IMPACT OF METRO RAIL TRANSIT SYSTEM ON RESIDENTIAL PROPERTIES

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Abstract: Housing is one of the basic needs of society, the prices of which are affected even through a smallest variation in the surrounding. The variation is dependent on various factors. One of the major factors is the accessibility benefits available nearby the property, which is essential as one needs to commute almost every day for one's own requirements. In the major cities of India, the most versatile option to commute is Metro Rail Transit System. Within the past few decades, Delhi NCR has faced rapid growth in urban development due to the improvement in road and highway systems as well as the introduction of new public transportation i.e. Metro Rail System. It has been almost 20 years till the commencement of Delhi metro but still a little research is available on its impact on real estate. So, the study focuses on identifying the impact of metro rail transit system on the cost of residential properties located around the metro stretch. There are various attributes of properties located around metro stretch, which affects the cost of property either positively or negatively. So, this paper focuses on to identify such attributes, rank them and then use it to create a model which can forecast the property price around a metro stretch using the selected attributes. Hedonic Regression is used to formulate three separate equations for Low Income Group, Middle Income Group and High Income Group properties, to forecast the property price around metro stretch. From the study it was concluded that the price of a property located around a metro stretch depends on various attributes which are listed and ranked in this paper. Secondly, that the metro has high impact in low income group areas and low impact in high income group areas. Further as the distance of property increases from the metro station, the value of property varies.

Index Terms – **Metro Rail Transit, Residential Properties, Hedonic Regression, Trend Analysis, Impact & Control Area**

1. INTRODUCTION

1.1 Metro Rail Transit System in India

India is the second most thickly populated country in the globe with a projected population of around 135 crores, requires a transportation system that can accommodate huge number of people. It demands development of an effective public transportation system which is able to deliver quick and fast travel, favorable environmental conditions, better mobility and active growth of economy. In present era, effective, secure, authentic and comfortable public transportation system is one of the pre-requisites of good living. The solution is Mass Rapid Transit System (MRTS) also called Metro Rail. Metro railways can be defined as modern urban, automated, and electrical and environment friendly transportation means having high passenger carrying capacity and it runs at a very fast speed as it has separate track which is totally independent from other traffic roads or pedestrians (Kumar, 2013). Metro rail is built either in underground tunnels, same grade as roads or on elevated rails above road level and it uses designated lines between stations with electric multiple units on rail tracks. They are typically integrated with other public transportation system like with local busses, rickshaws and autos to provide better mobility and last mile connectivity to the commuters.

India, currently operates 13 metro systems in 21 cities. For example, the Delhi Metro itself is connected to few other nearby cities in the NCR. India has 671.52 kilometers of operational metro lines with 540 stations as of August 2019. A further 550+ km of lines is under construction. Metro rail lines in India is mainly composed of standard gauge. Kolkata Metro was the first rapid transit system in India, which started operations in 1984. The Delhi Metro Rail Corporation has the largest network in the entire country while the newest metro opened is Nagpur Metro.

1.2 Residential Housing in India

Housing, being one of the basic needs of human, accounts to significant percentages of national transactions per year (Ioannides, 2003). The real estate sector has grown to such a sensitive entity; that even smallest variation has substantial effect on the economic development of country. These variations are dependent on the value of housing property and various extrinsic and intrinsic factors affecting it. Land and property are main components of real estate whose value varies due to demand and supply conditions (French, 2004). Hence, for a developing land market, a common concern that normally emerges is the measurement of asset values for investment purposes (Ling, 1996). Real estate markets differentiate themselves from other markets, as the value of properties are heterogeneous and vary from similar transactions.

The real estate sector in India has taken on increasing importance with economic liberalization. In the Indian real estate cycle, the energy period lasted for six years from 1990 to 1996 followed by the bust from 1996 to 1999. Prices began to level off from 1999 onwards. Real estate prices in some markets have recorded growth of about 15% to 20 percent from 2008 to 2012 (Chandrasekar & Sanghvi, 2012). The last decade saw a rise in real estate prices. The increase in revenue due to information technology (IT), IT enabled services (ITeS), loan

inflation, inflation after 2005, has caused real estate prices to increase backed by strong demand. The subsequent increase in business opportunities and population migration has increased the demand for commercial and real estate. This need is mainly motivated by the pulsating environment of real estate, development in the retail, hospitality and entertainment industries etc. A housing index called Residex provided by India's National Housing Board (NHB), shows that of all Indian cities, house prices have risen 9.6 percent in Delhi and Mumbai.

