THESIS REPORT

IMPACT OF METRO RAILWAY NETWORK EXPANSION ON RESIDENTIAL LAND PRICES IN THE NATIONAL CAPITAL TERRITORY OF DELHI

デリーの首都圏における住宅地価格へのメトロ鉄道ネットワーク拡張の影響

A Thesis submitted to the Graduate School of Public Policy, The University of Tokyo in partial fulfilment of the requirements for the Degree of Master of Public Policy/ International Program (MPP/IP)

Submitted By

KAUSHAL KUMAR SAHU

(STUDENT ID: 51-188206)

ADVISOR

UEDA KENICHI

(Associate Professor, Graduate School of Economics)

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Kaushal Kumar Sahu

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DECLARATION OF ORIGINALITY

I hereby declare that the Master's thesis submitted to the Graduate School of Public Policy, The University of Tokyo, is my original research under the guidance of my thesis advisors Professor Kenichi Ueda, Professor Taisuke Nakata and Professor Manabu Nose. I have not submitted the whole or any part of my research to any other institution or university for any other purpose.

I certify that I have not violated the proprietary rights of any author, academic researchers, academic institutions, and publishers. I have followed APA reference requirements and acknowledged the sources of literature, maps, and researches to give due credits to the authors, researchers, institutions, and publications.

Kaushal Kumar Sahu

June, 2020

ABBREVIATIONS

BRTS	: Bus Rapid Transit System
CBD	: Central Business District
CPI	: Consumer Price Index
DiD	: Difference in Difference Regression
DMRC	: Delhi Metro Rail Corporation
DPR	: Detailed Project Report
FAR	: Floor Area Ratio
FE Model	: Fixed Effect Regression Model
GIS	: Geographic Information System
GLS	: Generalized Least Square Regression
GST	: Goods and Services Tax
INR	: Indian Rupee (Currency of India)
l_business_est	: Log of number of business establishment
l_colleges	: Log of number of colleges
l_hospitals	: Log of number of hospitals
l_population_density	: Log of population density
l_workers	: Log of number of workers
l_trip	: log of number of trips (generation + Attraction)
LRT	: Light Rail Transit
MRTS	: Mass Rapid Transit System
NCT	: National Capital Territory of Delhi
OLS	: Ordinary Least Square Regression
PPHPD	: Passenger Per Hour in Peak Direction
RE Model	: Random Effect Regression Model
SPV	: Special Purpose Vehicle
Station_hat	: Fitted value of number of stations, an estimator of stations
TOD	: Transit Oriented Development
VAT	: Value Added Tax
VCF	: Value Capture Finance
2SLS IV	: Two Stage Least Square Instrument Variable Regression

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THESIS SUMMARY

The thesis on the topic "Impact of metro railway network expansion on residential land prices in the National Capital Territory of Delhi" estimates the effect of metro railway expansion in Delhi on house prices and residential land prices. The thesis also assesses the value capture finance amount from the estimated effect of metro railway expansion on residential land price increase between 1992 – 2018. The thesis is divided into eight chapters and six appendixes.

Chapter 1 of the thesis explains the motivation behind this research. The lack of empirical economic research on estimating the value capture from the residential land price increase is the motivation to carry out this research. Chapter 1 also provides the research hypothesis and research questions and public policy relevance of the study.

Chapter 2 provides the literature about the Metro Policies in India and the researches on the effect of the metro railway network on the residential properties. Section 1 is dedicated to the metro policies and the studies on the impact of the rail transit network in India. Section 2 gives an overview of the researches about the effects of the transit network in the cities of the world. Section 3 explains the research settings and the effect of infrastructure on the welfare and economic development. This chapter also describes how this thesis differs from previous researches and its contribution to the literature.

Chapter 3 gives a brief detail of the study area that is National Capital Territory of Delhi and the Delhi Metro Railway project executed in Delhi under Phase-I, II, and III. Chapter 4 explains the research methodology for the empirical investigation of the research questions. This chapter provides details about the primary, secondary, and instrument variables generated for the research. This chapter also explains the use of Google Earth Pro used to create the primary and instrument variable of metro station length in districts of Delhi.

Chapter 5 of this thesis explains the econometrics models used under Research Design 1, 2, and 3. The research design 1 uses Dummy variable GLS regression to estimate the effect of the metro network within and outside the influence zone. Research Design 2 uses the difference in difference and 2SLS IV Fixed Effect regression model to estimate the effect of the variable metro station and other control variables on the residential land price. Research Design 3 explains the correlation analysis of the house prices and residential land prices within and outside the influence zone in the urban area of Delhi.

Chapter 6 gives the details of the regression results of research design 1, 2, and 3 and interprets the result outcomes. The research design outcomes have been compared with the outcome of similar researches in different cities. The outcomes of the research designs find a significant effect of distance from the metro network on average house prices and a significant difference of 48.96% on average house prices within and outside the metro influence zone. Research design 2 estimates that there is no significant difference in residential land price change between treatment and control groups of districts. The 2SLS IV Fixed Effect regression result suggests that the expansion of the metro network causes 7.87% increase in the residential land price in Delhi. The correlation analysis of research design 3 finds a higher premium on low land value houses situated within the metro influence zone. The average house price of the high property value within the metro influence zone is lower than the houses located outside the metro influence zone.

Chapter 7 uses the outcome of research design 2 to estimate the Value Capture Finance (VCF) amount from the property tax and stamp duty revenue of the Municipal Corporations of Delhi and State Government of Delhi. Chapter 7 also provides policy implications of the value capture financing (VCF) amount in financing 5% of project cost of ongoing Phase-IV of Delhi Metro. The estimate suggests that the transfer of an annual VCF amount can turn the net loss of Delhi metro into profit. This chapter also estimates the potential of VCF to reduce the sovereign and subordinate debt burden of Delhi Metro Rail Corporation. The final section of this chapter explains the research outcome by answering the research questions and review the validity of the research hypotheses.

Chapter 8 provides the conclusion of the thesis research by summarising the research methods, research findings, and its public policy implications. The appendix 1 to 6 provide details on the concepts and theory of econometrics models (Appendix1); Google Earth Pro map plots and geodata of the plots (Appendix 2); details of sources of primary and secondary variables used in this research (Appendix 3); sources of the house prices in cities of Delhi (Appendix 4); sources of residential land price in Delhi from 1987 to 2018 (Appendix 5); and STATA do file, results, graphs, and tables under Appendix 6.

ABSTRACT

The Central and the State governments of India are discussing policy provisions to transfer a certain amount of the revenue generated from the increase in residential land value to part finance mass rapid transit system in India. The lack of empirical researches on the impact of the metro network on residential land prices is a constraint to arrive at the Value Capture Finance amount. This research got motivation from these policy discussions and estimated the impact of the metro railway network on house prices and residential land prices in Delhi. The primary data of district wise metro length and distance of urban area centroid from the metro network are created using Google Earth Pro. The secondary data of variables such as population density, number of business establishments, and workers generated from the Census reports. The research design 1, 2 of this thesis uses Dummy variable GLS regression, Difference in Difference (DiD) regression, and 2SLS IV Fixed effect econometrics models to estimate the effect on metro network expansion in Delhi on house prices and residential land prices. The research design 3 presents a correlation analysis of house prices and residential land prices within and outside the metro influence zone. The estimated influence zone of the metro network in Delhi is 0.73 kilometers. An identification strategy of metro rail density has been used to divide nine districts of Delhi into treatment and control groups of districts. This research estimates 48.96% higher house prices within the metro influence zone than the houses situated beyond 0.73 kilometers to 4 kilometers. The DiD regression of research design 2 not find significant differences in residential land price changes in treatment and control group districts. The 2SLS IV Fixed effect regression model instrumented the variable stations with metro route length and trips. The 2SLS IV Fixed Effect regression result predicts that the addition of stations has caused 7.87% increase in the residential land price in Delhi's districts from 1992 to 2018. The public policy implication of this finding has been assessed by estimating the Value Capturing Finance (VCF) amount. The VCF amount has been estimated as 7.87% of the revenue of the property tax and stamp duty revue of Municipal Corporations and State Government of Delhi. The research estimates that the estimated Value Capture Finance (VCF) amount has the potential to finance 5% of the project cost of ongoing Phase-IV of Delhi MRTS Project and reduce the subordinate and sovereign debt requirement by 9.71%. The transfer of Value VCF amount can turn net losses of Delhi Metro into profit and help Delhi Metro Rail Corporation to keep the travel fare minimum to attract more ridership and ensure a sustainable metro railway operation.

CHAPTER-1

INTRODUCTION

1.1 Motivation

The search for innovative financing mechanisms has been under discussion in India to generate additional capital to finance Mass Rapid Transit Projects (MRTS). One of the measures identified by Metro Policy 2017 is Value Capture Finance (VCF) of the metro railway projects. The policy suggests that the state government should transfer the benefit accrued due to the escalation of land prices to the project implementing agency. The Metro Policy 2017 does not mention the method for estimating the VCF amount. It is one of the research motivation to assess the effect of metro railway expansion on the residential land price increase in the National Capital Territory of Delhi and estimate the VCF amount for the financing of Metro railway projects in Delhi. The lack of empirical researches in India on the effect of the metro station on residential and house prices in Delhi is another motivation to estimate the quantitative share of the metro railway network on the house price within the influence zone and the residential land price. The Government of India is also promoting Transit Oriented Development (TOD) policy in cities which have implemented the Metro Railway Projects. The government suggests that the state government should levy an additional FAR charge on the house and residential properties falling within influence zone; however, the TOD policy does not mention the tax levied on properties situated within influence zone. The thesis research has first estimated the influence zone distance of metro stations in Delhi and estimated its effect on the mean house prices. The National capital territory of Delhi is chosen as the study area because the metro network of Delhi has the most extensive metro route length and the largest number of stations in India.

1.2 Research Background

The metro cities of India have seen rapid population growth, the outward expansion of the city, and emergence of new central business districts (CBD). It has also caused traffic congestion on the existing road network and increased air pollution due to automobile emissions. It necessitated those metro cities prepare a mobility plan and implement the Mass Rapid Transit System (MRTS) to cater mobility need of the city dwellers. The Government of the National Capital Territory of Delhi and the Ministry of Housing and Urban Affairs, Government of India, proposed 413 kilometers of metro network in Delhi

to provide a viable public transportation system by implementing Delhi MRTS Project in four phases by 2021. Implementation of the MRTS project in Delhi has led to the escalation of the residential land in Delhi. The people's preference to seek houses and offices near the metro railway network also contributed to an increase in the house prices of the urban areas. The thesis report has studied this impact of metro railway expansion in the National Capital Territory of Delhi on the increase in the residential land prices while keeping other factors constant. The panel data of these variables have been created by collecting the data for the years 1992, 1998, 2005, 2012 and 2018. The selection of panel years are closely related to the inception of the construction work of Delhi Metro in 1998 and the completion of three phases of Delhi Metro Projects in the years 2005, 2012, and 2018. Data for the year 1992 has been selected to analyze the trend of the residential price movement from the year 1992 to the year 1998 and comparing this trend with respect to residential land price movement in the year 2005, 2012, and 2018 after operationalization of Delhi Metro Network under Phase 1, Phase 2 and Phase 3 respectively.

Delhi revenue districts have been chosen as a unit of analysis. The primary and secondary data of the variables have been generated for nine revenue districts of Delhi to undertake the research. The difference in difference regression method estimates the variation of the residential land price trend in the control and the treatment group of districts of Delhi. The years after 1998 are the treatment years for the analysis when the metro stations became operational in all nine revenue districts of Delhi under different phases. The unique identification strategy of metro rail density groups the nine revenue districts under the treatment and control group. The Two Stage Least Square Instrument Variable (2SLS IV) Fixed Effect econometrics model has been used to estimate the unbiased and consistent effect of metro stations on the residential land price in Delhi. The other factors that contributed to an increase in residential land prices are the number of hospitals, colleges, population density, number of business establishments, workers employed in such business establishments in each district of Delhi during 1992 to 2018. The 2SLS IV Fixed Effect regression model also estimates the individual effect of these variables on the residential land price increase. In addition to the above analysis, the thesis assesses the influence zone distance of the metro network and estimates the effect of distance from metro stations on the house prices in Delhi's urban area.

