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The Price of Proximity: How Bengaluru's Metro Affects Residential Property Values

Shikha Ballal* and Sabyasachi Tripathi**

Abstract

Transit networks significantly influence city evolution, with mass rapid transit systems enhancing access to jobs, housing, and infrastructure. Indian Government is promoting metro rail projects to strengthen public transport, and many cities are developing their metro rail corridors, making understanding their impact crucial in the Indian context. This study investigates the impact of the mass rapid transit system (Namma Metro) on residential property values in Bengaluru, India. It investigates the impact of recently operational and existing metro lines on property values in different neighborhoods across Bengaluru. The research uses a mixed-methods approach, combining quantitative data analysis with hedonic price regression based on household surveys. The regression results show that proximity to metro stations and higher income levels lead to significant housing value increases. The dense areas and longer metro operation years contribute to higher property values, while the distance from the city centre and higher metro connection costs negatively impact property values. The findings have significant implications for urban planning and policy decisions. It helps understand how building metro stations leads to real estate development and value creation in the vicinity of the metro corridor and how transit-oriented development policies around metro stations can support land value capture.

Keywords: Metro rail, transport systems, distance, housing value, Bengaluru, India

JEL Classifications: L90, R21, R32

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1. Introduction

Indian cities have seen substantial transitions over the last three decades, owing to increased population, fast infrastructural development, and a diverse social fabric. The Mass Rapid Transit System (MRTS) in cities allows customers, family members, and employees to easily move from their homes to their workplaces and other sites. It offers the quickest, safest, and most reliable mode of transportation. The benefits of transit systems to society include less traffic, increased societal equity, lower pollutants, and economic growth (Boarnet et al., 2013, Mohammad et al., 2013). The construction of an MRTS project is often anticipated to increase property prices in any given city. It has long been documented that the provision of community infrastructure has a profound influence on the blueprint and pattern of metropolitan development and the spatial division of urban housing values (Wey et al, 2009). High population migration into these areas stimulates the growth of retail operations. Metro accessibility influences house prices by raising demand and boosting property value. Investments near metro stations capitalize on the value of transportation infrastructure, which may have a positive externality. This enhances locational conditions, lowers transportation costs, and raises house values (Zhang and Jiang, 2020).

The greatest demand for sustainable urban and transportation planning is found in middle- and low-income countries, which are the world's fastest urbanising regions (Kurle et al, 2022). Land values are affected by the distance to the metro lines, and the impact is higher on commercial prices than residential prices (Debrezion et al, 2007). Finally, the impact on prices has been greater after the metro operation rather than in the planning and demand and hence would impact property prices (Tan et al, 2019). Metro connectivity improves an area's appeal to residential and commercial developers and investors by improving accessibility and desirability (Suzuki et al, 2013). Property values usually grow in response to this increasing demand, giving existing property owners significant capital appreciation and drawing in real estate expansion projects (Agostini et al, 2008). Better metro connectivity reduces travel times and expenses for commuters outside the local influence zones, promoting balanced urban growth and reducing the strain on excessively crowded city centres due to real estate development and investment in newly connected areas.¹ The metro has a greater impact on residential prices in the peripheries than in areas with high residential densities (Swamy, 2009).

¹ https://www.hindustantimes.com/real-estate/heres-how-metro-projects-in-multiple-cities-will-impact-real-estate-markets-101709735854902.html (accessed on 5 April, 2024)[.]

On the other hand, the demand for luxury real estate in India is driven by the rising affluence and lifestyles of the urban population. Metro cities like Mumbai, Delhi, Bengaluru, Chennai, Kolkata, Hyderabad, and Pune are becoming hotspots for luxury housing, attracting high-net-worth individuals and expatriates.²

There are very few studies on property prices in Indian cities. Tiwari et al. (1999) used the hedonic price method to determine the impact of various household characteristics and distance to the central business districts (CBD) on house rents in the Mumbai Metropolitan Region. This was one of the first studies on modelling property prices in the Mumbai region, and it estimates the price and income elasticities for housing demand. Nallathiga (2006) estimated the impact of floor space index (FSI) regulations on land prices in Mumbai. The study found that FSI regulations impact the denser areas in and around the CBD and the suburbs. India's infrastructure development and real estate sector are intertwined, creating a mutually beneficial relationship. Recognizing and leveraging this symbiotic relationship is crucial for sustainable and inclusive cities, ensuring economic growth benefits are shared across all societal segments.³ In Pune, the level of influence is greatest when the distance is between 200m and 350m and remains notable when the distance is less than 500m, leaving the station as the principal access point. The effect is negligible for houses located more than 500 metres from the metro station (Wagh et al., 2021). Similarly, Urban rail has a strong positive effect on property values in Bengaluru. Land prices of residences in the city rose by an average of 4.5% following the building of metro stations. The impact is greatest in the immediate area of metro stations when land prices rise by up to 25% (Sharma et al., 2022).

