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Impact of Transit System on Housing Property Value in Order to Assess Transit-induced Gentrification

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Abstract

Today, the rapid transport system (RTS) stands as an indispensable solution to meet the travel demands of urban agglomerations worldwide. Ongoing research in this field underscores its significance. The implementation of RTS not only alleviates city traffic congestion but also contributes to achieving sustainability goals. Furthermore, assessing economic benefits with precision emerges as a crucial parameter for examination and analysis. In this context, a study was conducted to examine the impact of RTS in Hyderabad city, where the Hyderabad Metro Rail (HMR) operates on three lines, witnessing a steady rise in ridership. Focusing on two stations, Kukatpally and Ameerpet, the study utilized a hedonic model to gauge the impact on residential property values. Factors considered included proximity to metro stations, building area, train frequency, and distance to nearby amenities like schools, parks, and hospitals. The findings revealed a positive impact at Kukatpally metro station, indicating a decrease in property value with increasing distance from the station. Conversely, Ameerpet metro station exhibited a negative impact attributed to factors such as market potential, ridership, and inadequate land use management. The analysis may be useful in understanding of transit-induced gentrification as well. In addition to this, land use analysis was conducted to evaluate the mix of land uses before and after metro construction, employing the entropy index. The analysis demonstrated an improvement in mixed land use, with the entropy index shifting from 0.77 to 0.65.

Keywords: Hedonic price model, land use mix, transit-oriented development

INTRODUCTION

Transport infrastructure, including highways and public transit services like bus rapid transit systems (BRTS), light rail transit systems (LRTS), and mass rapid transit systems (MRTS), profoundly influence the land use development of cities. Enhanced neighborhoods accessibility yields broad economic benefits, not only improving commuting times but also fostering trade intensification, agglomeration, and land use enhancement, consequently boosting land and property values. The magnitude of accessibility benefits varies across different transport systems, with road access typically ranking highest. Public transit's contributions are comparatively lesser and contingent upon the specific type of system. Rail-based transport systems, in particular, exhibit considerable variability in their effects on land and property values compared to other modes like road and water transport. While the majority of studies report a positive impact, some suggest negative effects near stations due to factors such as inadequate land-use management, perceptions of crime and privacy, and nuisance effects, with others indicating no significant impact.

Examining the relationship between accessibility to transport systems, particularly metros, and

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property values offers valuable insights for decision-makers involved in transport planning and implementation. Understanding the interplay between transit station locations and property values is crucial for land markets and urban structure, as public transit facilitates access to central business districts, employment centers, and schools, thereby enhancing regional accessibility [1–7].

Transit stations serve as pivotal access points to transit systems, and urban economic theory, rooted in utility maximization, suggests a link between transport system improvements and property values. Higher property values are anticipated in areas within walking distance of a station, under the assumption that places accessible by public transit significantly influence property values.

LITERATURE REVIEW

Impact of Transit on Property Values

Various case studies from around the world have examined the changes in property values near transit stations and a summary of the studies are presented here. Gallo [4] identified that high-frequency metro lines had appreciable effects on real estate values compared to low-frequency lines in Naples. He developed a hedonic model to estimate external benefits, suggesting that an increase in high-frequency metro lines led to increased real estate values. Forouhar and Hasankhani [8] analyzed the effect of Tehran metro rail system on residential property values in high- income and low-income neighborhoods. Found a positive impact on property values in low-income neighborhoods within 250 m of metro stations, suggesting the need for transit-oriented development planning. Ransom [9] explored the impact of light rail transit construction on nearby residential property values around seven metro stations using difference-in-differences analysis. He found price appreciation near stations except at one station. Sun et al. [3] explored the impact of subway construction on surrounding property values, considering variables such as distance to the central business district and nearby amenities. Developed hedonic pricing models to analyze data and found significant positive effects on property values. Mohammad et al. [2] investigated the impact of the Dubai Metro on residential and commercial property values. They found a positive influence on both property types, with a stronger effect observed for commercial properties within 701 to 900 meters from metro stations. Seo et al. [7] analyzed the relationship between house values and proximity to stations and highways, using multiple distance bands and spatial hedonic models. Found significant positive effects for both highways and light rail transit, decreasing with distance from stations. Zhang and Jiang [10] studied the impact of metro station proximity on property value in Nanjing, China, finding a positive partial effect of the metro on property value, particularly within 500 m to 2 km from stations. Yan et al. [11] explored the impact of a new light rail system in Charlotte, North Carolina, on single-family property values. They found a modest impact of distance to metro stations on property values, with values increasing after metro operation due to changes in land use zoning. Wang [12] investigated the impact of Light Rail Transit-Oriented Development on residential property values in Shanghai. He found no statistical influence of metro on residential properties post-construction, with a positive impact on properties located within 0.25 to 0.50 miles from stations. Hess and Almeida [6] examined the impact of proximity to light rail transit stations on residential property values in Buffalo, New York. They found positive effects near stations, with variables like number of bathrooms and home size being influential. Bowes and Ihlanfeldt [5] assessed the impacts of rail transit stations on residential property values in Atlanta, considering factors like commuting cost savings and neighborhood characteristics. Found negative externalities near stations but positive effects at intermediate distances, especially in high-income areas. Al-Mosaind et al. [1] analyzed home sales near light rail transit stations in Portland, Oregon. Positive effects on home values were observed within 500 m of stations, indicating stronger positive impacts of accessibility over nuisance effects [8–23].