1.3 Research Objective:

The objective of this thesis research is to empirically investigate the effect of metro stations on the mean residential land price from 1992 to 2018. The findings of the study will provide necessary input to the policymakers and Delhi Metro Rail Corporation to discuss the Value Capture Financing of the Delhi MRTS project by sharing the gain of residential land price increase in Delhi due to the expansion of metro railway network. The research aims to estimate the potential benefit of value capture financing (VCF) to project implementing authority in terms of reduced debt burden and sustainable metro operations. The thesis report will compile the empirical findings of the impact of distance from the metro network on the house prices of Delhi. The empirical findings will help the policymakers to discuss and determine the additional premium on the property taxes and stamp duty for the properties falling within the influence zone.

1.4 Research Hypothesis and Research Questions:

The thesis research is perhaps the first empirical study in India to estimate the impact of the metro railway network on the land price over 26 years. The thesis is also the first academic research to empirically estimate the influence zone of the metro network and estimate its effect on the house prices in Delhi. The thesis hypothesis is that the residential land price in Delhi has increased many folds in the last three decades due to the development of infrastructure and associated economic development. The following hypothesis will be tested empirically through three research designs:

1. The metro network expansion in Delhi has increased the land value and the house prices in the districts of Delhi.
2. The average house price in Delhi is higher within the influence zone of the metro network as compared to the residential properties situated beyond the influence Zone.
3. The residential land price is affected by the demographic changes, the number of educational and health institutions, and business establishments in the city.

Three research design has been proposed in this thesis to examine these hypotheses through the following research questions:

1. Estimate the effect of metro railway network expansion in Delhi on the residential land value and house price of Delhi?

2. What is the influence zone distance of the metro network and estimate the effect of the influence zone on house prices of the urban area of Delhi?
3. Estimate difference in residential price trend in the treatment and control group of districts after the policy treatment of the introduction of the metro railway in Delhi?
4. Does social infrastructure, demographical and economic factors affect residential land prices of Delhi's districts from 1992 to 2018?
5. Assess the effect of the expansion of the metro network in Delhi on value capturing from increased land price and examine public policy relevance of the research findings?

The thesis research has searched answers of research questions by collecting the residential house price data from the real estate property websites for period the 2012 to 2018 and the residential land price data from the Department of Land Office, Ministry of Housing and Urban Affairs, Government of India and Delhi Development Authority. The Google Earth Pro is used to measure the distance of urban area centroid from the metro network. The thesis research answered the research questions through econometric models using the GLS regression model with a dummy variable to estimate the effect of the influence zone on average house prices in the urban area of Delhi. The difference in difference method calculates the change in the residential price trend in treatment and control group districts, and the 2SLS IV Fixed Effect regression model estimates the effect of metro stations and other control variables on the mean residential land price. The research also estimated the amount of value capture financing from the outcome of the effect of metro stations on the residential land price. It assesses the relevance of the value capture finance (VCF) on the upcoming Delhi MRTS Phase-IV Project, and how VCF can lead to passenger welfare if transferred to supplement the operational revenue of project implementing agency Delhi Metro Rail Corporation Limited.

1.5 Public Policy Relevance of the Study:

The research findings will help policymakers to decide on financing of Mass Rapid Transit System (MRTS) Project from Value Capture Finance (VCF). The Value Capture Finance amount depends on the land value capturing of increased residential and commercial properties because of the introduction of the metro network in Delhi. The Metro Policy of India 2017 suggests that the government should impose additional Floor Area Ratio (FAR) charges on lands to generate revenue for the financing MRTS Projects in Delhi and other

cities of India. However, there is no empirical evidence available on the quantitative effect of the metro station on residential land prices. The findings of the thesis research will be useful for public policy decision-makers to enforce land value capturing in Delhi. Further, this research will encourage academics and professionals of India and other countries of the world to undertake similar research to estimate the effect of the metro railway on residential land prices in other metropolitan cities.

CHAPTER-2
LITERATURE REVIEW

The thesis research has taken inspiration from the available literature to frame the research designs. Most available researches use the hedonic price model regression analysis to estimate the effect of railway transit on house prices. The thesis research has also taken inspiration from the research model used in analyzing the impact of infrastructure on the welfare and economic development. This chapter is divided into three sections to provide an overview of the existing literature. Section 1 of this chapter provides an overview of the exiting policy for planning metro railways in the metro cities of India, followed by research on the effect of the metro railway in Chennai Bengaluru, Mumbai city of India. This section also included research on the impact of railway construction on the real income of the Indian districts during pre-independence British India. Section 2 of this chapter explains the research findings of the effect of the metro railway, LRT, and railway on the real estate price in other cities. Section 3 provides literature on the impact of infrastructure and policy treatment on welfare and regional development. The theoretical concept of econometrics models used to analyze the effect of policy treatment is covered separately under Appendix 1.

Section1 : Literatures on Metro Railway Policy and Effect of Rail Transit in India

2.1 Metro Railway Policy of India and Researches on Effect of Metro Railway and Rail Transit in India:

Transit Oriented Development (TOD) Policy 2019 for Delhi:

Transit Oriented Development (TOD) Policy for Delhi was notified by the Ministry of Housing and Urban Affairs Government of India on December 24, 2019, as an amendment to the Master Plan of Delhi 2021. The TOD policy has defined the transit-oriented development node as a mass transit station where the TOD policy will be applicable. The TOD policy also describes 'Influence Zone' as a notional area of 800 meter radius from the point of alighting at the station. The objective of the TOD policy for Delhi is to intensify the development around the mass rapid transit corridor by allowing additional FAR (Floor Area Ratio) that is 1.5 times the allowable FAR or 300 whichever is higher. The maximum permissible FAR in the TOD influence zone is 500 on the plot of 4 Hectare subject to feasibility of the development. The TOD Policy provides that residential

development on a minimum of 50% of the total FAR in the Residential Use zone. The minimum FAR utilization for residential development will be 30% in other land use zones such as Commercial, Transportation, Government and Mixed land Use zone. The TOD policy aims to intensify the residential development in the influence zone of the metro railway network to promote public transportation and reduce the use of the motorized vehicle that causes congestion in the city. A separate chapter of TOD policy in the Master Plan of Delhi 2020 provides enabling regulation for development within the influence zone.

Metro Railway Policy 2017

Metro Railway Policy 2017 notified by Ministry of Housing and Urban Affairs provides detailed guidelines for the state governments to plan for mass rapid transit system (MRTS) in the urban area of states with a population more than one million. The Metro Policy 2017 recognizes the importance of Mass Rapid Transit System (MRTS) in providing a reliable public transportation system in the urban area, which helps to reduce traffic congestion, road accidents, greenhouse gas emissions and air pollutants. Metro Policy classifies the Mass Rapid Transit System (MRTS) as Bus Rapid Transit System (BRTS), Metro Railway, Tramway, Light Railway Transit (LRT), and Regional Railway. The selection of a type of MRTS depend upon the passenger volume on the road measured in terms of passenger per hour per direction of traffic (PPHPD) for example the metro railway system is a preferable option for high passenger volume of 40000 – 80000 PPHPD and BRTS is suitable for 10000 – 150000 PPHPD.

Metro Policy 2107 provides detailed information about the financing model of existing metro companies and proposes a systematic approach for the planning of a new metro railway system for the city. Metro Policy 2017 suggests that a Comprehensive Mobility Plan and Multi-Modal Integration plan should be part of the Detailed Project Report (DPR) for considering any proposal of a new metro project for approval by the Central Government. Metro Policy 2017 also requires that a new project proposal should contain a chapter on Transit Oriented Development and Value Capture Financing (VCF). Metro Policy 2017 makes the inclusion of the mandatory section in the Detailed Project Report to outline the ways to increase the non-fare box revenue, such as revenue from advertisement and leasing of spaces.

Prof. D. Karthigeyan and Dr. Sheeba Chander (2020), Hindustan Institute of Science and Technology, Chennai, March 2020, studied the impact of metro stations in its immediate neighborhood. They analyzed the various parameters surrounding the metro stations of the Chennai Metro Phase-I Rail Network. They ranked the metro stations to help authorities to facilitate development regulation surrounding the metro stations. The study area consists of 33 metro stations of the Chennai Metro Network. All the stations were operational at the time of their study. They used eight parameters to estimate the effect of metro stations on nearby localities. The source of population density and land use were Greater Chennai Disaster Management Plan 2017 and Chennai Second Master Plan 2026, respectively. The Other six parameters were sourced from Google maps to collect data for proximity to transport network, accessibility, nearest to CBD, social facilities, and land for future development. The researchers collected land value data from real estate websites, such as 99acres, Makan, Magicbricks, and Sulekha.

They ranked the metro stations based on the score obtained by 20 metro stations on seven parameters. They collected the data within 800 meters of influence area of the metro stations and then ranked these metro stations based on their ranking. The research concluded the final scores of 20 stations range between 43 to 70 points, and they find that 12 stations achieve 50 to 60 points with moderate impact on immediate surroundings. Researchers find that only two stations have the highest impact on the immediate surrounding. The Overall impact on land price on immediate surroundings was 10 basis points.

Rohit Sharma (2018), Curtin University Sustainability Policy Institute, Australia, in his Ph.D. Thesis titled "Financing Urban Rail Projects through Land Value Capture – The Indian Case" used hedonic price model for Bangalore Metro and Mumbai Metro network to estimate the impact of the metro railway network on land markets. Sharma (2018) used the panel data of 458 condominiums (apartment/flat projects) prices over 2012 to 2016 on a half annual basis. The researcher also collected the prices of the 898 condominiums of Bangalore city in 2016. He also used data from 333 homes between 2014 to 2015 of Mumbai city to regress the Hedonic price model with the dependent variable as land value and independent variable as the factors influencing land value such as distance from CBD, neighborhood, workplace..

Sharma (2018) estimated that the land value of condominiums of Bangalore city located within 500 meters to 1.1 kilometers is 25% higher than 11% price uplift within 500 meters from a metro railway station and 8% price uplift within 1 km to 2 km. from metro station. Sharma observed that the area within 500 meters is characterized by noise and traffic congestion due to paratransit mode of transport. It is the reason for a lower premium on the land value within 500 meters of a metro station as compared to the properties situated between 0.5 to 1 kilometer. Sharma (2018) also observed that increase in the property value across Bangalore city was 1.8% before one year of the construction of the metro project, 4.5% during the development phase of the metro project (4 years), and 1.8% after operation of the metro stations. However, his thesis does not mention about the general trend of increase of property value in Bangalore.

Sharma (2018) estimated a similar effect for the catchment area of the Mumbai Metro network that metro network impact is beyond 500 meters and statistically significant after 1 km to 2 km catchment from the metro station. He reported an increase of 14% in property value in the Mumbai metro network catchment area.

Dave Donaldson(2018), MIT, Department of Economics research on "Railroads of the Raj: Estimating the impact of transportation infrastructure, American Economic Review, 2018, investigated the impact of vast railroad network built in colonial India (India, Pakistan and Bangladesh) and estimated the effect of railroad network on India's trading environment, welfare gain in terms of increase in per capita income. Donaldson(2018) collected economic data from British government records and started his empirical analysis by developing the Ricardian trade model with many regions, many commodities, where trade occurs at a cost.

Donaldson(2018) used these data to construct a district dataset on prices, output, rainfall, and interregional and international trades in India. He also prepared digital railroad network maps of India with a segment of 20km each and coded each segment with its year of opening. The coding based on the year of railway network operation used to analyze India's district economy before, during, and after the expansion of the railway network in India. The empirical strategy of Donaldson (2018) is used in this thesis to estimate the effect of the metro railway network on the residential land price. Donaldson (2018) estimated that the trading cost parameter governing the trader's route decision on road, coasts, and railroad network significantly reduced the cost of trading in India. His research

also estimated that a district railroad network contributes 16 % increase in district real income.