1.3 Impact of Metro on Residential Properties

The relationship between accessibility and land value is in the heart of urban economic theory. Urban economic theory implies that the value of land is essentially influenced by the trade-off between accessibility and transport costs (Alonso, 1964). The price of land in urban economic theory, however, is treated as the price of pure land at a specific location, which is contrary to some recent suggestions that land is a composite good, and its value should be based on location-specific characteristics including neighborhood and local public amenities (Cheshire & Sheppard, 1995). Infrastructure improvement thus plays an important role in the rise of land values. In particular, accessibility improvement in the form of public transportation or road improvement is found to cause the value of land to rise (Medda & Modelewska, 2010).

Transport infrastructure improvements are being made to improve accessibility at the district or city level and to reduce traffic congestion in these areas. New or improved transport infrastructure such as stock train systems change access to jobs, commercial activities and entertainment in the area (Agostini & Palmucci, 2008). Improved accessibility indicates a decrease in travel costs, which would in turn offers the opportunity for higher land or property values. This process is referred to as property value uplift (Li, 2018). The arrival of metros at different locations in Delhi has impacted the area and hence led to an increase in the prices of residential housing areas adjacent to the metro line. According to studies done by Swamy, (2008), for residential and commercial areas, on average, land value within 500 m of a metro line increased by 11.3% and 18.1%, respectively. In addition, land value changes are consistent and higher after the metro operation, compared to the construction and planning phase, and increase by 2-5% annually. It was seen that inflation depends largely on the income received from the people living in the area, and whether or not the area is planning to improve.

A comprehensive study of the impacts of mass transit development on property values in Europe, Asia and North America has provided insight into the differences found in these results. Issues such as urbanization and other neighborhood characteristics, the demographic and economic status of nearby residents, the quality and size of the public transit network, and the overall economic structure of the city are all investments. However, relatively little research has focused on the impacts of mass rail transit investment on housing prices in Indian cities.

The development is evaluated by property owners and residents in the affected areas, and is capitalized in the price of housing. However, the effect of new transportation development, may have both positive and negative effects on the price of housing. Given possibilities of crime or excessive nuisance around metro rail transit stations and riders, a negative effect is also plausible (Billings, 2011). The first study of the impacts of Tyne and Wear metro revealed that there was a rise of residential housing price close to two of the metro lines, but a fall in housing prices for the other two metro lines at the same time (Du & Mulley, 2007).

The quality of metro rails transit systems, also affects the real estate values: the higher the quality and quantity of transit system services in an urban area, the higher the active and passive accessibility of the area, and the higher the average real estate values (Gallo, 2018). Also According to (Gu, 2010), the impact of metro on the cost of low income group residential properties are higher than that of high income group residential properties in terms of the premium they provide.

The impact of investments in public transport facilities is, therefore, not limited to public transport, and their effect on housing markets might be particularly important in cities such as Delhi NCR, which are expanding their transportation systems significantly.

Within the past few decades, Delhi NCR has faced rapid growth in urban development due to the improvement in road and highway systems as well as the introduction of new public transportation. Many new residential developments in Delhi NCR have grown rapidly. Like many developing countries, India lacks effective land value-capturing policies (Ratanawaraha, 2010). As a result, the disparity between the land close to new public transit and the land farther away has not been considered. Nevertheless, there have been few studies of residential land in India, even fewer with spatial effects taken into consideration and little is known about the impact of metro on residential housing values.

1.4 Need of the study

A forecasting valuation model which can estimate the value of real estate property along the Metro corridor can aid Investors in accurately predicting when and where to forecast along the length of the corridor. Economic theories predict that the benefits of the different facilities and public transport services will be capitalized totally or in part into land and housing. Despite these predictions, no consistent relationship between proximity to transport lines and residential property prices has been demonstrated.

Further, existing literature is mainly based on the International context and may not be applicable to Indian cities characterized by high rates of metro usage and high-density development. Indian metropolitan areas are characterized by high dependence on public transit. Passengers in these metropolitan areas may be much more sensitive about the nuanced variations of public transit services than those in International contexts. The metro corridor can be considered as a basis for evaluating the trends since the changes in pricing over a stretch of the corridor can be comparatively analyzed and evaluated over a period of time.