This research aims to fill these gaps by measuring the impact of metro availability on property values. Firstly, it compares the impact of both recently operational and existing metro lines, focusing on the effect of newer lines and the established impact of existing lines. Secondly, it seeks to define the value capture zone, the area experiencing the most significant property value uplift due to the metro, by comparing property prices within and beyond 1 kilometre of the metro corridor. This specific focus is driven by the concept of a transit station/corridor influence zone (500-800m), as outlined in the National Transit Oriented Development Policy 2017 by the Government of India. It aims to assess the factors influencing the impact of the

 ² The rising tide of luxury housing in India's metro cities. *Construction Week Online*. Accessed on February 29, 2024. <u>https://www.constructionweekonline.in/people/the-rising-tide-of-luxury-housing-in-indias-metro-cities</u>
 ³ How real estate is redefining inclusive urban development. *Construction Week Online*.

https://www.constructionweekonline.in/people/how-real-estate-is-redefining-inclusive-urban-development. Accessed on January 3, 2024.

mass rapid transit system on property values, examine the spatial impact of metro stations, and investigate the influence of the metro line's operational time. By addressing these objectives, the research contributes a novel perspective on the relationship between metro systems and property values, informing urban planning efforts and maximizing the positive economic impact of metro infrastructure development. It aids in understanding how metro station construction leads to real estate development and value creation along the metro corridor, as well as how TOD policies near metro stations might assist Land Value Capture.

This article adopts the following structure. The following section reviews the related literature to find out the research gap. Section 3 explains the data and methodology used for the study. Section 4 presents the empirical results. Section 5 highlights discussions and recommendations based on estimated results. Finally, section 6 concludes it.

2. Literature Review

2.1 Theoretical Review

Transit-oriented development (TOD) is a theory that suggests that property values in adjacent areas can increase due to the installation of high-capacity public transport systems, such as metro lines. These systems provide easy access to jobs, education, and conveniences, making nearby areas more attractive to potential residents and businesses. The influence zone of a transit station is within walking distance of the station, with a radius of 500-800m. TOD positively and significantly impacts residential property values (Jiang and Gu, 2020). Globally, it has been acknowledged that TOD planning policies and value capture mechanisms are efficient means of advancing the sustainability of urban rail transit (Zhao and Larson, 2011). Housing prices in a good pedestrian environment and near a station are significantly higher than a condo in a similar neighbourhood not near a station (Duncan, 2010).

The Location theory, developed by Von Thunen in 1826, focused on spatially dividing production processes to save transportation costs. Longer distances from the city centre have greater transportation expenses, making them less appealing for growth. Conversely, areas with lower transportation costs, like those closer to the city centre or with good public transportation access, become more attractive for development. Landowners can command higher rents due to superior accessibility, incentivizing denser development like apartments and high-rise buildings to maximize land potential and cater to the demand for centrally located housing or commercial spaces (Maranzana, 1963).

William Alonso's bid-rent theory explains how real estate prices and demand change with distance from a city's central business district (CBD). Different land users, including

residential, commercial, and industrial, compete for desirable locations within a city, offering benefits such as accessibility, agglomeration economies, and shared infrastructure (Alonso, 1964). The distance decay effect in urban economics suggests that factors like accessibility, amenities, and property values weaken with distance from a central point, such as the CBD. This leads to longer commuting times and higher transportation costs, weakening the strength of agglomeration economies and land prices. Distance decay of effective density may also reflect transport supply and land use in surrounding areas (Hansen, 1959).

2.2 Empirical Review

Empirical studies explored the impact of transportation infrastructure, specifically metro and light rail network (LRT) systems, on residential and commercial property values in global and Indian contexts. The studies use various methodologies, including hedonic price regression, spatial analysis, and panel data hedonic price modelling. Results show that proximity to metro and LRT stations generally positively impacts property values (Cervero, 2013; Zhang, 2008; Camins-Esakov et al, 2018; Ksomsri et al, 2015; Sharma et al, 2022). However, variations exist based on factors like housing market type, development stage, rail technology, and distance.