Section 2: Literatures on Impact of Metro Railway, LRT and Railways on Real Estate Prices in other Cities of the World

2.2 Researches on Effect of metro railway network on the Real Estate Price in other metro cities of the world:

Oskari Harjunen (2018), Working Paper on Metro Investment and the Housing market Anticipation Effect, used the Hedonic price model to analyze the residential housing market in the Helsinki Metropolitan Area. Harjunen (2018) used the decision to build West Metro as a quasi-experimental setting to examine its effect on the house price market's variation through before and after analysis. The plan for underground West Metro was ready in 2005, but the construction began in 2009 and targeted to be operational from 2014. However, the opening of metro stations postponed and eight stations – two in Helsinki and two in Espoo, became functional from the year 2017. The West metro network became operation in 2014. Harjunen (2018), used the difference in difference model to estimate the effect of treatment of metro station on house price by using the following regression model equation:

$$Log(Price_{it}) = \alpha + \beta * treatment_i + \gamma * treatment_i * after_t + \partial \boldsymbol{X}_{it} + \mu_t + \varepsilon_{it} \quad (1)$$

Where the interaction term of treatment and after period indicator estimates the anticipation price effect. The housing market data of Helsinki and Espoo from 2003 to 2016 was used to determine the effect of metro construction on housing prices.

Harjunen divided the data into an equal interval of 400 meters up to a distance of 2000 meters of the metro station. The Year 2009 was the treatment year to compare the house price trend. The regression model estimated the significant difference in price trend up to 800 meters distanc. Oskari Harjunen estimated that the average treatment effect on house prices from 2010 to 2016 is 4.2% within 400 meters and 3.6% within 400 – 800 meters with statistical significance at 1% level. However, the treatment effect on prices after 800 meters was not statistically significant. Harjunen (2018) strategy of the difference in difference method to estimate the impact of the metro station has been adopted in the research design 2 of this thesis.

Qisheng Pan (2018), Tongji University Texas Southern University, studied the impact of the Houston Rail transit light rail (LRT) line on residential property value in the non-zoning city. Qinsheng Pan used the traditional OLS model and multilevel regression model to examine the effect of rail transit on residential real estate at two levels, one at the individual property level and another at the zonal level. The data used for the regression model include residential house price data, Consumer Price Index (CPI), and other variables between 1982 to 2010. The dependent variable was the logarithm of house sales prices in 2010. Qishan Pan plotted house sale price trend between 1982 – 2010 into two categories: property located within Harris County region, and property situated 3 miles from the light rail transit. The individual property level analysis includes variables like home size, age, access to the station, workplace access, and dummy variable about home transactions before and after opening the line. The zonal level analysis includes median income, population density, job density, percentage of minority, etc. as the explanatory variable. Qisheng Pan estimated that the combination of explanatory variables of the physical, neighborhood, and accessibility contributed 43.60% variance in the natural log of house price than the prices in Harris county region. Pan (2018) also concluded that the immediate proximity to stations within a quarter-mile has a negative impact on property value. Overall the opening of stations has a significant positive effect on house price value.

Dube, Theriault and Rosiers (2013) study on Commuter rail accessibility and house price in Montreal, Canada used the Hedonic Price model using GLS and DiD method of estimation. The data source was the sample report from 1992 to 2009. Dube et al. found that Nearness to station account for 11% price premium of mean house price, and an overall market premium is 2.6% on mean house price of the entire region.

Zhang, D, and Jingjuan Jia (2013) studied how Does Urban Rail Transit Influence Residential Property Values in Beijing. The research method used was the hedonic price model with OLS and Spatial lag error model. They collected house price data from the online sources and estimated that LRT in Beijing has a significant positive effect on land development and value premium for nearby properties.

Seo, Kihwan, Golub, Aaron, Kuby, Michael(2014) studied the combined impacts of highways and light rail transit on residential property values using spatial hedonic price model for Phoenix, Arizona. The method used for research was a combined lag and error

model and 2SLS GLS model to estimate the coefficient of distance from Highway and LRT exits. The researchers collected neighborhood characteristics data for median household income, and population density from census data. The neighborhood amenities data was generated from the GIS data source to create a proximity measure. The distance from highway and LRT was bundled into bands of 350 meters up to 3000 meters. Seo et al. (2014) observed an inverted U type pattern of the coefficient from distance from the transit exists..

Amir Forouhar (2016) estimated the impact of metro stations on residential property values in Tehran. The researcher collected data on housing characteristics from 1800 sales transactions. The treated properties were the properties situated within 0.4 kilometers, and the control properties were the properties located more than 1.6 kilometers away from the stations. Amir (2016) did trend analysis and estimated the effect of metro stations on the slope of housing sales values. The DiD model estimated an increase in the value of 46% for residential properties within 0.4 km of Shemiran station..

Wagner, Gary A. and Komarek, Timothy, Martin, Julia (2016) studies the impact of light rail transit on the residential houses in Hampton Road, Virginia Norfolk. They observed that the Tide LRT began operation from 2011 and experience disappointing ridership compared to other metro corridors. Wagner et al. used the difference in difference (DiD) method and considered several outcomes, including house price sales, sale list price spread. Wagner et al. found that properties within 1500 meters experienced an 8% decline in sale price

Michael R Ransom (2017) studied the effect of light rail transit services on nearby property values in his paper titled 'Quasi-experimental evidence from Seattle'. Ransom studied the sale of homes in areas around the seven stations in the Rainier Valley using Difference in Difference regression method. Ransom estimated that the impact of LRT was positive for only one station and negative for two stations, and the impact was negligible and statistically insignificant for the remaining four stations.

Jacob Camins Esako (2018) researched the Impact of a Light Rail Extension on Residential Property Values in his Ph.D. thesis. Camins used repeat sales analysis of Bayonne, New Jersey before 2008, and after the opening of the stations in 2011. The DiD regression method of estimation was employed to conclude that a one minute decrease in

walking distance to LRT station causes 0.21% to 0.25% decline in annual price appreciation. Camins also observed reciprocal relation between distance and house prices and found that property value appreciation disappeared after 12 minutes walk or 0.6 miles (1 Kilometre) to the station.

Mulley, C., Tsai, C., & Ma, L. (2018) in their paper "Does residential property price benefit from light rail in Sydney?" researched the hypothesis that public transportation increases accessibility that increases the land values in Sydney. The outcome variable of their research was house prices from 2011. They used Geographically Weight Regression (GWR) model to identify the price uplift. Mulley et al. observed that the LRT has more impact on residential value outside the city center and near to the stations.

Diao, M., Leonard, D., & Sing, T. F. (2017) studied the opening of the new Circle Line (CCL) in Singapore on private housing values. Diao et al. used the local polynomial regression approach to identify the CCL impact zone that shows a discontinuity in the house price gradient between the treatment and control zone. Diao et al. used the Spatial Difference in Difference (SDiD) regression method that accounts for autocorrelation in house price change before and after the opening of the new Circle Line in Singapore between 2009 to 2011. Diao et al. used data from 'Realis' covering database of house price transaction value, date, postal location, etc. from 2007 to 2013. Diao et al. found a 7.8% increase in the house prices situated within 600 meters of the CCL network. They also observed anticipation effect appear one year before the opening of the new CCL line.

Freddie Mac Report (2019) on 'Proximity to metro station and its impact on Washington DC Metropolitan House Price: Amenity or not ?' used Hedonic price model based OLS regression using the data of house property sold during 2015 – 2018. The finding of the study suggests that the house price premium is 13% for the median price of houses. A house within quarter mile sold at 8.6% higher premium than the houses located over 1 mile away. The houses situated quarter to half-mile sold at 7.5% higher than the houses located 1 mile away. The report finds that the proximity to the metro station has the smallest effect on the most expensive house because more expensive house buyers do not value proximity to the metro station as much as others.

The literature suggests the positive and negative effects of the introduction of a new transit system such as LRT, metro railway on the housing price value. The magnitude of the

impact of the transit system is different for each city. Pan(2013) estimated that immediate proximity to the station has a negative effect on the house price value in Houston. In contrast Dubey et al. (2013) estimated that nearness to station increased 11% of the house price. Estimates of Camins Esakov Vandedrift (2018) in Bayonn, New Jersey, and Ransom (2018) study on Washington, D.C. did not find the impact of LRT on the house price premium. Zheng and Wang (2013) estimated a positive effect of LRT on house prices in Beijing city. Seo (2014) assessed a positive impact of LRT on the house prices in Phoenix, Arizona, with a U type curve of the coefficient of effect to the distance from the transit exits. Diao (2015 and 2017) assessed the positive effect of heavy rail transit on house prices in Boston and Singapore. Dion (2017) also estimated that the housing value of properties located within 600 meters of stations in Singapore increased by 7.8%.

Section 3: Literature on Effect of Infrastructure on Regional Development

2.3 Research Findings of Infrastructure on Regional Development and Welfare:

Naoyuki Yoshino and Umid Abidhadjaev (2015) in the paper 'An Impact Analysis of Investment in Infrastructure: The case of the Railway Connection in Uzbekistan' examined the impact of railway connection in Southern Uzbekistan. The positive effect reflected in the increase in industrial output and aggregate services, with estimates of 5% and 7% respectively, and positive changes in a neighboring regional area in anticipation of the railway connection. It also caused 2% of GDP growth due to the spill over effect..

Alfredo M Pereira and Jorge M. Andraz (2013) in their paper 'The economic effects on public infrastructure investment: A survey of the international evidence', present a comprehensive discussion of empirical researches regarding the impact of public infrastructure investment on the economic performance. The paper also included a discussion on methodological developments, output elasticity estimation based on the production function, and vector autoregressive models..

Marta Santamaria (2019) paper on 'The Gains from Reshaping Infrastructure: Evidence from the division of Germany', found that half of the highway kilometer built after the division of Germany deviated from initial pre-war Highway plan and relocation of the investment increased 1.08% of welfare and 0.64% of real income annually. She solved the equilibrium expected utility of infrastructure investment to predict the optimal highway

construction from the pre-war highway plan and estimated welfare gain from reshaping of the Highway plan after the division of Germany..

Esther Duflo and Rohini Pande (2017) paper 'Dam' studied the productivity and distributive effects of large irrigation dams in India. They choose economic outcomes at the district level. They used the nonmonotonic relationship between river gradient and the likelihood of dam construction as a basis for identification strategy. Duflo et al. used Generalised Least Square (GLS) and 2SLS IV regression model to estimate the effect of Dam construction on the poverty gap, agriculture production, headcount ratio, and rural welfare using annual data of 271 districts of India for years 1971 – 1999.

Nathaniel Baum-Snow et al. (2017) paper on 'Roads Railroad and Decentralization of Chinese Cities' investigated how the construction of radial highways in Chinese cities since 1990 has displaced 4% of central city populations and each radial railroad reduces central city industrial GDP by about 20%. Their econometric model uses urban land use theory to estimate the change in GDP. They used instrument variable (IV) of change in the labor migration to estimate the result.

Cellini, Ferreira, and Rothstein. (2010), in their paper 'The Value of School Facility Investments: Evidence from Dynamic Regression Discontinuity Design' used RD design to show that bond passage on school investment increased the housing price over time for treated districts.

Gonzalez-Navarro and Quintana-Domeque. (2016) 'Paving Streets for the Poor: Experiment analysis of Infrastructure Effects' is the first experimental paper that estimates the effects of street pavement on property values in urban Mexico. Their model used reduced form 2SLS estimates. They used instrument variable (IV) of intent to treat in reduced form equation to estimate the fitted value of outcome in the year 2009. The effect on property value was then estimated by 2SLS regression. This empirical strategy is used in this thesis to find the fitted value of the metro station in the first stage of 2SLS IV Fixed Effect regression to estimate the effect of the metro station on the residential land price in NCT of Delhi.

Kenneth Button (2017) paper 'High Speed Railway: Do They Produce Economic Growth' argued that the extension of the Washington DC to New York High Speed

Railway beyond New York is overly optimistic and anticipated economic growth in minimal or negative.

Li Zhong-min and Liu Yu-Hong of International Business school, **Shaanxi Normal University, Xian, China**, focused their research on spatial econometrics analysis of panel data in their paper titled 'Transportation Infrastructure Facilities and Total Factor Productivity of the New Silk Road'. The researchers observed that transportation infrastructure facilities have a significant positive impact on Total Factor Productivity (TFP), and this project has a spillover effect on TFP to the extent of 74.59%.