Impact of Transit on Land Use

Trinidad [16] studied the impacts of rail transit investments on demographics and land use. Lee and Sener [17] analyzed changes in land use and population characteristics around station areas using GIS (geographic information system) analysis and panel regression. Pan [18] found an increase in the share of workers commuting by public transport and a decrease in median incomes around stations. Lee et al. (2017) [17] investigated the effect of Light Rail Transit on land use in Houston, a city without zoning. They collected parcel-level land use data for three years to evaluate changes before, during, and after the metro line opened. They calculated the entropy index and multidimensional balance index to assess land use changes, revealing increased development along the light rail transit corridor outside the central business district. Sekar and Gangopadhyay [15] studied the impact of the light rail transit system on land use in Chennai. They examined land use maps for different years and identified temporal changes. The authors used population density as an indicator of development and growth, observing concentrated development along the railway line and changes in land use type and form. Higgins et al. (2014) demonstrated that rail transit alone is not the primary driver of land use change. They identified six beneficial factors affecting the ability of rail transit systems to reshape and revitalize cities. They emphasized the importance of locating transit stations along corridors with high levels of existing demand to achieve high levels of initial ridership [14]. Roukouni et al. [13] emphasized the importance of locating transit stations along corridors with high levels of existing demand to achieve high levels of initial ridership the impacts of a metro station on land use and the transport system using the Thessaloniki metro as a case study. Analyzed land use characteristics within a 500 m buffer zone and conducted a stated preference (SP) survey for visitors and residents. The authors used principal component analysis for interpreting data from the survey. The results provided insights into how a metro station affects land use and trip characteristics in its vicinity [13].

STUDY AREA AND FIELD DATA COLLECTION

Study Area

To estimate the impact of transit system on residential property values, two metro stations in Hyderabad were selected namely Ameerpet and Kukatpally. Ameerpet is a well-established knowledge hub, recognized as one of the largest in Asia. The Ameerpet metro station serves as an interchange station, connecting corridor 3 from Raidurg to Nagole, thereby linking the eastern and western parts of the city. Ameerpet is also known for its bustling market area and can be considered as the central business district of Hyderabad. Kukatpally is primarily a residential area located along the old National Highway 9. Over the years, Kukatpally has experienced rapid growth in residential development and has expanded in various directions in terms of land use. In recent years, it has also witnessed the emergence of commercial activities. For the study, a buffer zone of 1000 m from the station is adopted, as this distance is considered an acceptable walking distance in many previous studies. These two metro stations represent different contexts within Hyderabad: Ameerpet, with its significance as a knowledge hub and commercial center, and Kukatpally, characterized by its residential dominance and growing commercial presence. Studying the impact of the metro on property values in these areas can provide valuable insights into the dynamics of urban development and transportation infrastructure in Hyderabad.