Swamy (2008) investigated the impact of Delhi Metro on Real Estate through Linear Regression. Post this research, there is a substantial development of Metro network in Delhi and little research work has been carried out due to which, it is viable to research further in this area.

1.5 Aim
To determine the impact of Metro Rail Transit System on the cost of Residential properties.

1.6 Objectives
1) To study the pricing trends of the properties along the metro stretches.
2) To identify and select the attributes that impacts the cost of residential properties along the metro stretch.
3) To establish a relationship between the cost of residential properties with the selected attributes.

1.7 Scope of Work
The scope of this work is limited to sale price residential apartments.

1.8 Hypothesis
Based on the understanding gained from Literature review, the following is the hypothesis:
1) As the distance of property is increased from the metro station, the impact of metro will decrease and vice versa.
2) The impact of metro on Low income group residential areas will be more as compared to High Income group residential properties.

2. STUDY AREA

Delhi, or the National Capital Territory (NCT) of India, is the largest metropolitan area in India. Delhi is the fifth most populous city in the world and the largest city in the Indian-wise region. Delhi has an estimated population of 18.6 million (2016).

The NCT and its urban area have been given special status of the National Capital Region, and the NCR includes neighboring cities like Ghaziabad, Greater Noida, Noida and more than 50% districts of Haryana. The NCR has an estimated population of 24 million, surpassing Delhi's 17.8 million population in 2014.

2.1 Delhi Metro

Delhi Metro is the largest and busiest rapid transit system in India connecting the country's capital region with satellite cities.

The metro system is operated by Delhi Metro Rail Corporation (DMRC), a public sector company established by the Government of India and the Government of Delhi in March 1995.
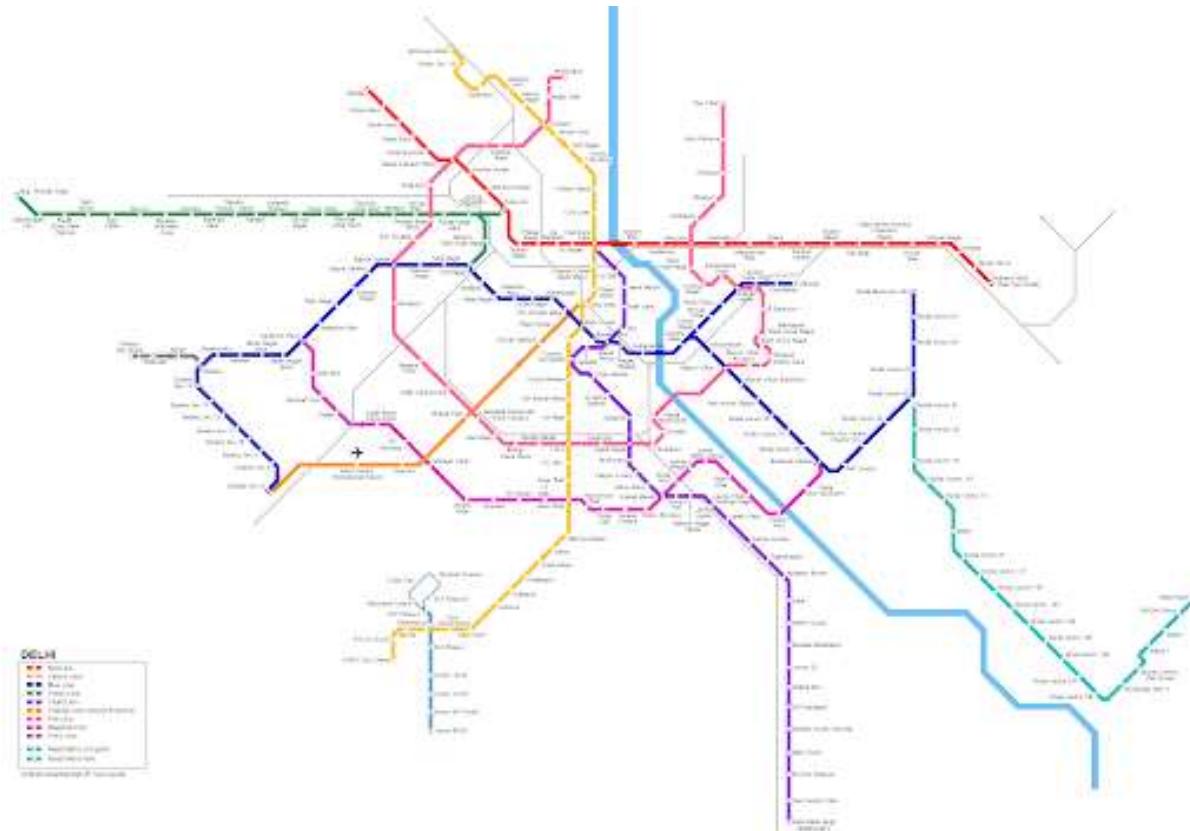