Most of the literature of sections 1 and 2 have focused either on the effect of distance from the metro station or the policy treatment of opening of the metro station on change in house prices using the difference in difference, GLS, and OLS regression models. However, these researchers did not investigate the causal effect of metro stations on residential land prices in the cities, which changes slowly and often fixed by the government. In contrast, house prices in the city fluctuated due to demand in the market, and the house price movement is often linked with economic growth and real estate boom. Further, these researchers did not estimate the influence zone of the metro stations; instead, these studies selected distance intervals from the metro station to estimate its effect on house prices.

2.4 Contribution to the literature

This thesis's research designs aim to estimate the effect of metro stations on residential land price and house price increase. First, the thesis calculates the influence zone distance of the metro station from the house price trend. Research design 1 uses the metro influence zone as dummy variable identification criteria to represent the district's urban area nearness to the metro station. Research design 1 estimates the effect of distance on average house prices, and the average house prices difference within and outside the influence zone of the metro network.

Second, this thesis research also controlled the endogeneity and district level fixed effect by using the 2SLS IV Fixed Effect regression model. New identification criteria of metro railway density used to bifurcate the districts into the treatment and control group of districts. Researches in the effect of infrastructure on welfare employ 2SLS IV regression model to control endogeneity, and eliminate the fixed effect to estimate the impact of policy treatment on welfare and economic gains. Research design 2 has adopted this empirical

strategy by using Difference in Difference method (DiD), and 2SLS IV Fixed Effect regression model to estimate the effect of policy treatment of the introduction of the metro railway in Delhi on the residential land price in districts of Delhi..

Third, the primary data of district-wise metro length is created using Google Earth Pro. The primary data of trips attracted and generated in each district also calculated for nine revenue districts. These two variables are used as instrument variable in the research design 2 to estimate the causal effect of the metro station on the mean residential land prices of districts. The thesis also finds the correlation between house price and residential land prices within and outside of influence zone for the period 2012 – 2018 to investigate the effect of the metro station on change in the residential and house price trends.

This research provides an opportunity for future researchers to utilize the technique used in this thesis to quantify the spatial data to estimate the effect of metro stations on real estate property values in other cities

The existing literature on the effect of the metro network on house price uses the Hedonic price model with OLS, GLS, and Difference in Difference (DiD) regression models to estimate the effect of transit system on the residential property value. The literature on the effect of infrastructure uses the 2SLS IV regression method to estimate its impact on the welfare and the policy outcome. This thesis adopts the Difference in Difference (DiD), and 2SLS IV Fixed Effect regression models based on the learning from the literature on the effect of infrastructures. The number of observations in research design 2 is small; however, the dataset has a considerable panel period for investigating the impact of metro stations on the residential land price objectively. The thesis has enriched the literature by providing a method to estimate the land value capture amount from the residential land value appreciation. It has an important public policy implication for project financing through land value capturing.

CHAPTER- 3
STUDY AREA

3.1 National Capital Territory of Delhi

Delhi is the national capital of India, and all the national policy decisions are made from Delhi. The Parliament of India and the headquarters of most Central government organizations are situated in New Delhi. The National capital territory of Delhi is the second most populated city of India, with a city population of 11 million (2011 census) and the largest city of India spreading over 1483 Sq. kilometers. Delhi was the second most productive metro area of India in 2016. The city administration is divided into 11 districts, 9 revenue districts, 33 subdivisions, 59 census towns, and 300 villages. The local administration is divided into five Municipal corporations, namely East, North, South Delhi Municipal Corporations, New Delhi Municipal Council and Delhi Cantonment Board. Besides this, Delhi has legislative assembly having 70 constituencies. The administrative division of the National Capital Territory of Delhi is given under Fig.3.1.

Fig.3.1: Administrative Division of National Capital Territory of Delhi (Source: Department of Revenue, Government of NCT of Delhi, 2012)

The National capital territory of Delhi has recorded high population growth during the 20th Century after the declaration as the Capital of British administered India in 1912. The population of Delhi metropolitan area was 214,115 in 1901 which rose to 1,437,134 in 1951, 12,791,458 in 2001, and 16,349,831 in 2011. The projected population of Delhi for the year 2021 is 19,570,374. The city offers vast economic and employment opportunities, which creates a strong pull effect to attract the migration not only from the neighboring regions but also the far-off places in the country. This large scale immigration in Delhi has put pressure on the resources and infrastructure of the city.

Delhi was declared as a State in the year 1992 under the National Capital Territory Act 1991. National Capital Territory of Delhi shares boundary with Faridabad, Gurugram, Ghaziabad and Noida megacities. It makes Delhi as one of the most populated urban agglomerations of the World. Delhi is a prosperous state with the second largest per capita income of INR 365,529 (US$5100) in India. According to the Sixth Economic Census of Delhi 2013, the total number of business establishments in Delhi is 875,000. Total 98.58% business establishments are operating from urban areas, while the remaining 1.42% are operating in the rural area.

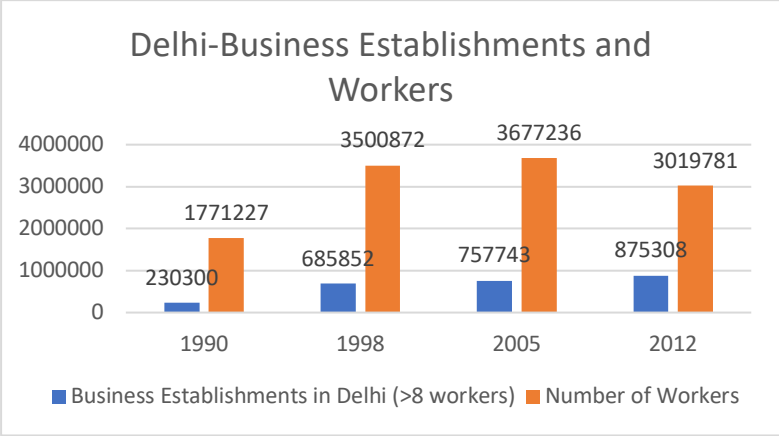


Fig.3.2: Delhi Business Establishments and Number of Workers (By Author)

The sixth economic census 2013 reports an annual growth of business establishment at the rate of 1.94% over the number of business establishments recorded in the fifth Economic Census 2005.

The population density of 11320 persons per sq.km. in Delhi is highest in India as per the Census of India 2011 because 98% of the total population resides in the urban area. The population density in the urban area recorded as 14698 as per Census 2011. However, about one-third of the urban population of Delhi lives in substandard housing such as slums

and unauthorized colonies. The decadal growth of population in Delhi from 2001 to 2011 was 21.2 percent. The number of the working population in Delhi grows at a rate of 0.46%. The ratio of female workers to the total working population is 14%.

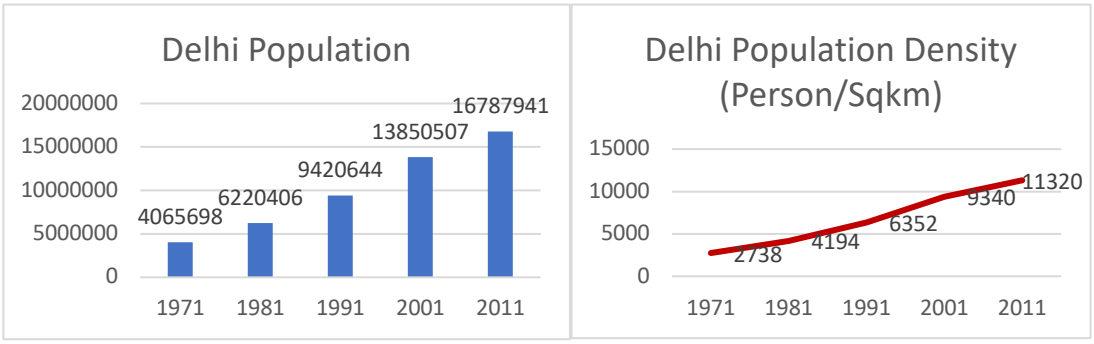


Fig.3.3: Delhi Population and Population Density from 1971-2011 (By Author)

The Gross State Domestic Product (GSDP) of Delhi at the current price during 2018-19 is INR 77965.2 million, with a growth of 12.98% over the GSDP level of 2017-18. The per capita income of Delhi on the current price is INR 365529 in 2018-19, which is 11.11% higher than the per capita income of INR 328985 during 2017-18. Delhi's per capita income is almost three times larger than the average per capita income of India. According to the Economic Survey of Delhi 2018-19, the service sector's economic contribution is 84.12% of Delhi's total income. The share of primary and secondary sectors on the total income of Delhi on the current price estimate is 1.88% and 14%. The revenue receipt of Delhi during 2017-18 is INR 3866.7 million. The revenue from Goods and Services (GST) Tax was INR 1362 million followed by Value Added Tax (VAT) (INR 1114.9 million), State excise (INR 445.3 million), stamp and registration including land revenue (INR 411.85 million), Grants and receipts from central Government (INR 218.4 million) and taxes on vehicles (INR 211.5 million).

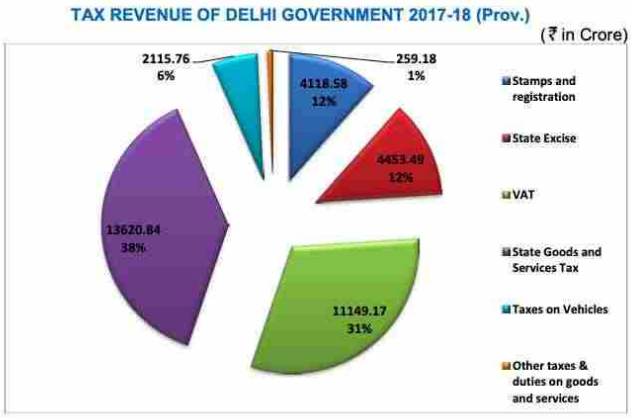


Fig.3.4: Tax Revenue of Delhi Government 2017-18
(Source: Chart 4.3, Economic Survey of Delhi 2018-19, 1 Crore = 10 Million)

The tax receipt from the stamp and registration, including land revenues, recorded the highest growth at 30.92% in the year 2017-18, followed by revenue receipt by taxes on vehicles with a growth of 16.97% over revenue receipt in the year 2016-17. Overall the share of VAT and GST on total revenue receipts of Delhi is 69.35%, followed by State Excise (12.47%), Stamp and Registration including land revenue (11.53%), and Taxes on Vehicle contributed 5.92% of total revenue during 2017-18.