Data Collection

For the study, data collection involved a questionnaire survey and obtaining property values from secondary sources. The variables considered include area of building, number of floors, distance to metro station, distance to nearest school/park, and others. Both straight-line and network distances from properties to the metro station and the nearest school/park are measured. It's noted that variables like distance to the central business district and the number of nearby stations are not considered significant for this study. By gathering data on these variables and analyzing their relationships with property values, the study aims to understand the impact of the metro on residential property values in the selected areas of Hyderabad.

MODEL DEVELOPMENT AND RESULTS

To estimate the impact of the metro on residential property values, three hedonic price models are developed, each expressed in semi-log linear form. These models include one combined model for both stations and two separate models for individual stations. For the combined model, the independent variables may include characteristics relevant to both stations, while for the individual station models, station-specific variables may be included. The specific form of each model will depend on the variables deemed relevant for the study and the specific characteristics of the Ameerpet and Kukatpally stations. The models will be estimated using statistical software, and coefficients will be interpreted to assess the impact of the metro on residential property values in Hyderabad.

Hedonic Model for Combined Stations

For the two stations data a combined model is developed as shown in Equation 1:

$$\log(P) = \beta 0 + \beta 1*(\text{No. of floors}) + \beta 2*(\text{Area of building}) + \beta 3*(\text{Distance to metro station}) + \beta 4*(\text{Distance to school}) + \beta 5*(\text{Frequency}) \quad (1)$$

Here, $\beta 0$, $\beta 1$, $\beta 2$, $\beta 3$, $\beta 4$, and $\beta 5$ are the coefficients representing the effect of no. of floors, area of building, distance to metro station, distance to school, and frequency, respectively. Logarithm of property values represents the percentage change in property value for unit change in any of the variable.

The results of both the network distance and straight-line distance are almost similar with small change in magnitude as given in Table 1. All the variables are logically significant except distance to metro station. The property value increases by 4% for every 100 m increase in distance from station.

Hedonic Model for Individual Station: Ameerpet

For an individual station the hedonic model developed is as shown in Equation 2:

$$\log(P) = \beta 0 + \beta 1*(\text{No. of floors}) + \beta 2*(\text{Area of building}) + \beta 3*(\text{Distance to metro station}) + \beta 4*(\text{Distance to school}) \quad (2)$$

The intercept term represents the estimated property value when all independent variables are zero. Coefficients indicate the change in property value for a one-unit change in the corresponding independent variable. Variables with p-values less than 0.05 are considered statistically significant. Figure 1 gives the relationship between distance to metro station and property values. The figure shows a nonlinear relationship between distance to the metro station and property values. Property values decrease within 250 m from the station and then increase with increasing distance. The distance to the metro station is statistically significant within 250 m, indicating a decrease in property values within this range. The interaction term between property values and distance to the school/park is statistically significant, suggesting a decrease in property value by 0.01% for every 1-m increase in distance from the home to the school/park.

Hedonic Model for Individual Station: Kukatpally

The hedonic regression model developed for this station is the same as the model developed for Ameerpet station. The regression results of the model are given in Tables 1-3.

R^2 value of 0.80 explains a strong relationship between the variables. The coefficient of distance from nearest school/ park is positive showing a negative relationship, which is not statistically significant.

With increase in distance from metro station, the property values decrease, showing a positive impact of metro on residential property values as given in Figure 2.

LAND USE ANALYSIS

The land use analysis involves gathering data spanning the years before, during, and after the construction and opening of the metro system. The entropy index is computed for each of these periods to assess changes in land use patterns.

Table 1. Regression results for combined stations.

Parameter	Straight Line Distance		Network Distance	
	Coefficients	*t Stat*	*Coefficients*	*t Stat*
Intercept	5.1546	109.74	5.2065	106.15
No. of floors	0.0320	4.95	0.0339	5.33
Area of building (m^2)	0.0012	21.59	0.0012	21.36
Distance to metro station (m)	0.0004	8.05	0.0002	5.03
Distance to school/park (m)	-0.0002	-4.33	-0.0003	-5.72
Frequency	0.0560	23.35	0.0587	24.82
R^2	0.81		0.81	

Table 2. Regression results for individual station: Ameerpet.