Globally, research on rail transit development and its impact on urban development, particularly in developing countries, has shown a positive correlation between proximity to transit stations and property values. Rail transit also influences land use patterns, with studies showing a shift towards increased development intensity and a mix of residential, commercial, and industrial uses near stations. Accessibility and appreciation rates also increase with distance (Zhang, 2008). Construction impact can also cause temporary dips in housing prices within 500 meters of planned MRT stations (Chi-Ming et al, 2020). However, challenges include data availability and coordination between transportation and land use.

In the context of India, studies have shown that metro development in India leads to increased property values, particularly near stations (Wagh et al, 2021; Sharma et al, 2022; Malhotra et al. 2020). The strongest positive impact is found within 200-500 meters of metro stations, with the effect diminishing with distance (Wagh et al, 2021). Construction impacts may cause temporary dips in values near stations (Tyagi et al, 2021). These studies provide strong evidence that metro development in India leads to increased property values and can influence land use patterns. Appendix Table A1 presents a detailed explanation of the most relevant empirical studies.

3. Data and Methodology

3.1 Data

Despite its high-tech reputation, Bengaluru, India's tech capital, is plagued by traffic congestion. Despite its innovation, the city's rapid expansion and inadequate infrastructure planning have worsened traffic issues. Bengaluru presents an ideal study area for examining the impact of metro stations on property values due to its rapid metro expansion, diverse neighbourhoods, available data, economic significance, and policy relevance. Traffic is a severe concern for the residents of Bengaluru. In 2023, Bengaluru was adjudged the sixth most congested city in the world regarding traffic on its streets, per the traffic index from TomTom, a Dutch location technology firm.⁴ Metro construction projects have narrowed roads, causing slower traffic and increased congestion. Despite government promises, public transport initiatives continue to face delays, causing long queues for commuters.⁵

Namma Metro continually strives to enhance the quality of life for its citizens, even though managing the worst traffic and connecting the last miles is still a distant dream. A metro rail system may significantly impact traffic, with benefits to the economy, ecology, and public health. In a developing country like India, augmentation of road infrastructure and construction of mass fast rail systems are envisaged as the way to handle this issue (Bishwas et al., 2023). In this context, it becomes essential to understand the impact of the metro in urban development scenarios.

Bengaluru is serviced by the Bengaluru (Namma) Metro. Namma Metro operates in two phases, as shown in Figure 1: Phase 1, operational since 2011, consists of the Purple Line and Green Line, connecting Whitefield to Silk Institute, covering 72.1 km and 61 stations. Phase 2 will extend the Green Line to Madavara and construct new lines- Yellow, Pink and Blue.⁶

⁴ Bengaluru drops to sixth position as the most congested city in the world, *Indian Express*. <u>https://indianexpress.com/article/cities/bangalore/tomtom-traffic-index-2023-bengaluru-drops-to-6th-position-in-global-congestion-rankings-9141862/</u>, Accessed on February 3, 2024.

⁵ What will really help Bengaluru's traffic woes, *The NEWS Minute*, Accessed on Oct 4, 2023. https://www.thenewsminute.com/karnataka/explained-what-will-really-help-bengalurus-traffic-woes ⁶ Updates on Bangalore Metro, *Magicbricks*.

https://www.magicbricks.com/blog/bangalore-metro/127962.html. Accessed on June 24, 2024.





Source: Metro Detailed Report Phase 2A https://english.bmrc.co.in

3.2 Methodology

The structured questionnaire is designed to investigate the impact of metro systems on residential property prices. By collecting data on demographics (age, income, employment), travel habits (frequency of metro use, reasons for using it, connecting modes of transport, time and cost spent on reaching the metro), and property details (location, distance to metro station and major employment centers, property size, and value changes), we can analyze how the introduction or proximity to a metro station affects residents' lives and property values.