The district area taken for analysis is nine revenue districts of Delhi, which is different from the eleven administrative districts of Delhi. The nine revenue districts have been selected as the unit of analysis because two districts Shahdara and South East Delhi, are created recently out of North East Delhi and South Delhi districts. The segregation of data for these two districts from their previous districts may invite potential measurement errors due to the bifurcation of data. Further, the Economic Census Reports have published the number of establishment and number of workers data as per nine revenue districts hence nine revenue district has been taken as the unit of analysis to minimize the measurement errors in data. The district areas of nine revenue districts are the sum of the Tehsil area under their jurisdiction. The jurisdiction of revenue districts of North Delhi, North West, New Delhi, and South West Delhi is different from their administrative boundaries. The difference in revenue district and administrative district can be depicted from the Fig.3.5 given below:

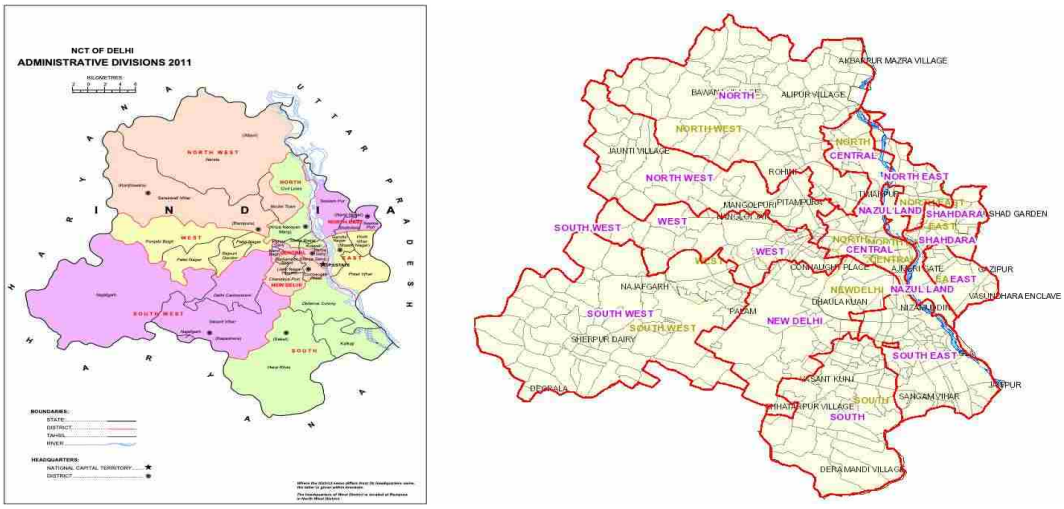


Fig. 3.5: Administrative and Revenue District Division of Delhi
(Source: Census of India 2011, Revenue Geo Portal Khasra Information, Geospatial Delhi Limited, http://gsdl.org.in/revenue/)

It is necessary to explain the jurisdiction area of each district of revenue districts. A brief detail of the revenue districts and its population, area (in Sq.KM.) and tehsil under the jurisdictions of nine districts of Delhi are as follows:

Table 3.1: Population Trend of Revenue Districts of Delhi (By Author)

Revenue District	Tehsil	1992	1998	2005	2012	2018	Area (Sqkm)
North Delhi	Narela, Model Town	762671	985779	1232585	1427371	1630538	289
North West Delhi	Rohini Khanjwala	1779837	1785575	2019474	2287801	2613206	151
North East Delhi	North East Shahdara	1220940	1628040	2002680	2277600	2601600	60
East Delhi	Mayur Vihar, Preet Vihar	1108224	1363648	1579072	1736768	1983808	64
Central Delhi	Central Delhi Karol Bagh Civil Lines, Kotwali	1360595	1408025	1447040	1493875	1706375	85
West Delhi	Punjabi Bagh, Patel Nagar, Rajouri Garden	1571091	1982472	2331417	2584128	2951649	129
New Delhi	Chanakyapuri, Delhi Cant, Vasant Vihar	206181	318711	344379	337776	385764	93
South Delhi	South Delhi & South East Delhi	1653250	2107000	2495250	2775750	3170500	250
South West Delhi	Dwarka, Najafgarh, Kapasheda	1183016	1469720	1833892	2136162	2440242	362
Total =		**10845805**	**13048970**	**15285789**	**1427371**	**19483682**	**1483**

The state of Delhi has recorded high literacy percentage of 86.2%, fourth-highest among states of India. Delhi is also known for good quality schools, colleges, universities, and research institutes, which attracts students from other parts of India to pursue their studies in Delhi. Delhi government has about 1227 government schools, which is 21.30% of the total schools in Delhi. Recently, the Government of Delhi has introduced 'happiness

curriculum and digital classrooms' in their schools to include moral education and impart quality education among the students. Other state governments are replicating this education model of Delhi in their schools. There are 218 higher educational institutions in Delhi in 2018-19, which include 100 professional colleges and institutes, 90 general education colleges, 4 institutes of national importance, 11 deemed universities, and 13 Universities. Total enrollment in the higher institutions is 1.027 million students, whereas the number of women enrollment is 496 thousand students during 2016-17.

Delhi has a total 1279 numbers of health institutions with a sanctioned bed of 57194. The health infrastructure in Delhi includes the Hospitals funded by Delhi Government, Municipal Corporations of Delhi, Government of India, other autonomous bodies, charitable trusts, and other private institutions. Seventeen medical colleges in Delhi provide undergraduate courses in Allopathy, Ayurveda, Unani & Homeopathy. Delhi government expenditure on public health schemes in 2017-18 was INR 19124 million, which is 13.28% of total spending in all government programs of the Delhi Government. The per capita expenditure on medical and public health in Delhi was INR 2492.58 during 2017-18.

The transportation infrastructure of Delhi is well developed. The city is known for the most number of motor car ownership in India. The number of vehicles in Delhi was 10.38 million in 2016-17, which increased to 10.98 million in 2017-18. The outward expansion of urban areas around Delhi has led to the substantial increase in vehicles in the National Capital Region cities of Gurugram, Faridabad, Ghaziabad, and Noida. The maintenance of Delhi's road network is the responsibility of multiple agencies such as four Municipal Corporations of Delhi, the Public Works Department of State Government, and the Delhi Development Authority. The public transportation operation in Delhi is the responsibility of Delhi Transport Corporation (DTC), Indian Railways Ring Rail Service, and Delhi Metro Rail Corporation Limited (DMRC) - a Special Purpose Vehicle (SPV), a Joint Venture of Government of NCT of Delhi and Government of India. Delhi's public transportation system is the lifeline of Delhi, as both DTC and DMRC carry more than 4 million passengers every day within Delhi and from the neighboring cities of Delhi. The ring rail services in Delhi is the most economical in Delhi. The ring rail system is used by the people of adjoining cities to commute daily to their workplaces in Delhi.

3.2 Phase- I, II and III of Delhi Metro Railway Network:

Delhi Metro Rail Corporation operates the metro railway network in Delhi. The total length of the metro railway network in Delhi is 389 kilometers, which carries an average of 4.7 million ridership per day. The physical construction of Phase-I of Delhi Metro was began on October 1, 1998, and the first line commenced operation from December 25, 2002. Phase-I of Delhi metro consists of three metro Lines with 59 stations with a route length of 65 km. Phase-I of Delhi MRTS project completed in November 2006.

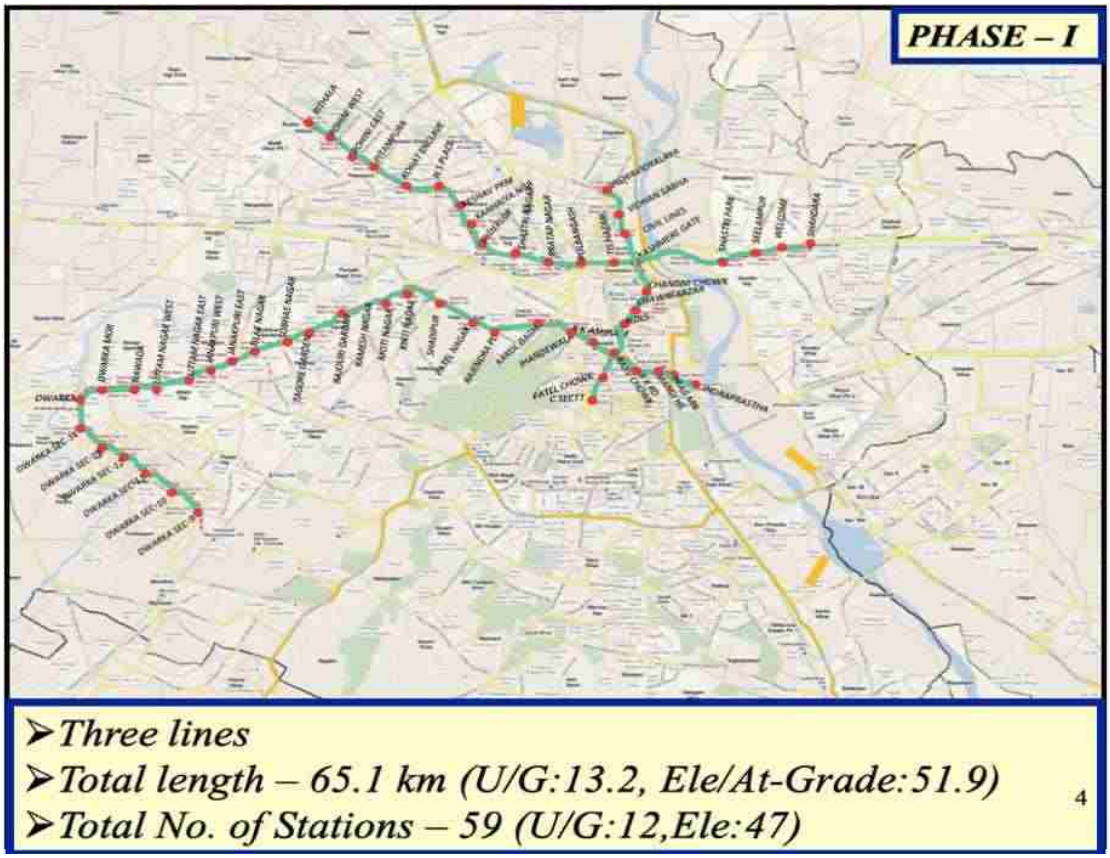


Fig. 3.6: Delhi Metro Phase-1 Network (Courtesy: Planning Department, Delhi Metro Rail Corporation Limited)

The Phase-II of Delhi Metro Network consists of 124.90 km of route length with 86 stations. The existing three lines extended and 4 new metro lines constructed, including Airport Express Line. The Phase-II of the Delhi Metro network expanded to neighboring city Ghaziabad, Noida, and Gurugram during Phase-II. The stations of the Phase-II network became operational from June 4, 2008, to August 27, 2011. Fig. 3.7 explains the index map of the Delhi Metro network after completion of the Phase-II network**.**

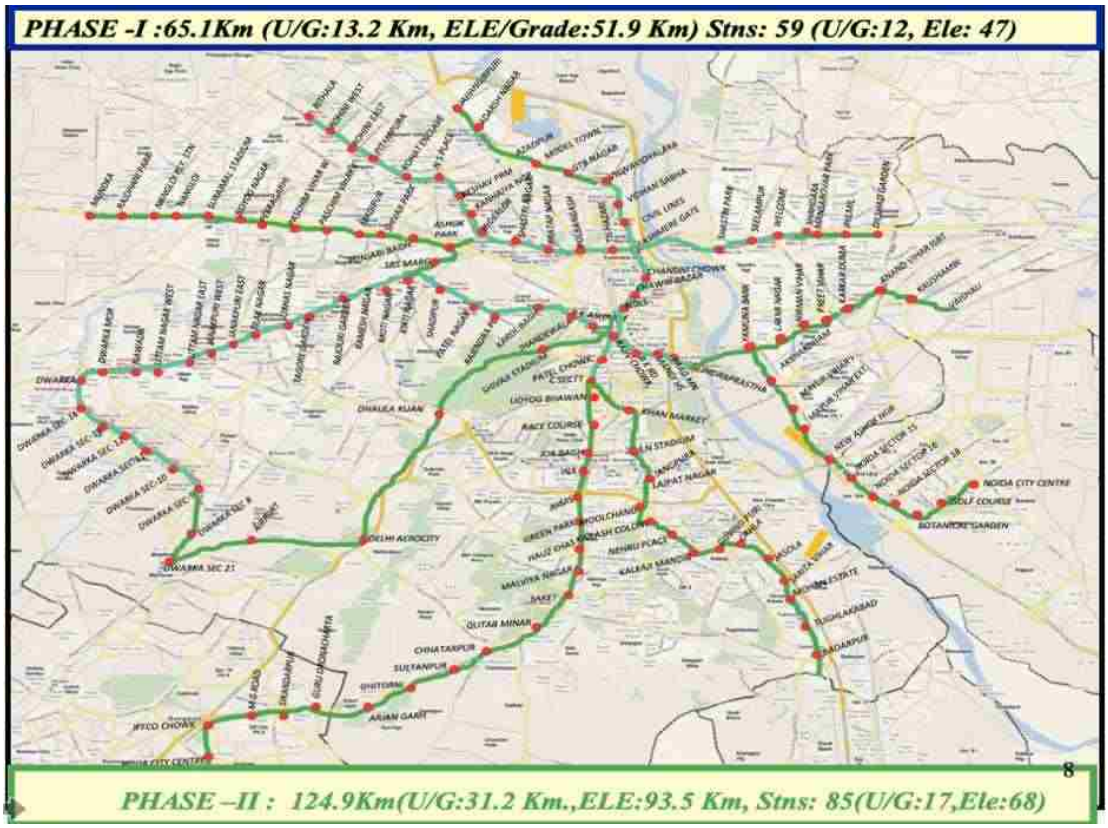


Fig. 3.7: Delhi Metro Phase-I & II Network (Courtesy: Planning Department, Delhi Metro Rail Corporation Limited)

The construction of Phase-III of Delhi Metro Network started soon after completion of Phase-II. The Phase-III of Delhi Metro project was completed in the year 2019, and the metro lines became operational in stages from 2015 to 2019. Table 3.2 provides the detail of commencement of the operation of sections of the metro network of Phase-I, II, and III.