Parameter	Straight Line Distance		Network Distance	
	Coefficients	*t Stat*	*Coefficients*	*t Stat*
Intercept	6.4068	139.67	6.4157	59.56
No. of floors	0.0346	3.59	0.0365	3.74
Area of building (m^2)	0.0010	12.64	0.0010	12.78
STD (0–250 m)	-0.0009	-2.97	0.0005	4.31
STD (250–500 m)	0.0006	6.54		
STD (500–750 m)	0.006	8.63		
STD (750–1000 m)	0.0006	8.99		
Distance to school/park (m)	-0.0001	-2.03	-0.0001	-2.65
R^2	0.74		0.73	

STD: Scheduled time of departure

Table 3. Regression results for individual station: Kukatpally.

Parameter	Straight Line Distance		Network Distance	
	Coefficients	*t Stat*	*Coefficients*	*t Stat*
Intercept	6.2220	175.24	6.2381	166.94
No. of floors	0.0288	4.09	0.0284	4.02
Area of building (m^2)	0.0013	20.80	0.0013	20.59
STD (0–250 m)	0.0001	2.69	-0.0003	-3.58
STD (250–500 m)	-0.0003	-3.69		
STD (500–750 m)	-0.0003	-3.52		
STD (750–1000 m)	-0.0003	-3.52		
Distance to school/park (m)	0.0002	1.97	0.0001	1.98
R^2	0.80		0.79	

STD: Scheduled time of departure

The entropy index quantifies the degree of uniformity in land use distribution within a given area. In this study, land use is classified into 10 distinct categories: residential, commercial, mixed-use, public and semi-public, transportation and communication, manufacturing, settlements, agriculture, recreational areas, and undeveloped land.

The entropy index is calculated using the formula

$$\text{Entropy index} = [\sum P_i * \ln(1 / P_i)]/\ln(k) \quad (3)$$

where P_i is the proportion of land use category of i with i = 1 to k, k is the total number of land use categories. The values of entropy index ranges from 0 to 1 where 1 represents a perfect mix of land uses.

The assessment of land use mix, a pivotal component of transit-oriented development (TOD), is conducted to gauge the influence of the metro system on land use transformations. The entropy index, which measures the evenness of land use distribution, is computed based on land use proportions recorded during the route alignment phase and the commencement of metro construction. Data regarding land use is sourced from the Hyderabad Metropolitan Development Authority (HMDA), highlighting the distribution of land use categories for 2008 and 2012 as shown in Figures 3 and 4. Additionally, the analysis includes the presentation of land use heterogeneity as shown in Figure 5.

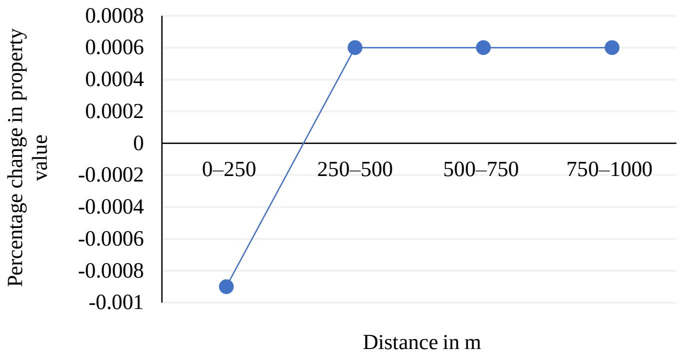

Figure 1. Variation of property values of Ameerpet with distance.

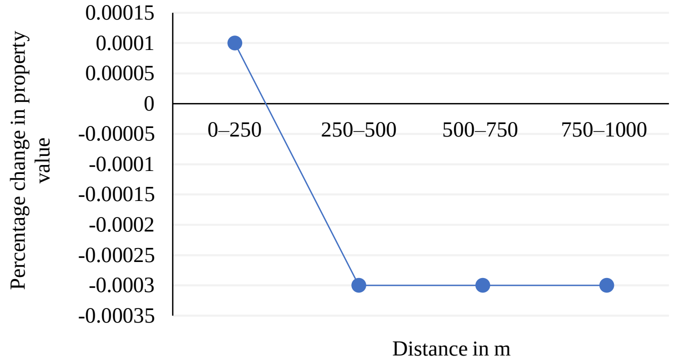

Figure 2. Variation of property values of Kukatpally with distance.