Figure 2: Data collections and interpretation steps



Source: Authors' compilation

Our econometric model to investigate the impact of transport system on urbanization on takes the following representation:

 $RPV = \beta_0 + \beta_1 MLP + \beta_2 IL + \beta_3 POP + \beta_4 YOP + \beta_5 DCC + \beta_6 TMA + \varepsilon$ ------ (1) where RPV is the residential property value, MLP is metro line proximity, IL is income level of household, POP is population, YOP is years of operations, DCC is distance from city center, TMA is total money required to avail metro, β_0 to β_6 are regression coefficients, and ε is the error term. Table 1 presents the description of variables used for the regression analysis. The sample size of the study was 88 residents from different wards and neighborhoods of Bengaluru which is split up into 198 wards, each of which is represented by a counselor. The selection of respondents was random which indicates every respondent had equal chance to participate.

Table 1: I	Description	of the	variables	used for	the	regression	analysi	S
								~

Variable	Description	Source	Expected sign (+/-)	Reason for expected sign
Dependent	variable	I	~ 8 (')	
Property values	Residential Property Values (in Rs per sq ft)	Survey		
Independen	t Variables			
Metro line proximity	Distance of the property to the nearest metro line (in meters)	Survey	-ve	The urban economic theory of bid-rent suggests that properties near transit hubs have higher land values due to increased accessibility and reduced transportation costs.
Income level	Income level of the residents in the area (in Rs)	Survey	+ve	Higher income levels are generally associated with greater ability to pay for premium locations with convenient amenities like metro access.
Population	Population of the area	GeoIQ website (https://geoiq.ai/in)	+ve	Agglomeration economies suggest that urban population density increases housing demand, potentially resulting in higher property prices due to limited land supply in urban areas.
Years of operation	Years since the nearest metro station has been in operation (in years)	Namma Metro records	+ve	Metro Station Maturity allows surrounding area to develop, capitalizes on transportation benefits and increases desirability and property values.
Distance of property from city centre	Distance of the property to the city center (in meters)	Survey	-ve	The monocentric city model's theory suggests that property values increase in proximity to the central business district, indicating a decline in value with distance.
Total money required to connect to metro	Cost of residents to connect to Metro line (in Rs)	Survey	-ve	Higher costs associated with connecting to the metro (e.g., bus fare, cab rides) might make the property less attractive to some buyers, potentially leading to lower values.

Source: Authors' compilation

4. Empirical Results

Table 2 shows that the coefficient of variation (CV) of property price (0.338) is relatively low, indicating a moderately symmetrical distribution. Conversely, years of operation (1.165) have a higher CV, suggesting a wider range of values across the observations. The data suggests a diverse range of property values likely influenced by location and accessibility. There is a mix of properties in affluent, densely populated areas with established metro access and in less affluent, sparsely populated areas with newer or no metro access.

		Standard			
Variable	Mean	deviation	Minimum	Maximum	CV
Property Price (in Rs)	9560.77	3256.52	3647	19110	0.338
Metro line proximity (in meter)	1832.386	1647.325	250	6000	0.893
Income level (in Rs)	765909.1	817825.7	75000	3500000	1.061
Population of area (Headcount)	103838.6	80496.56	2510	361799	0.77
Years of operation of metro line (in					
years)	5.77	4.004	0	12	1.165
Distances of property from city					
centre (in meter)	10.42	6.17	3.7	33	0.589
Total money required to connect to					
metro (in Rs)	37.29	43.7	0	200	0.689

Note: The analysis is based on 88 observations

Source: Authors' estimations based on primary survey

Table 3 shows the results of estimated hedonic price regression models. We estimate parsimonious regression models as they fit the data well while utilising a small number of independent variables. Parsimonious regressions are used to obtain accurate results with minimal variables, allowing for easier interpretation and less overfitting, thereby identifying relevant factors influencing property values without unnecessary complexity or potential biases. The hedonic price model successfully identified statistically significant relationships between all independent variables and the dependent variable of residential property value. Specifically, in regression Model 1, for every meter increase in distance from the nearest metro station, property value decreases by 0.822 Rupees per sqft. On the other hand, for every hundred-rupee increase in income level, property value increases between 0.07 and 0.09 Rupees per sqft. Similarly, the dependence is calculated for all other variables. The population size of the ward and the years of operation of the metro line have positive and statistically significant effects on the dependent variable. However, the distance of property from the city centre and the money required to avail of the metro has a negative effect on the value of residential property. All independent variables match with the expected sign.