Figure - 1 Delhi Metro Map (Source - Delhi Metro)

3. ISOLATION OF IMPACT OF METRO ON THE COST OF RESIDENTIAL PROPERTIES

3.1 Control & Impact Area Approach

The impact area is defined as the area within a reasonable walking distance from the metro station. An area of this size tends to experience the greatest impact from station site.

A control area is selected for each impact area based on having the same characteristics as the impact neighborhood in the base year except it was not located near an active or proposed metro station.

OR

A control area can also be defined as the area located outside the radius of Impact area.

Impact will be calculated on the Impact area relative to the Control Area. As can be cleared from Fig.2, the properties located within the radius "r", from the metro station, will be treated as Impact Area and the properties located away from the radius "R" will be treated as Control Area.
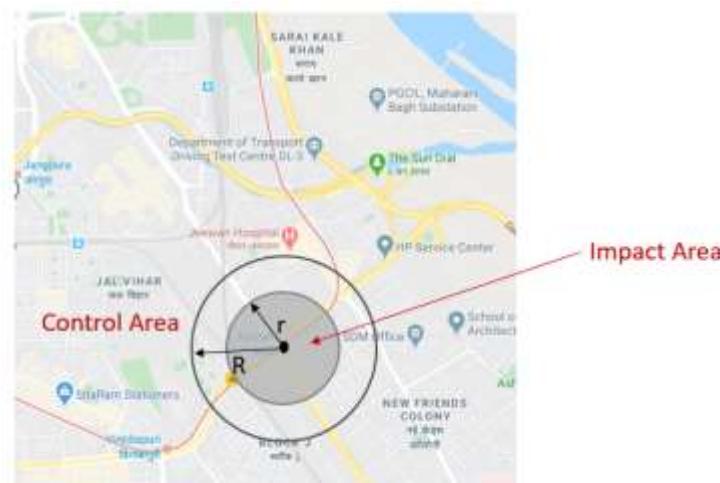

Figure - 2 Control and Impact Area

For this study, the Impact Area is selected as the properties which are located at a radius of 1 km from metro station and properties located away from the radius of 1.5 km are considered to be Control Area.

4. PRICING TRENDS OF LOW INCOME GROUP (LIG) RESIDENTIAL PROPERTIES AROUND METRO STRETCHES

Pricing trends of Nirman Vihar, Delhi a residential area around the selected stretch of metro is depicted in Fig.3. The figure represents the price (in Rs/sq. ft.) of that area of past 10 years from 2010 to 2020. The metro on that stretch became operational on 27 Jan 2010 and after that we can see a rising trend of price from approx. Rs 4000 / sq. ft. in 2010 to Rs 7200 / sq. ft. in the mid of 2011 and further rise to Rs 8100 / sq. ft. in 2012 and it remained stable till 2013. Though there must be a number of factors due to which the price was escalated from 2010 to 2013 but the impact of metro would certainly be one of the major factors.
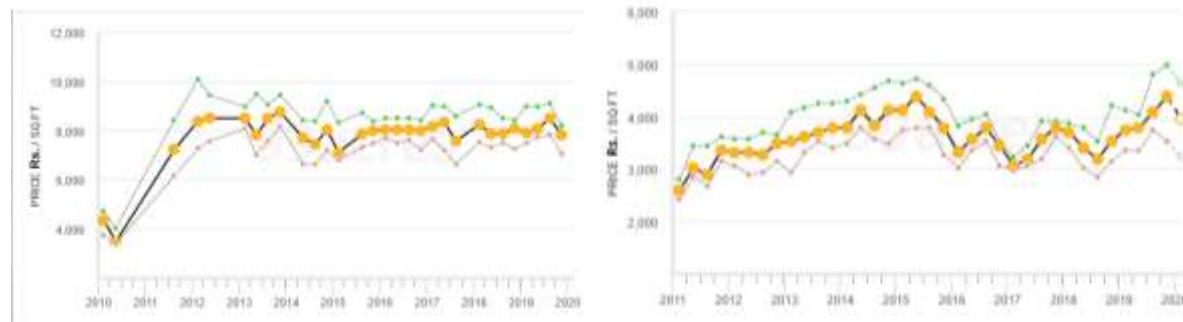