Table 3.2: Commercial Operations of Delhi Metro Phase-I, II & III Network (By Author, Source: Delhi Metro Rail Corporation Limited and Wikipedia Page)

Corridor	No. of Stations	Districts Covered	Date of Commencement
Phase- I : 59 stations, 65 Km.			
Red Line (Line-1)			
Shahdara – Tis Hazari	6	North East Delhi, Central Delhi	25 December 2002
Tis Hazari - Inderlok	4	Central Delhi, North West Delhi	4 October 2002
Inderlok - Rithala	8	North West Delhi	1 April 2004
Yellow Line (Line-2)			
Vishvavidyalaya - Kashmere Gate	4	Central Delhi	20 December 2004
Kashmere Gate - Central Secretariat	6	Central Delhi, New Delhi	3 July 2005
Blue Line (Line-3)			

Barakhamba Road - Dwarka	22	New Delhi, West Delhi, South West Delhi	31 December 2005 / 1 January 2006 (for passenger)
Dwarka – Dwarka Sector 9	6	South West Delhi	1 April 2006
Barakhamba - Indraprastha	3	New Delhi	11 November 2006
Phase- II: 85 Stations, 124.93 KM			
Red Line (Line-1)			
Shahdara - Dilshan Garden	3	North East Delhi	3 June 2008
Yellow Line (Line-2)			
Vishvavidyalaya - Jahangirpuri	5	Central Delhi, North Delhi	3 February 2009
HUDA City Centre to Qutub Minar	9	South Delhi, Gurugram (Haryana)	21 June 2010
Central Secretariat – Qutub Minar	10	New Delhi, South Delhi	3 September 2010
Blue Line (Line-3 & 4)			
Indraprastha – Yamuna Bank	1	New Delhi, East Delhi	10 May 2009
Yamuna Bank – Noida City Centre	10	East Delhi, Noida (Uttar Pradesh)	13 November 2009
Dwarka Sector 9 – Dwarka Sector 21	2	South West Delhi	30 October 2010
Yamuna Bank – Anand Vihar	5	East Delhi	27 January 2010
Anand Vihar - Vaishali	2	East Delhi, Ghaziabad (Uttar Pradesh)	27 January 2010
Green Line (Line 5)			
Inderlok - Mundka	14	West Delhi	2 April 2010
Kirti Nagar – Ashok Park Main	2	West Delhi, North West Delhi	27 August 2011
Violet Line (Line 6)			
Central Secretariat – Sarita Vihar	13	New Delhi, South Delhi	3 October 2010
Sarita Vihar - Badarpur	3	South Delhi	14 January 2011
Airport Metro Express Line (Orange Line)			
New Delhi – Dwarka Sector 21	6	New Delhi South West Delhi	23 February 2011
Phase- III: 108 Stations, 159 KM			
Red Line (Line-1)			
Dilshad garden – Shaheed Sthal (Ghaziabad Bus Adda)	8	North East Delhi, Ghaziabad (Uttar Pradesh)	9 March 2019
Yellow Line (Line 2)			
Jahangirpuri – Samaypur Badli	3	North Delhi	10 November 2015

Blue Line (Line-3 & 4)			
Noida City Centre – Noida Electronic City	6	Noida (Uttar Pradesh)	9 March 2019
Green Line (Line 5)			
Mundka – Bahadurgarh -	7	Bahadurgarh (Haryana)	24 June 2018
Violet Line (Line 6)			
Central Secretariat – Kashmere Gate (Heritage Line)	7	New Delhi, Central Delhi	28 May 2017
Badarpur – Escort Mujesar	9	Faridabad (Haryana)	6 September 2015
Escort Mujesar – Ballabhgarh	2	Faridabad (Haryana)	19 November 2018
Pink Line (Line 7) , New Line on inner ring road			
Majlish Park – Durgabai Deshmukh South Campus	12	North Delhi North West Delhi West Delhi New Delhi	14 March 2018
Durgabai Deshmukh – Lajpat Nagar	6	New Delhi, South Delhi	6 August 2018
Trilokpuri – Shiv Vihar	15	East Delhi North East Delhi Ghaziabad (Uttar Pradesh)	31 October 2018
Lajpat Nagar – Mayur Vihar Pocket 1	5	South Delhi, East Delhi	31 December 2018
Magenta Line (Line 8), New Line on outer ring road			
Kalkaji Mandir – Botanical Garden	9	South Delhi, Noida(Uttar Pradesh)	25 December 2017
Janakpuri West – Kalkaji Mandir	16	West Delhi, New Delhi, South Delhi	29 May 2018
Grey Line (Line 9), New Line			
Dwarka - Najafgarh	3	South West Delhi	4 October 2019
Najafgarh – Dhasna Bus Stand	1	South West Delhi	December 2020 (Expected)
Airport Express Line (Orange Line)			
Dwarka Sector 21 – ECC Centre (Dwarka Sector 25)	1	South West Delhi	December 2020 (Expected)

The Phase-III network consists of 108 stations with a route length of 159 km. Out of this 159 km, a total of 103.05 kilometers metro lies within Delhi's state boundary is 103.05 km, with 67 stations. The Phase III project extended the existing 6 lines, and 2 new lines

constructed on the inner ring road and outer ring road of Delhi. One new line constructed to connect Najafgarh in South West Delhi. The total kilometer length and the number of stations increased significantly from the planned length of 103 KM due to the extension of the Delhi Metro network to Ghaziabad, Noida, Gurugram, and Faridabad. After completion of Phase -III, the Delhi Metro network consists of 285 stations with a total route length of 389 km. Fig. 3.8 shows the index map of the Delhi Metro Phase-3 corridor.

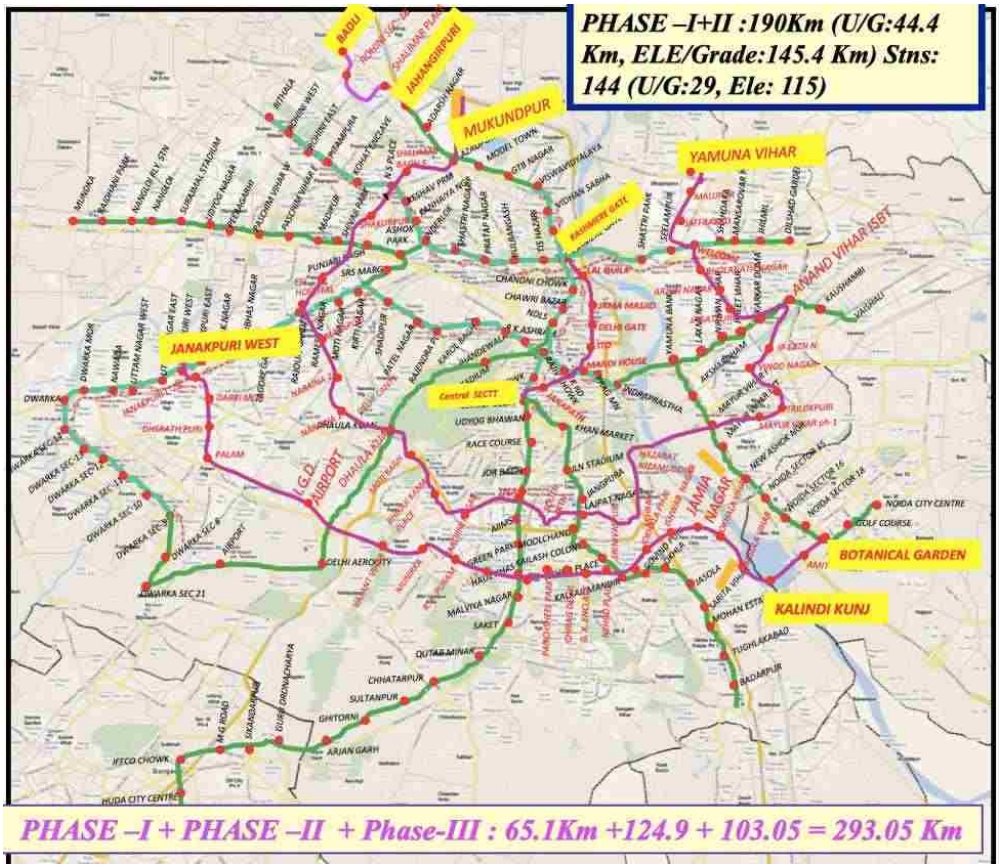


Fig. 3.8: Delhi Metro Phase-1, 2 & 3 Network (Courtesy: Planning Department, Delhi Metro Rail Corporation Limited)

The Phase-IV of Delhi Metro Network will further increase access to the most reliable high-speed public transportation system to the citizen of Delhi living away from the existing metro network. The Phase-IV of Delhi Metro network will add 103.93 km of route length and 79 number of stations in the existing Delhi Metro network by 2026. Phase-IV of Delhi Metro Project execution started with the commencement of construction on the three priority corridors. The Government has approved the First stage of Phase-IV to construct three priority corridors with 45 stations by 2024. The work of the remaining three corridors will be taken up by Delhi Metro Rail Corporation after the approval of the Government of India. The second stage of Phase-IV scheduled to be completed by the year 2026.

CHAPTER - 4
RESEARCH METHODOLOGY AND DATA

4.1 Research Methodology

The research objective of the study is to estimate the effect of the metro station on house prices and residential land prices in the National Capital Territory of Delhi. The research method has employed econometric models under research design 1, 2, and 3 to estimate the effect of chosen explanatory variables on the dependent variable of house price and residential price in Delhi. The research outline has been drawn under Fig.4.1 to show the methods used to generate primary and secondary data and empirical investigation of the effect of the expansion of the metro network in Delhi and its policy implications.