VARIABLES	Dependent variable Residential property value					
	Model 1	Model 2	Model 3			
Population	0.00954***		0.0127***			
	(0.00316)		(0.00324)			
Years of operation of metro line	219.9***					
	(64.99)					
Metro line proximity	-0.822***					
	(0.163)					
Income level	0.000877***	0.00101***	0.000902***			
	(0.000282)	(0.000317)	(0.000301)			
Distance of property from city centre		-97.48**				
		(45.02)				
Total money required to avail to		-40.60***	-37.82***			
metro						
		(6.318)	(5.894)			
Constant	8,136***	11,319***	8,959***			
	(718.5)	(584.4)	(539.1)			
Observations	88	88	88			
R-squared	0.593	0.478	0.534			
Star	ndard errors in pa	arentheses				

Table 3: Determinants of residential property values: Hedonic price regression model

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

To have more robust results, we consider a dummy of two important variables: existing and recently operational lines and properties within and beyond 1km from the metro station.

Comparing Existing and Recently Operational lines:

Variables: Years of operation (Dummy): Captures the age of the nearest metro station. A value of 0 indicates a station less than 3 years old considered "Existing" A value of 1 indicates a station older than 3 years considered "Recently operational"

Comparing properties within and beyond 1km:

Variables: Metro line proximity (Dummy): Captures the distance of the property from the nearest metro station.

A value of 1 indicates the property is within 1 kilometer of the metro line.

A value of 0 indicates the property is beyond 1 kilometer of the metro line.

According to Table 4, the Years of Operation dummy explains that properties near metro stations older than three years have a ₹1,217 higher predicted value than those near stations less than three years old, all else equal. A suggestive increase in property value is associated with older metro stations (over three years). This is due to factors like better-established

infrastructure or surrounding development in these areas, which can be explained as the "infrastructure maturity effect." Similarly, the Metro line proximity dummy explains that properties located within 1 kilometre of the metro line have a predicted value ₹2,653 higher than those further than 1 kilometre, all else equal. Typically, a radius of nearly 500-800m from the transit station (10 - 12 minutes walking distance) is considered the influence zone of the metro station area. The results show that this zone has a significant and strong positive effect on property values. Properties closer to metro lines (within 1 km) have significantly higher predicted values due to increased connectivity and access to amenities.

`	Dependent variable					
VARIABLES	Residential property value					
	Model 4	Model 5				
Population	0.00947***	0.0104***				
	(0.00337)	(0.00307)				
Years of operation dummy (1= if a station older	1,218**					
than three years; $0 = if a$ metro station less	(593.0)					
than three years old)						
Your income level	0.000962***	0.000674**				
	(0.000298)	(0.000281)				
Metro line proximity	-0.894***					
	(0.171)					
Years of operation		250.4***				
		(61.93)				
Metro line proximity dummy (1= property is		2,653***				
within one kilometer of the metro line; $0 = if$		(499.6)				
property is beyond one kilometer of the metro						
line)						
Constant	8,691***	5,166***				
	(745.9)	(478.3)				
Observations	88	88				
R-squared	0.560	0.603				
Standard errors in parentheses						

 Table 4: Determinants of residential property values with years of operation and metro line proximity dummies

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

5. Discussion and recommendations

5.1 Discussion

This study evaluates how mass rapid transit systems affect real estate prices. We consider how metro stations affect the built environment and explore the effects of metro line operating years. It also compares the impact of new and existing metro lines and defines the value capture zone, comparing property prices within and beyond 1 kilometer of the metro corridor. It informs

urban planning efforts and maximizes the positive economic impact of metro infrastructure development. It uses a mixed-methods approach, combining quantitative data analysis using hedonic price regression based on household surveys.

The study reveals several factors that influence residential property values, including the accessibility effect, income effect, urban amenities effect, infrastructure maturity effect, distance decay effect, and metro connectivity cost. The accessibility effect confirms that properties near metro stations have higher property values due to greater spatial access to various parts of the city. The years of operation dummy suggests that properties near metro stations older than three years have a higher predicted value of ₹1,217, attributed to factors like better-established infrastructure or surrounding development, resulting in an "infrastructure maturity effect." Higher-income residents are willing to pay a premium for desirable locations with amenities like metro access, contributing to the income effect. Urban amenities in denser areas, such as shops, restaurants, schools, and entertainment options, also increase property values, reflecting the urban amenities effect. The infrastructure maturity effect suggests that areas around metro stations may see more development and establishment of amenities over time, driving up property values. The distance decay effect indicates that properties further from the city center have lower property values due to reduced access to amenities and opportunities. Finally, properties requiring a higher cost to connect to the metro tend to have lower property values, highlighting the importance of metro connectivity for property values. For example, Delhi-NCR has seen significant growth in recent years, especially in the expansion of the metro network. This has improved connectivity, eased traffic congestion, and positively impacted the commercial real estate sector. Since the commissioning of the Blue Line in 2005, around 1413 commercial properties have been sold, leading to a 6% year-on-year increase in property prices between April and June 2023.⁷ The metro connection in Old Gurgaon may lead to redevelopment activity, offering new commercial property options and potentially increasing prices by 15-20% in these areas.⁸