Figure - 3 Pricing Trend of Residential Areas in Nirman Vihar & Bishanpura, Delhi

From the above figure, it is clear that the areas like Nirman Vihar are impact areas in our case and the rest of the area will be considered as Control Area. For instance, a residential area named "Bishanpura" is taken away from 1.5 km radius zone and its pricing trends is shown in Figure 3-13. From the graph it can be seen that price of property is around Rs 2700 / sq. ft. in 2011 and has gradually increased to Rs Rs 3700 / sq. ft.in 2013.

It can be clearly seen that the slope of trend line of Control Area i.e. Bishanpura is less than the slope of trend line of Impact Area i.e. Nirman Vihar. So, if we subtract the slope of trend line of Impact Area with the slope of Control Area, we will get the slope which is majorly showing the impact of metro on the cost of that residential properties. For example, the prices in Nirman Vihar rose from Rs 4000 / sq. ft to Rs 8100 / sq. ft. which shows a percentage increase of 102.5 % whereas in case of Bishanpura the prices rose from Rs 2700 / sq. ft. to Rs 3700 / sq. ft. which shows a percentage increase of 37.03 %. So, by subtracting them, it can be inferred that due to metro the property prices rose about 65 % in 3 years.

5. PRICING TRENDS OF HIGH INCOME GROUP RESIDENTIAL (HIG) PROPERTIES AROUND METRO STRETCHES

As a one more case example, a stretch from Panchsheel park to Nehru Enclave is also taken to study the impact of metro on High Income group residential areas. This stretch became operational in 2018.

As we can see from Fig.4, which depicts Pricing Trend of Residential Areas in Greater Kailash 3 & Panchsheel Park, New Delhi. The metro stretch became operational in 2018
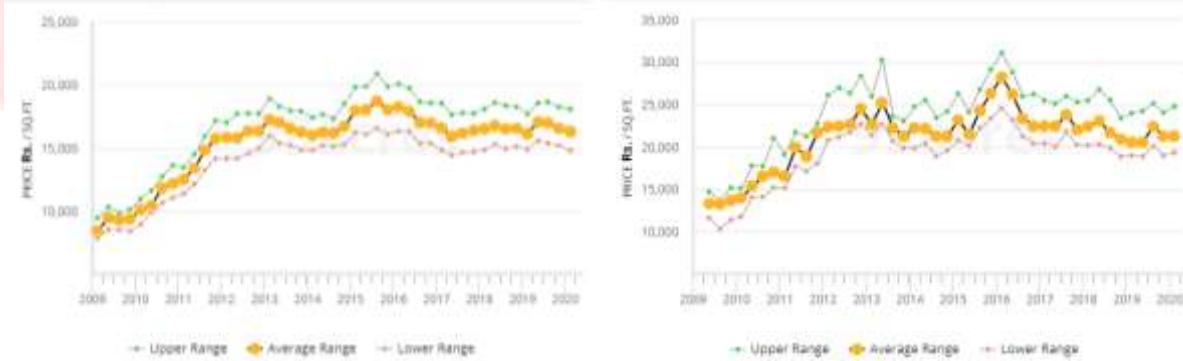
Figure - 4 Pricing Trend of Residential Areas in Greater Kailash 3 and Panchsheel park, Delhi

The construction of metro stretch started nearly in 2014 at which time the property rates were approximately Rs 16,000 /sq. ft. During the construction time, the property rates started rising to Rs 19000 /sq.ft. in 2015 and then again declined to Rs 16,000 /sq. ft. till 2017. From 2017 the prices were remained almost stagnant till 2020 with an increase of Rs 1500 /sq. ft. at the end of 2018.

The construction of the same metro stretch started nearly in 2014 at which time the property rates were approximately Rs 21,000 /sq. ft. During the construction time, the property rates started rising from Rs 24,000 /sq.ft. in 2015 to Rs 28,000 /sq.ft. in the mid of 2016 and then again declined to Rs 23,000 /sq. ft. till 2017. From 2017 the prices were remained almost stagnant till 2020, except with an increase of Rs 1000 /sq. ft. in 2018.

