
Financial Management	1.987	0.048	0.138	0.148	38.947	Accepted
Fare Revenue Alone Is Insufficient	3.194	0.002	0.271	0.267	46.085	Accepted
Property Development	3.722	0	0.292	0.301	74.419	Accepted
Financial Transparency	1.275	0.203	0.184	0.19	46.796	Rejected
Partnerships with Private Entities	2.195	0.029	0.24	0.25	46.903	Accepted
Revenue from Retail Outlets	2.311	0.021	0.191	0.204	41.025	Accepted
Increasing Ridership	-2.134	0.033	0.066	0.059	19.484	Accepted
Focus on Non-Fare	2.05	0.041	0.204	0.22	55.37	Accepted
Government Subsidies	-0.169	0.866	0.17	0.175	35.015	Accepted

Table 5 presents the hypothesis testing results with the key variable “Financial Sustainability of the Delhi Metro Rail Corporation,” using t-values, significance levels, Pearson’s correlation (r), Spearman’s rho (ρ), and Chi-square (χ^2) values. Property Development shows the strongest association ($t = 3.722$, $\text{Sig.} = 0.000$, $r = 0.292$, $\rho = 0.301$, $\chi^2 = 74.419$), leading to hypothesis acceptance and confirming its major contribution to financial sustainability. Fare Revenue Alone Is Insufficient also demonstrates a significant positive relationship ($t = 3.194$, $\text{Sig.} = 0.002$, $r = 0.271$, $\rho = 0.267$, $\chi^2 = 46.085$), supporting hypothesis acceptance. Advertising Revenue ($t = 2.798$, $\text{Sig.} = 0.005$, $r = 0.261$, $\rho = 0.267$, $\chi^2 = 55.363$) and Partnerships with Private Entities ($t = 2.195$, $\text{Sig.} = 0.029$, $r = 0.240$, $\rho = 0.250$, $\chi^2 = 46.903$) also exhibit significant positive relationships, resulting in hypothesis acceptance. Revenue from Retail Outlets ($t = 2.311$, $\text{Sig.} = 0.021$, $r = 0.191$, $\rho = 0.204$, $\chi^2 = 41.025$) and

Focus on Non-Fare Revenue ($t = 2.050$, $\text{Sig.} = 0.041$, $r = 0.204$, $\rho = 0.220$, $\chi^2 = 55.370$) further confirm significant associations. Financial Management shows marginal significance ($t = 1.987$, $\text{Sig.} = 0.048$, $r = 0.138$, $\rho = 0.148$, $\chi^2 = 38.947$), supporting hypothesis acceptance. Increasing Ridership ($t = -2.134$, $\text{Sig.} = 0.033$, $r = 0.066$, $\rho = 0.059$, $\chi^2 = 19.484$) also remains statistically significant despite its negative t -value. However, Financial Transparency ($t = 1.275$, $\text{Sig.} = 0.203$, $r = 0.184$, $\rho = 0.190$, $\chi^2 = 46.796$) leads to hypothesis rejection due to insignificance, while Government Subsidies ($t = -0.169$, $\text{Sig.} = 0.866$, $r = 0.170$, $\rho = 0.175$, $\chi^2 = 35.015$) shows no meaningful statistical influence.

8. Conclusion

“This study evaluated the financial sustainability determinants of the Delhi Metro Rail Corporation using responses from 421 metro users across the National Capital Region along with financial data analysis. The demographic profile indicates balanced participation, with 54.2% male and 45.8% female respondents, and a majority married (68.2%), reflecting consistent metro usage among working adults.” Graduates (37.8%) and postgraduates (23.0%) formed the largest educational groups, suggesting an informed commuter base. Spatial representation was broad, with 46.3% respondents from Delhi, followed by Gurugram (19.7%) and Noida (13.3%). Travel behavior shows strong network reliance, as 44.4% used double-line connectivity and 27.8% triple-line routes. Most respondents (56.3%) accessed metro stations via public transport, highlighting the importance of integrated urban mobility systems in supporting financial and operational sustainability.

The results clearly demonstrate that diversified revenue strategies significantly contribute to Delhi Metro’s financial sustainability, “leading to acceptance of the main hypothesis (H1). The regression model indicates a moderate relationship ($R = 0.457$), with 20.9% of variation in financial sustainability explained by selected determinants and a statistically significant overall model ($p = 0.000$).” Property Development emerged as the most influential factor ($\beta = 0.178$, $\text{Sig.} = 0.000$), followed by Fare Revenue Alone Is Insufficient ($\beta = 0.153$, $\text{Sig.} = 0.002$), Advertising Revenue ($\beta = 0.134$, $\text{Sig.} = 0.005$), and Revenue from Retail Outlets ($\beta = 0.107$, $\text{Sig.} = 0.021$). Partnerships with Private Entities and Focus on Non-Fare strategies also showed significant positive effects. In contrast, Financial Transparency and Government Subsidies exhibited limited statistical influence, emphasizing that long-term financial sustainability depends primarily on revenue diversification and efficient financial management practices.

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