5.2 Recommendations

The Bangalore metro serves as a prime example of how metro systems can stimulate economic growth in expanding cities. By creating vibrant communities, integrating residential areas with shops, restaurants, and entertainment options near stations, and connecting the city through

⁷ https://www.financialexpress.com/money/impact-of-metro-expansion-on-commercial-property-prices-in-delhi-ncr-3405468/

⁸ https://www.india.com/business/gurugram-metro-real-estate-sectors-anticipated-to-experience-maximum-price-impact-property-house-price-business-news-6731398/

feeder bus routes, the metro can create walkable, mixed-use communities that attract residents, boost property values, and reduce reliance on private vehicles. Mobility expert Srinivas Alavilli suggests public transport and walkability are two factors that need to be amped up in the city; one can only exist with the other. One needs to ensure that clean and safe footpaths are also installed so that people are not forced to take vehicles after getting down from a metro station. Enhancing last-mile connectivity by introducing metro feeder buses to and from areas lacking nearby metro stations is also crucial.⁹ Investing in feeder bus routes ensures accessibility for all residents, promoting a more equitable distribution of the metro's economic benefits and property value gains.

The city with the highest metro distance per 1,000 population is the London Underground at 41.2 km, followed by the Beijing Subway at 30.6 km. Shanghai Metro has 27.8 km per 1,000 population, while Moscow Metro has 35.9 km. Delhi Metro and Bengaluru Metro have relatively lower metro distances per 1,000 population at 10.4 km and 5.1 km, respectively. Bengaluru and Delhi have a lower metro length per capita compared to cities like Beijing, Shanghai, Moscow and London, indicating a less extensive metro system. This leads to traffic congestion and longer commute times. In contrast, cities like Beijing and London have a higher metro length per capita, indicating a well-developed network that can serve a larger population, reducing traffic congestion and improving commute efficiency. The Bengaluru Metro's low metro distance per 1,000 population of 5.1 km is insufficient to meet the city's transportation needs. This is due to inadequate coverage, with only 72.1 km of metro lines, leading to heavy reliance on other modes of transportation. To improve connectivity and serve a larger population, the metro needs to expand its network, with Phase 2 under construction and Phase 3 being crucial. To maximize the effectiveness of the metro system, it should be integrated with other modes of transportation, such as buses, taxis, and shared mobility options.

A long-term vision for the metro is to promote TOD principles, which encourage sustainable urban growth and reduce car dependence. Estimated savings by the Bengaluru metro in CO, HC, NO_x emissions are 5.19, 0.54, and 0.66 tons per day, respectively (Gavimath et al., 2021). Densification near metro lines maximizes land use while minimizing the distance decay effect on property values in surrounding areas. By leveraging the metro's power to drive development, cities can unlock significant economic growth, improve air quality, reduce traffic congestion, and create a more livable urban environment. The Bangalore metro serves as a blueprint for

⁹What will really help Bengaluru's traffic woes, *The NEWS Minute*, Accessed on Oct 4, 2023. https://www.thenewsminute.com/karnataka/explained-what-will-really-help-bengalurus-traffic-woes

the future, and by embracing a strategic development plan, cities can harness the power of public transportation to build a more sustainable and prosperous future.

6. Conclusion

The research reveals that Mass Rapid Transit Systems (MRTS) significantly impact residential property values. It reveals that properties near metro stations experience significant increases in value due to improved spatial access, reduced commute times, and increased connectivity to employment opportunities and amenities. Higher-income levels among residents also contribute to property value increases, as they are willing to pay a premium for locations with amenities like metro access. The presence of dense urban areas and the maturity of metro lines further enhance property values, creating a more desirable living environment.