Now there is a residential area named Greater Kailash 1 which is approximately 2.5 km away from the metro stretch and this area is taken a Control Area for the Impact Areas, Greater Kailash 3 & Panchsheel Park.
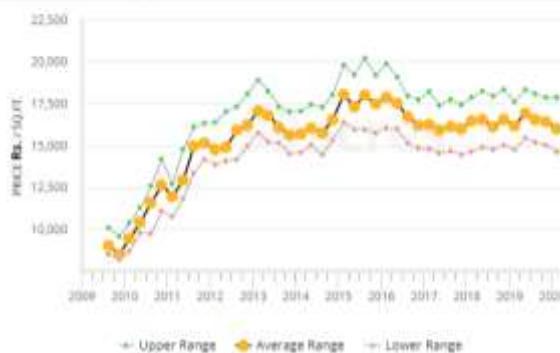
Figure - 5 Pricing Trend of Residential Areas in Greater Kailash 1, Delhi

As can be seen from the pricing trends of Greater Kailash 1 in Fig.5, the control area, the prices in 2018 were Rs 16,000 /sq.ft. and in 2020 the prices were also Rs 16,000 /sq.ft. So, there is no overall increase in the prices hence we can say approximately 0 % increase in the rates after commencement of operations of the metro stretch.

In Greater Kailash 3, the property rates were Rs 16500 /sq.ft. in 2018 and Rs 17000 / sq. ft. in 2020. So, there's a 3 % increase in the rates after commencement of operations of metro stretch. And in Panchsheel Park, the rates were Rs 22,000 /sq.ft. and Rs 21,000 in 2020. So, we can say there is a 4.54 % decrease in the rates after commencement of operations of metro stretch.

So a conclusion can be drawn from the above example that the impact of metro is either negligible or negative in high income group areas and the impact is high in low income group areas.

6. ATTRIBUTES AFFECTING PROPERTY VALUE AROUND METRO STRETCH

Value Drivers are the attributes that generally add value to a product or service. The value added can be tangible or intangible. This chapter will talk about the overview of different independent and dependent attributes of metro which affect the cost of residential properties.

There are two kinds of attributes (variables) which impacts the housing price, Spatial attributes and Temporal Attributes. Spatial attributes which takes into account the characteristics of space dimensions. Temporal Attributes takes into account, the dimension of time, and study is based on pre & post of that particular event.

Because the dataset covers a relatively long period and house prices increase continuously during the past decade, temporal effects are also expected to play a role in illustrating the variation in the selling price of houses. So, sales year dummies to capture the temporal effects can also be used. These account for the inflation, real value changes and other temporal effects across the time-period.

Surface area of the house (including the built-up and the non-built-up part of the property), the age of the house, the number of rooms and the number of bathrooms; all these variables are continuous. The rest of the physical characteristics, such as the monument status of the dwelling, availability of a gas heater, presence of an open fireplace and presence of a garden and garage, are indicated by dummy variables.

From the Literature the following attributes that affect the residential housing price due to metro are identified and shown in Table 1:

Table 1 Attributes affecting price of properties along metro stretch

Spatial Attributes	8) Nuisance due to metro
1) Property Size	9) Criminal Activities around metro
2) Developments in neighborhood due to metro	10) Traffic Congestions around metro
3) Distance from metro	11) Last mile connectivity from Metro
4) Accessibility Improvements due to metro	Temporal Attributes
5) Parking Facility by Metro	1) Announcement of Metro
6) Interchange	2) Construction Stage of Metro
7) Ridership	3) Operations of metro

With the help of interview with the experts, the weightages are given to all the identified attributes, and those weightages are used to calculate Relative Importance Index (RII) of each attribute to rank them and will help to select the final attributes to formulate the relationship of these with the price of houses and the same is shown below:

Table 2 Relative Importance Index for Attributes

S No.	Attributes	Rank	W/A*N
1	Distance from metro	1	0.943
2	Distance from New Developments in neighbourhood due to metro	2	0.893
3	Property Size	4	0.714
4	Presence of Interchange	5	0.600
5	Last mile connectivity from Metro	6	0.586
6	Accessibility Improvements due to metro	6	0.586
7	Transit Oriented Development along metro	8	0.571
8	Criminal Activities around metro	8	0.571
9	Parking Facility by Metro	10	0.524
10	Nuisance value due to metro	11	0.500
11	Traffic Congestions around metro	12	0.446