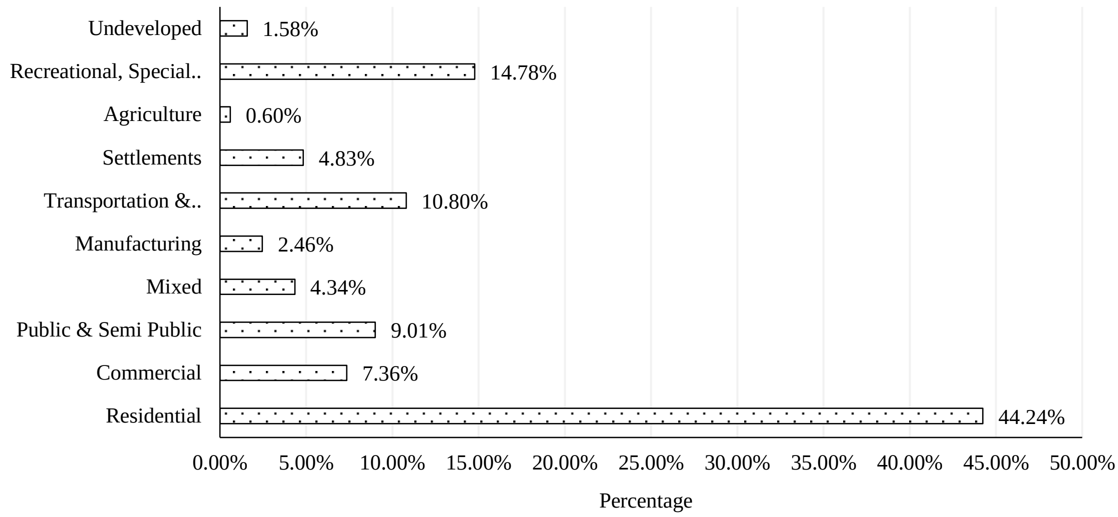

Figure 3. Percentage share of land use in the year 2008.

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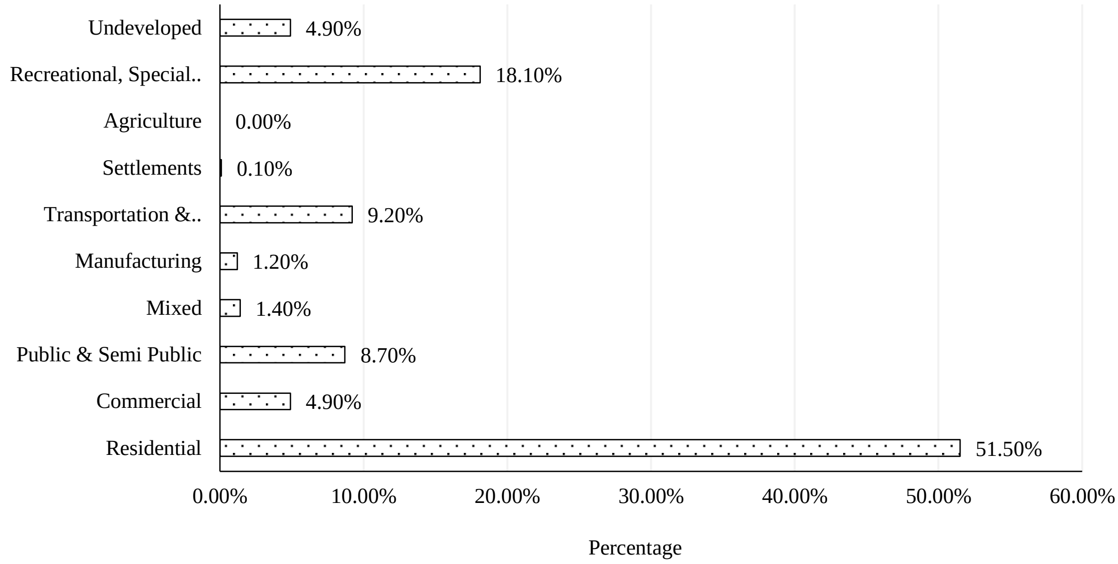

Figure 4. Percentage share of land use in the year 2012.