However, the study also identifies potential negative impacts on property values, such as distance decay and higher metro connection costs. Properties further from the city center tend to have lower values, reflecting the concentration of amenities and opportunities in central areas. Moreover, properties requiring a higher cost to connect to the metro may experience decreased values, highlighting the importance of affordability in determining property value. The findings highlight the importance of TOD policies in supporting land value capture and enhancing urban livability. By understanding the dynamics of property value changes in response to metro development, policymakers can make informed decisions to promote equitable development and sustainable urban growth.

The study on residential property value has limitations as the exact value may differ when it is actually sold. It faces challenges in longitudinal analysis due to the unavailability of data and lack of scientific valuation methodologies. Despite these limitations, the study provides valuable insights into urban planning and real estate investment decisions. Future research can address these limitations. Longitudinal studies can track property values over time, providing a more dynamic understanding of the metro's impact. Comparative analysis across cities or regions with varying metro implementations can reveal best practices and inform policy decisions in different contexts. These future efforts further strengthen our understanding of the worldwide relationship between metro infrastructure and residential property values.

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Author Name	Objective(s)	Variables	Methodology	Source of Data	Findings
Global context					
Cervero (2013)	To highlight the challenges of coordinating transportation and land use in developing countries, provide examples of how improved transportation and land-use integration can benefit developing cities.	Sale Price, Size, Units,Bath, Bed,Age,Housing density, Income,Racial profile,% Senior citizens,% Vacant land, Half mile LRT, Highway/ freeway	Hedonic Price regression	Residential data for year 2000, there were 1,495 parcel records for multi-family housing, 9,672 for condominiums, and 14,756 for single-family homes.	Multi-family: Prices for residential properties near 800 metres of an East Line Trolley stop have risen by 17.6%. Condominiums: Prices went up 6.4% near East Line Trolley stations and 46% near Coaster stations. Single-family: A 17% rise in price for homes within 800 metres of a non-downtown Coaster station.
Zhang (2008)	Analyze evidence that rail transit influences land use/development in Shanghai, China. Determine the effects of rail transportation on land use mix, land development intensity, and property values.	Land use composition: Percentage of land used for residential, commercial, industrial, and other purposes. Land development intensity: Floor area ratio Property values: Sales prices of residential units.	Spatial analysis to identify patterns in land use change around rail transit stations. Hedonic price modeling to estimate the influence of rail transit on residential property values.	The Shanghai Municipal Bureau of Statistics. The Shanghai Municipal Land Administration Bureau. The Shanghai Real Estate Trading Center.	Shanghai's rail transit has shown encouraging results in urban development and land use changes. The transit proximity premium is around 152 yuan/m2 for every 100 meters nearer to the metro station. Other cities in China are also anticipating rail transit's strategic role in urban mobility.
Camins-Esakov & Vandegrift (2018)	Analyze influence of light rail expansion on property values	Real estate property values, Distance from light rail station	Longitudinal (before-after) analysis with hedonic price model	Household Survey for residential property values and property characteristics	Properties closer to new stations experience higher annual price appreciation (0.21-0.25% per minute closer) Appreciation diminishes with distance, disappearing around 12 minutes (0.6 miles) from the station.
Chi-Ming & Hui- Chuan (2020)	Analyze impact of MRT construction and operation on housing prices	Housing prices MRT construction start time, Distance to MRT station	Difference-in- Difference (DD) method with spatial lag and error models	A 500-meter distance from an MRT was considered as research range using GIS	Housing prices within the 500-meter influence range fell by 7.9% following the start of metro construction and had no essential effect on housing prices within the 500-meter influence range after the start of operation.