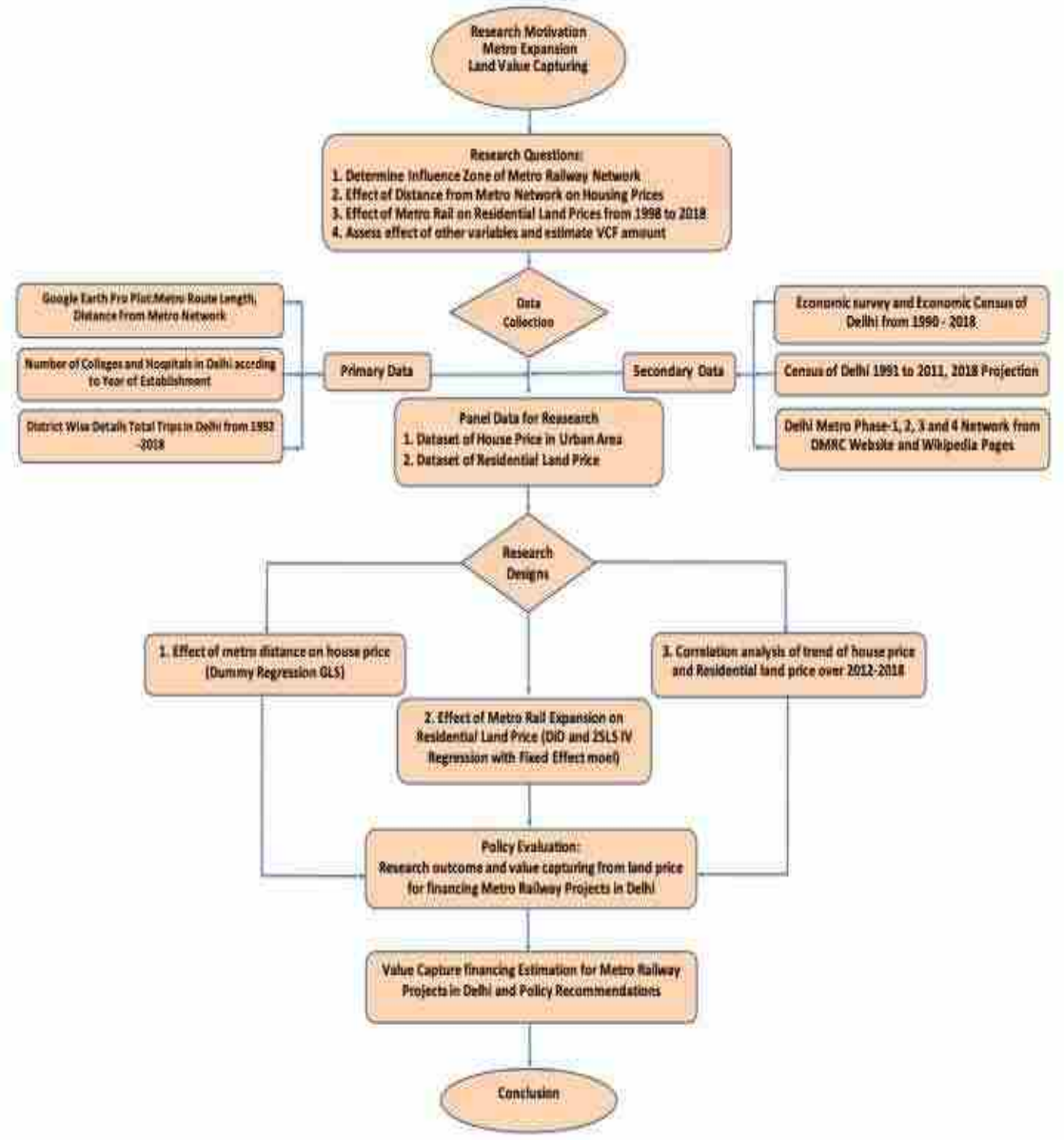


Fig.4.1: Flow Chart describing Research Methodology (By Author)

The unit of analysis for research question no. 1 is the urban areas of 9 districts for which house price data for the years 2012, 2014, 2015, and 2018 collected from the real estate website. The unit of analysis for research question no. 2 is districts of the National Capital Territory of Delhi. The data of dependent variable of residential land price and explanatory variables representing number of stations, colleges, hospitals, business establishments, workers, population density collected as secondary data from the Annual Economic Survey Reports, Economic Census of Delhi, Economic Census of India, Census Reports, and Notifications issued by Government of Delhi and Government of India. The Google Earth Pro and My Google Map have been used to generate primary data for the distance of urban area centroid from the metro station, and length of the metro route in each revenue district. The primary data of total trips (including generation and attraction) generated with the help of Ex-Traffic Expert of Delhi Metro Rail Corporation. These primary and secondary data are tabulated for the panel years 1992, 1998, 2005, 2012, and 2018 to carry out research investigation using econometrics models.

Cut-off Date for the inclusion of data in Panel Year: Thesis research has used the dependent variable of house prices and residential land prices. The house price data corresponds to panel the year 2012, 2015, and 2018, while the residential land price data correspond to the panel years 1992, 1998, 2005, 2012, and 2018. Data for explanatory variables consist of population density, the number of metro stations, business establishment, workers, colleges, and hospitals during panel years 1992, 1998, 2005, 2012, and 2018. The primary variable data represents the distance of urban area centroid from the metro railway network during the years 2012, 2015, and 2018. The data of instrument variables are represented by metro route length and total trips in each district of Delhi during the panel years 1992, 1998, 2005, 2012, and 2018. The cut-off month for the inclusion of the primary data, secondary data, and instrument variables are described below with reasons for their inclusion for a particular year:

Variable representing	Variable Type	Cut Off Month and Year	Remarks
House Price	Dependent Variable (Research Design 1)	June - December of corresponding year	Mid-year data
Residential Land Price	Dependent Variable (Research Design 2)		

Population Density	Explanatory variable	March of corresponding Year	Last month of Financial Year
Number of Business Establishments	Explanatory variable		
Number of Workers	Explanatory variable		
Number of colleges	Explanatory variable		
Number of Hospitals	Explanatory variable		
Distance from metro station	Explanatory variable (Variable of interest in Research Design 1)	December of corresponding Year	Commencement of operation of metro system takes 6 to 9 months after construction to carry out safety trials and get a safety certificate from the Commissioner Metro Railway Safety (CMRS). The price of residential property already increases in anticipation of opening of metro station after construction of metro physical infrastructure and before the start of commercial operation of the metro station.
Number of metro station	Explanatory variable (Variable of interest in Research Design 2)		
Metro route length	Instrument Variable		
Total Trips	Instrument Variable	March of corresponding Year	Last month of Financial Year

4.2 Primary Data:

The primary data of the explanatory variable of metro route length in each district of Delhi and distance of urban area from the metro network have been created by using Google Earth Pro by plotting the metro network in nine districts of Delhi. The centroids of the urban area, chosen for house price analysis, are place-marked on the Google Earth Pro map. The distance between the urban area centroids and the metro rail network is measured using the measurement tool on Google Earth Pro. Fig. 4.2 shows the Google Earth Pro plot of the district-wise metro rail network and the distance of urban area centroids in a different color for each district.

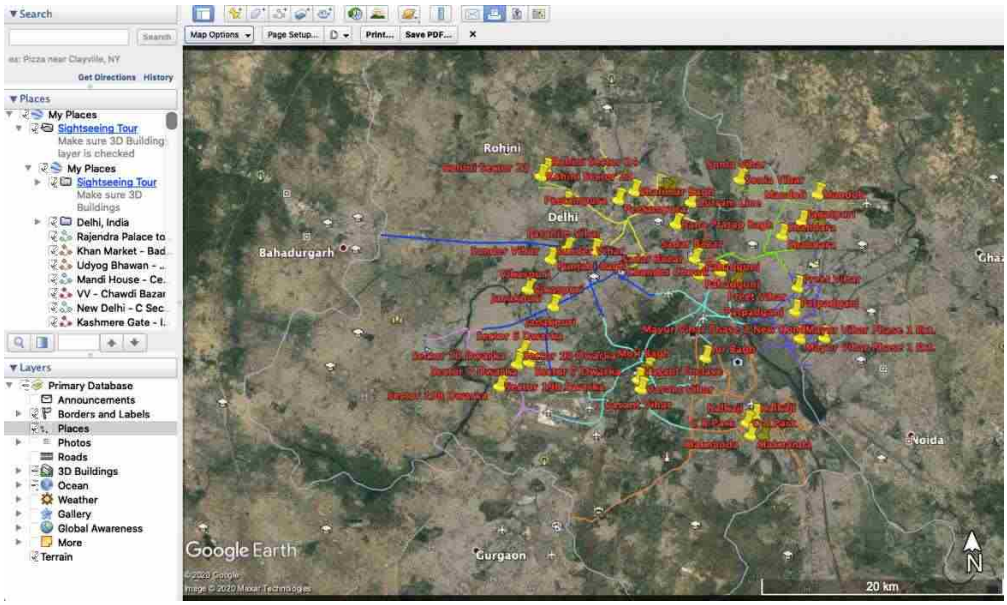


Fig.4.2: Metro Network and Urban Places plotted on Google Earth Pro (By Author, Google Earth Image Landsat/Copernicus ©2020 Google image © 2020 Maxar Technologies)

The accuracy of the plot has been checked by superimposing Google Earth Pro Plot (Fig. 4.2) on My Google Map to ensure that the distance measured on Google Earth is the same as measured from My Google map. The superimposed plot has perfectly matched on Google Map plot shown in Fig.4.3. The deviation in the metro route network is observed at some places because of modification in the Delhi Metro network alignment. **Appendix 2** details the Google Earth Pro and My Google Map plots, and its district wise bifurcation and layer details with latitude and longitude**.**

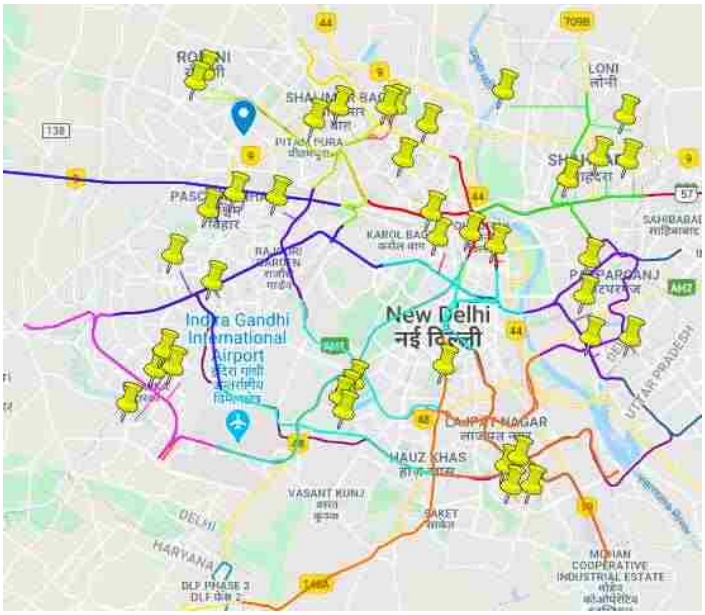


Fig.4.3: Metro Network and Place marks superimposed on Google My Map (By Author, Map Data ©2020)

Metro Rote Length and Distance from the Metro Network: The distance of the metro route length and the distance of urban places centroid from the nearby metro network measured from the Google Earth distance measurement tool. **Appendix 2** details the geodata layer of distance measurement of the route length and urban area centroid from the metro network. **Appendix 3** tabulates the distance of metro route length in kilometers for each district during the years 1992, 1998, 2005, 2012, and 2018. It is to mention that the Barakhamba – Dwarka section of Phase-I network inaugurated on December 31, 2005, but open for passengers from January 1, 2006, hence this section is not included in the panel year 2005. Each panel year represents the cumulative metro network length of each district up to December of the corresponding year. Table 4.1 provides district wise length of the metro railway network in different panel years.

Table.4.1.: District Wise Metro Route Length in kilometres (cumulative)

Districts	1992	1998	2005	2012	2018
North Delhi	0	0	0	6.36	15.09
North West Delhi	0	0	8.82	12.45	17.19
North East Delhi	0	0	6.36	9.51	18.68
East Delhi	0	0	0	11.97	25.57
Central Delhi	0	0	12.06	12.06	15.44
West Delhi	0	0	0	29.4	48.15
New Delhi	0	0	3.65	33.55	64.38
South Delhi	0	0	0	37.1	58.28
South West Delhi	0	0	0	14.18	14.18
Total (kilometre)	0	0	**30.89**	**166.58**	**276.96**

Number of Colleges and Hospitals: Other primary variables representing the number of colleges and the number of hospitals in each district of Delhi have been created by searching their location on Google Maps. Then the year of their establishment was confirmed from the webpage of these institutions. The criteria for selection of the data are campus area in case of colleges and the universities, and the number of beds in case of hospitals. For example, a hospital with at least 50 beds qualifies for inclusion in the district level panel data. Similarly, engineering, medical, law, and other reputed educational institutions with large campus areas have qualified as representative data because the educational institution campus size may affect the house price and residential land price. Data representing the number of hospitals and colleges are tabulated for the

panel years 1992, 1998, 2005, 2012, and 2018 based on their year of establishment, as shown in Table 4.2 & 4.3. **Appendix 3** provides the details of colleges and hospitals selected for creating the panel data**.**

Table.4.2: District Wise Number of Colleges established before Panel Year(Cumulative)

Districts of Delhi	Number of Colleges Established before Panel Years				
	Before 1992	1992-1998	1998-2005	2005-2012	2012-2018
North Delhi	1	1	3	3	3
North West Delhi	8	12	16	22	23
North East Delhi	2	3	5	6	6
East Delhi	4	6	8	8	8
Central Delhi	15	15	15	15	16
West Delhi	8	11	14	16	17
New Delhi	29	30	32	34	34
South Delhi	15	15	16	17	17
South West Delhi	3	7	8	16	18

Table.4.3: District Wise Cumulative Number of Hospitals with more than 50 beds and Area >1 acre

Districts of Delhi	Before 1992	1992-1998	1998-2005	2005-2012	2012-2018
North	3	4	6	7	10
North West	3	12	15	18	19
North East	3	4	7	10	12
East	4	8	11	15	15
Central	3	5	6	6	6
West	6	8	10	13	14
New Delhi	14	16	17	19	19
South	8	14	19	24	26
South West	2	3	4	11	13
Total =	46	74	95	123	134

Trips Generated and Attracted in District: A trip may be defined as one way movement of a person by mechanized means of transportation. The transportation researchers classify trip under 'trip generation' and 'trip attraction' to describe the number of the trips a region generates and trips a region attracts from the other regions of the city. A place with high residential colonies will produce a large number of trips, whereas the commercial centre (CBD) attracts trips toward the CBD. The mixed land use zone with residential and commercial activity produces as well as attracts the trips. The trip generation and attraction model is an important criteria for the planning of transit system. The transportation planners split the total trips in terms of mode of use such as

bus, train, car, etc., and the share of each mode of transportation is estimated to plan a public transportation system.