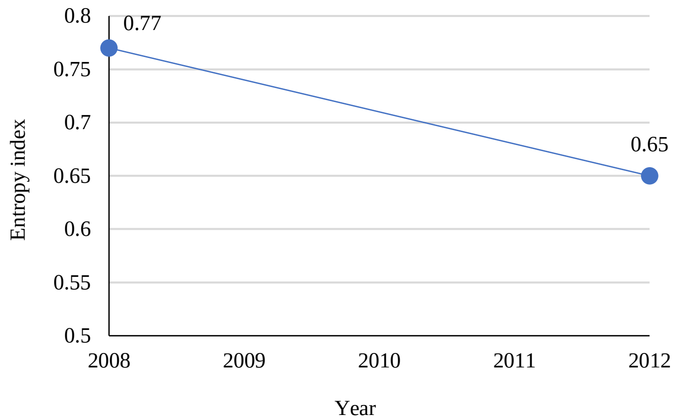

Figure 5. Land use mix indices for 2008 and 2012.

CONCLUSIONS

The introduction of urban rapid transit systems exerts a significant impact on various aspects of urban life, with one of the most notable effects being on residential property values surrounding metro stations. Properties situated in close proximity to stations tend to experience increased property values compared to those farther away. This study aimed at assessing the impact of metro station accessibility on residential property values in Hyderabad. Two metro stations, Ameerpet (an interchange station) and Kukatpally (a non-interchange station), were selected for analysis. A buffer zone of 1000 m was established, and properties within this zone were analyzed. Parameters such as building area, number of floors, distance to station, distance to nearest school/park, frequency of trains, distance to central business district, age of building, and number of nearby stations were considered. Age of building, distance to central business district, and number of nearby stations were excluded from the analysis due to lack of logical significance. The impact of the metro was assessed using both straight line distance and network distance measurements. Three models were developed, including one combined model and two models for individual stations. Each model follows a semi-log linear form.

In the combined model, all variables (building area, number of floors, distance to station, distance to nearest school/park, and frequency of trains) were included. The coefficient for distance to metro station was found to be 0.0004. The most influential variables were frequency of trains, number of floors, and building area. For the models developed for individual stations, all variables except frequency of trains were considered, and the data was grouped by distance to the station. The models for Ameerpet and Kukatpally stations achieved R^2 values of 0.74 and 0.80, respectively. Additionally, the study evaluates the effect of the metro on land use changes by estimating the land use mix during route alignment and the beginning of metro construction.

The study yielded several interesting findings regarding the impact of transit rail on residential property values and land use. Following is a breakdown of the key points:

- *Statistically Significant Relationship:* Only one model showed a significant relationship between the distance to metro stations and property values. This suggests that the impact of metro rail on property values might vary depending on the location.
- *Acceptable Walking Distance:* The study suggests that a distance of 250 m from a metro station can be considered an acceptable walking distance. Properties located within this distance may command higher prices, indicating that proximity to metro stations is valued by homebuyers.
- *Positive Impact at Kukatpally Station:* The study found a positive impact on property values near the Kukatpally station, with property values decreasing as distance from the station increases. This suggests that proximity to this station is desirable for homebuyers in that area.
- *No Impact at Ameerpet Station:* In contrast to Kukatpally, the model for Ameerpet station showed that property values increase with distance from the station. This indicates that the metro rail may have minimal impact on property values in the Ameerpet area, possibly because it is already a well-established market.
- *Influencing Variables:* The frequency of trains emerged as the most influential variable, followed by the number of floors in a property. This suggests that accessibility and convenience provided by the metro system are significant factors for property values.
- *Negative Impact of Distance to Schools/Parks:* The distance to the nearest school or park was found to have a negative coefficient, implying that property values decrease with increasing distance from these amenities. This highlights the importance of nearby amenities in determining property values.
- *Slow Land Use Development:* The study found minimal effects on land use development, indicating that changes in land use due to the presence of metro rail may take time to materialize. This suggests that the full impact of the metro on land use may not be immediately apparent.
- *Residential Land Use Development:* The land use mix was found to be uneven, with an increase in residential land use development. This suggests that the presence of the metro rail may be encouraging residential development in the area.

Overall, these findings provide valuable insights into how the metro rail system influences residential property values and land use patterns in the studied area and may further utilize these findings to assess the transit-induced gentrification model.

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