Appendix Table A1: Impact of metro system on property values

Martinez & Viegas	To assess the impact of	Bedrooms, typology, floor	Cross section	Cross-sectional data on	The metro rail accessibility characteristics
(2009)	metro rail access on residential property values in Lisbon, Portugal. To compare local vs. systemwide accessibility models	area, age of house, Educational Index The Entropy Index Metro Rail, Road Rail	Hedonic Price Modelling	housing for sale in February 2007, with a total of 8,742 full records inside Lisbon's municipality and the remainder in Amadora and Odivelas.	coefficients in the two models range from 3.49% to 5.18% for accessibility to two metro rail lines and from 4.62% to 6.17% for accessibility to a single metro rail line, indicating that metro rail proximity has a significant effect on property values.
Andrade & Maia 2009)	To research the link between modes of transportation and land use in the Recife area of Brazil as well as the impact of metropolitan railway lines on urban growth	The separation between main area, closest metro stops and closest significant transit centre. Neighborhood infrastructure, the primary land use, HDI, household income, population density.	The Hedonistic Pricing Technique was used to determine how the price of any urban land responds to the recent metro influx to the city.	Field survey, collecting data on property sales within a 500-meter radius on both sides of the metro line.	The model shows a concentration of the increase in value around metro stations, although this increase is not greater than in other regions of the city. The rise in the value is likely the use of metro among the residents of the informal settlements that almost half the population and found rise of 28% users in 2004 to 2.7% users in 1984.
Xu et al. (2016)	Is there a need to control for the spatial dependence effect to obtain unbiased estimates? Does the property value impact of rail transit differ by housing market type, development stage, rail technology and near- station land use characteristics?	Floor mixed with office, distance to urban centre, distance to transport hub, distance to main road, district with primary school in 800m with hospital in 800m,with open space in 800m	Estimate spatial regression models and compare the results with those from OLS models. estimate the models for multi- family and single- family markets separately and add several relevant interaction terms into the models.	Los Angeles County Metropolitan Transportation Authority, Property Sale Transaction Data: "single-family and multi- family property sale transactions in Los Angeles during 2003- 2004	The study examines the impact of Wuhan MRT#2 on commercial property values through spatial regression analysis, focusing on the 400m radius of road network distance from Metro stations, which is significantly smaller than the 700-1000m impact scope in residential areas.

Ksomsri and Tontisiri (2015)	Capture the impact of Mass Transit System in Bangkok, Thailand	Land value, Population density, Arterial road, distance to CBD, Airports, Hospitals, Parks, Schools and University	Hedonic Price Modeling	Cross-sectional data from 622 residential properties in the Bangkok Metropolitan Region for the year 2010.	USD 9210 rise in land value per 1 km proximity to the mass transit station
Indian Context					
Wagh and Sonar (2021)	Examine impact of Metro & station proximity on real estate values & land use	-Metro station proximity	ArcGIS Analysis	Real estate transaction data - Literature review for NDVI, NDBI, and BU indices	The level of influence is greatest when the distance is between 200m and 350m, and remains notable when the distance is less than 500m, leaving the station as the principal access point. The effect is negligible for houses located more than 500 metres from the metro station.
Tyagi and Singhal (2021)	Examine impact of Delhi MRTS stations on commercial property values	Metro station proximity	Hedonic Price Analysis (HPA) models	Commercial property sale data (pre & post- commissioning)	Negative impact near stations during construction. The coefficients show that the metro rail has induced increase in price premium by 732.7978 ₹ to 246.1906₹ (station-wise) in the vicinity and the impact extends to almost 500 meters away from MRTS stations.
Sharma and Newman (2022)	To examine the impact of urban rail on land value uplift in city of	Land value changes, metro line proximity, socio- economic factors,	Panel data hedonic price modeling and cross-sectional data	Real estate transaction data, metro line data, socio-economic data	Urban rail has a strong positive effect on property values in Bangalore. Land prices of residences in the city rise by an average of
	Bangalore, India.	accessibility factors, metro rail specific variables.	hedonic price modeling	from surveys	4.5% following the building of metro stations. The impact is greatest in the immediate area of metro stations, when land prices rise by up to 25%.

Malhotra et al. (2020)	1. Study property price	Dependent: Cost of	Control & Impact	Real estate transaction	1. Property prices are affected by a
	trends along metro	Residential Property (per	Area Approach	data (sale prices) for	combination of attributes including distance
	stretches. 2. Identify	sq. ft. or total price)	(define impact area	residential properties.	from metro, new developments, area size,
	key attributes impacting		radius, select	Data on metro stations,	presence of interchange station, last mile
	property cost 3.		control areas,	distances, and new	connectivity, accessibility improvements,
	Establish a relationship		compare prices).	developments. Public	crime rates, nuisance, traffic, parking
	between cost and		Hedonic	data on crime rates,	facilities, and income group of the area. 2.
	selected attributes.		Regression	traffic patterns, and	Price impact is higher in low-income areas
			Analysis (develop	parking facilities.	due to their higher reliance on metro for
			statistical models	Socioeconomic data to	commuting. 3. Property prices generally
			to estimate impact	classify income groups	decrease with increasing distance from the
			of each attribute on	of residential areas.	metro station. 4. Hedonic regression models
			property cost).		can predict property cost based on these
					combined influencing factors.