Table 2 shows the Relative Importance Index calculated for each attribute and the rank to them was given based on the highest value to lowest value. The final attributes will be selected with the RII value more than 0.7 for better accuracy. But as the distance from metro and Distance from New Developments in neighborhood due to metro can be clubbed together as they have high correlation with each other. Also, dummy variables are also taken for Impact & Control Area. Hence the final attributes are:

1) Distance from metro
2) Property Size (Built-up Area)
3) Dummy Variables for Impact & Control Area

7. FORMULATION OF EQUATIONS USING HEDONIC REGRESSION

The Hedonic Price Method (HPM), also known as hedonic regression, is used for estimating the value of a commodity and is a subset of multiple regressions. The HPM has been extensively used in real estate and housing market research in the recent past. Regression analysis related estimation approaches are common in HPM models in real estate as well. The fundamental assumption of regression applies that the relevant determinants of the dependent variable (rent, price, or value) are known precisely and in advance. A classical hedonic equation is as follows:

$$R = f (P, N, L, t) \qquad (1)$$

where R is rent or price of the house; P is property related attributes; N is neighborhood characteristics; L is locational variables and t is an indicator of time.

Regression was performed individually for all of the 3 types of houses (LIG, MIG & HIG) and presence of multi collinearity was also checked as it should not be present while applying regression. A total of 113 samples have been collected from the metro stretch "Noida Sector 50 to Noida Sector 81" and each house was categorized as LIG, MIG and HIG houses on the basis of the following built up area (to check the hypothesis) -

LIG – 700 – 1400 sq. ft.
MIG – 1400 – 2500 sq. ft.
HIG – more than 2500 sq. ft.

7.1 Equation for LIG properties

$$Y = \{a \times (79.97 + 3.12x_1 + 1.23x_2 + 0.023x_3 - 0.00879x_4)\}/100 \qquad (2)$$

7.2 Equation for MIG properties

$$Y = \{a \times (78.08 + 7.05x_1 + 2.35x_2 + 0.011x_3 - 0.0037x_4)\}/100 \qquad (3)$$

7.3 Equation for HIG properties

$$Y = \{a \times (88.0 + 4.918x_1 + 1.69x_2 + 0.00322x_3 - 0.00246x_4)\}/100 \qquad (4)$$

Where,
Y stands for Price/sq. ft.
a stands for Mean Price/sq. ft. of the selected residential area
x_1 stands for Impact Area (Dummy Variable, 0 or 1)
x_2 stands for Control Area (Dummy Variable, 0 or 1)
x_3 stands for Built up Area in square feet
x_4 stands for Distance from Metro in meters

These equations are applicable to the developing areas around already developed areas in Tier 1 cities.

Through regression, it was found out that Distance from metro is most significant attribute for LIG & MIG properties and Area is most significant attribute for HIG properties. Further it implies, that when controlling all the other factors, increase in each meter of distance from metro the property prices decreases by 0.51/sq. ft., 0.25/sq. ft. and 0.20/sq. ft. for LIG, MIG and HIG properties respectively.

8. CONCLUSION

From this study we can derive the following primary conclusions:

1) Price of a residential property around a metro stretch is affected by various attributes such as Distance from metro, Distance from New Developments in neighborhood due to metro, Area, Presence of Interchange, Last mile connectivity, Accessibility improvements from metro and criminal activities, nuisance, traffic congestions & parking facility from metro.

2) Through price trend analysis, it was determined that the impact of metro on the cost of residential properties is high in low income group areas and impact is low in high income group areas. The reason for the varied impact is that the residents of low income group areas are highly dependent on metro for commuting purposes but the same is not the case for the residents of high income group areas. The same results came after regression.

3) It is also inferred that the price/sq. ft. is decreases when the property is located away from the metro compared to the property which is in the influence zone of metro station. So as the distance from the metro increases, the value of a property decreases and vice versa. And the rate of increase/decrease of price of property is also dependent on the type and locality of a property.

4) Three forecasting equations are developed through Hedonic Regression for each type of property (LIG, MIG & HIG) which can be applied to any developing residential areas respectively, provided the mean price/sq. ft. is already known.

5) As the type of property changes, the amount of impact of a particular attribute also changes.

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