Table 4.4: District Wise Trip Generation and Attraction (D. Mukhopadhyay, 2020)

TRIPS PRODUCED
One way vehicular trip

NO	DISTRICT	1992	1998	2005	2012	2018
1	NORTH WEST	670704	835439	1078386	1391941	1733658
2	SOUTH EAST	650244	824163	1085638	1430026	1812342
3	NORTH EAST	276509	377798	543229	781074	1067094
4	EAST	377524	510727	725915	1031740	1395642
5	NEW	204968	235653	277038	325689	374402
6	CENTRAL	217248	232730	251948	272745	292155
7	NORTH	613016	750784	950190	1202521	1472634
8	WEST	378035	474968	619297	807457	1014405
9	SOUTH WEST	383415	465712	583741	731659	888622
10	SOUTH	374376	506468	719863	1023137	1384004
11	EXTERNAL	1082116	1376613	1825010	2429454	3121744
		5228154	6591054	8660256	11427434	14556703

TRIPS ATTRACTED
One way vehicular trip

NO	DISTRICT	1992	1998	2005	2012	2018
1	NORTH WEST	156845	197732	259808	342823	436701
2	SOUTH EAST	522815	659105	866026	1142743	1455670
3	NORTH EAST	313689	395463	519615	685646	873402
4	EAST	418252	527284	692820	914195	1164536
5	NEW	914927	1153435	1515545	1999801	2547423
6	CENTRAL	967209	1219345	1602147	2114075	2692990
7	NORTH	365971	461374	606218	799920	1018969
8	WEST	444393	560240	736122	971332	1237320
9	SOUTH WEST	392112	494329	649519	857058	1091753
10	SOUTH	731942	922748	1212436	1599841	2037938
11	EXTERNAL	NA	NA	NA	NA	NA
	TOTAL	5228154	6591054	8660256	11427434	14556703

The variable of the number of stations has instrumented by the variable of log of total trips in each district. Research design 2 uses the instrumental variable of log of total trips for the number of metro stations because trips are exogenous to the residential land price, a dependent variable, and variable trips have a high correlation with the number of metro stations. The total number of trips for each district is the summation of the trip generation and trip attraction for each district as shown below:

Districts	1992	1998	2005	2012	2018
North Delhi	978987	1212158	1556408	2002441	2491603
North West Delhi	827549	1033171	1338194	1734764	2170359
North East Delhi	590198	773261	1062844	1466720	1940496
East Delhi	795776	1038011	1418735	1945935	2560178
Central Delhi	1184457	1452075	1854095	2386820	2985145

West Delhi	822428	1035208	1355419	1778789	2251725
New Delhi	1829854	2306870	3031090	3999602	5094846
South Delhi	1106318	1429216	1932299	2622978	3421942
South West Delhi	775527	960041	1233260	1588717	1980375

Table 4.4 and Appendix 3 shows the detail of trip generation and trip attraction in each district of Delhi. D. Mukhopadhyay, Ex. Scientist Central Road Research Institute (CRRI) India and Ex. Traffic Expert/DMRC, prepared this trip generation and trip attraction data of each district of Delhi for the panel year 1992, 1998, 2005, 2012, and 2018 to facilitate this thesis research.

4.3 Secondary Data:

Population Census of Delhi, Economic Survey of Delhi, and Economic Census of Delhi published between 1990 to 2018 are the source of the data for the variables representing population density, number of business establishments, and number of workers in each district. The Population data for the years 1992 and 1998 is estimated from the annual population growth rate between 1991 to 2001. Similarly, the population in the year 2005 is estimated by the annual growth rate between 2001 and 2011. Population data for years 2012 and 2018 are estimated from the 2011 population data and projected population data for the year 2018. The district population of each district for the years 1992, 1998, 2005, 2012, and 2018 is divide by the district area to estimate the population density (person / Sq.km) data, as shown below:

Table 4.5: District wise population density (person/Sq.km.) in Delhi

Districts	Area (Sq.km.)	1992	1998	2005	2012	2018
North	289	2639	3411	4265	4939	5642
North West	151	11787	11825	13374	15151	17306
North East	60	20349	27134	33378	37960	43360
East	64	17316	21307	24673	27137	30997
Central	85	16007	16565	17024	17575	20075
West	129	12179	15368	18073	20032	22881
New Delhi	93	2217	3427	3703	3632	4148
South	250	6613	8428	9981	11103	12682
South West	362	3268	4060	5066	5901	6741

Economic Census of India Report 1990 and Fourth, Fifth and Sixth Economic Census of Delhi published in the years 1998, 2005, and 2013 are the source of data for the number of business establishments and the number of workers in each district of Delhi. The

district-wise number of business establishment and workers data was not available before the year 1995. Hence, the data representing the number of business establishments and workers in each district during 1992 estimated from the Economic Census of India 1990 Report data. The data for the panel year 1992 projected from 1990 data based on the district's proportional share of business establishment and workers during 1998. Similarly, data of these two variables for the year 2018 is estimated using the growth rate observed between 2005 and 2012 in each district. Table 4.6 and 4.7 describe the panel data of the number of establishments and the number of workers.

Table 4.6 District wise number of business establishments in Delhi

Districts wise Establishments	1990	1998	2005	2012	2018
North Delhi	21263	64819	71785	73724	75715
North West Delhi	38825	98925	131075	93297	66407
North East Delhi	28885	84511	97518	158335	257080
East Delhi	28281	71688	95479	80061	67133
Central Delhi	23870	67213	80587	150671	281705
West Delhi	30017	98925	101339	106726	112399
New Delhi	4044	35478	13654	38153	106610
South Delhi	31042	109735	104800	57126	31139
South West Delhi	18218	54557	61506	117215	223382
Total =	**224446**	**685852**	**757743**	**875308**	**1221571**

Table 4.7 District wise number of workers in Delhi

District wise Workers	1990	1998	2005	2012	2018
North Delhi	167396	330863	347531	318960	529162
North West Delhi	255475	504952	530390	286189	807589
North East Delhi	218253	431381	453113	412976	689924
East Delhi	185135	365923	384357	215979	585234
Central Delhi	173580	343085	360369	599058	548709
West Delhi	255475	504952	530390	313574	807589
New Delhi	91624	181097	190220	269225	289635
South Delhi	283394	560135	588353	145304	895845
South West Delhi	140896	278484	292513	458516	445390
Total =	**1771227**	**3500872**	**3677236**	**3019781**	**5599077**

The number of metro stations of each district of Delhi during the panel year 1992, 1998, 2005, 2012, and 2018 counted from the Delhi Metro Phase network based on the start of passenger services of metro stations. The number of stations is nil for the panel years 1992 and 1998 because no metro stations were operational during these two years. The first metro corridor became operational for passenger service on December 25, 2002. The

variable of the metro station is the variable of interest in research design 2, which estimates the causal effect of the metro stations on the residential land price in the district of Delhi. Table 4.8 provides the data of the number of metro stations operational during the panel year 1992, 1998, 2005, 2012, and 2018.

Table 4.8: Number of metro stations in districts of Delhi

Districts	Number of Metro Station (Cumulative)				
	1992	1998	2005	2012	2018
North Delhi	0	0	0	5	10
North West Delhi	0	0	8	11	12
North East Delhi	0	0	4	7	14
East Delhi	0	0	0	10	19
Central Delhi	0	0	12	12	16
West Delhi	0	0	0	27	39
New Delhi	0	0	4	20	38
South Delhi	0	0	0	27	43
South West Delhi	0	0	0	11	11
TOTAL =	**0**	**0**	**28**	**130**	**202**

The dependent variable of research design 1 is the house price in the selected urban area of Delhi. Four to six urban areas of each district of Delhi chosen for the research based on the following criteria:

1. Each district should represent the dominant residential land use form of the district. For example, Zone D residential land use should be selected for the analysis of movement in house prices if most of the residential urban areas of that district have zone D type land category.
2. The urban area selected within a district should have the same land category type. It helps to make a valid comparison of house price movement in the urban area of districts.
3. The urban area situated adjacent to each other should be preferred for study. The urban area selected in the district should not be situated far away from each other because the house prices within the same district may fluctuate due to the location of the urban area and its distance from CBD.

The above criteria helped to choose urban areas in all nine districts of Delhi; however, in some districts such as Central Delhi and New Delhi, the selected urban area situated away from each other. The selected area in these two districts represents similar characteristics and the same land use category, making these urban areas comparable. The average

house price of selected urban locations has been taken from 99acre.com for the years 2012, 2014, 2015, and 2018. **Appendix 4** tabulates the average house price and distance of these urban areas centroid from the metro network.

The source of the residential land price data is the Government records disclosed by the Land and Development Office, Delhi Division, Ministry of Urban and Housing Affairs, Government of India, and Delhi Development Authority for the year from 1987 to 2018. Appendix 5 has tabulated the residential land price data of the dominant residential land category of each district for panel period 1992, 1998, 2005, 2012, and 2018. Table 4.9 gives detail about the district-wise urban areas selected for data collection and their dominant residential land use category.

Table 4.9 District wise urban area selected for study and dominant land category

District	Selected Urban Area	Residential Land Category
North Delhi	Outram Line, Model Town Phase II, Model Town Phase III, Rana Pratap Bagh	Category 'D'
North West Delhi	Shalimar Bagh, Pitampura, Rohini Sector 23, Rohini Sector 24	Category 'D'
North East Delhi	Dilshad Garden, Shahdara, Mandawali, Sonia Vihar	Category 'F'
East Delhi	Preet Vihar, Mayur Vihar Phase I, Patpadganj, Mayur Vihar Phase III New Kondli	Category 'D'
Central Delhi	Chandni Chowk, Darya Gunj, Sadar Bazar, Pahad Gunj	Category 'E'
West Delhi	Punjabi Bagh, Janakpuri West, Paschim Vihar, Vikaspuri, Sunder Vihar	Category 'D'
New Delhi	Vasant Vihar, Moti Bagh, Anand Niketan, Vasant Enclave	Category 'B'
South Delhi	C R Park, Kalkaji, Kalkaji Ext., Alaknanda	Category 'C'
South West Delhi	Dwarka Secto 10, Dwarka Sector 6, Dwarka Sector 7, Dwarka Sector 19B.	Category 'D'

In addition to the above, the data for revenue earning of four municipal corporations of Delhi taken from their annual revenue statement records. The revenue earning data will help to estimate the share and value of revenue attributed to property tax earned by the Municipal Corporation, which depends the existing residential land prices. Table 4.10 provides a statement of the revenue income received by four Municipal Corporations of Delhi and the Government of NCT of Delhi with the percentage share attributed to revenue from property tax and stamp duty.

Table 4.10: Revenue share of property tax and stamp duty

(Actual receipts audited values in million INR)

Government and Local Authority	Total Own Tax Revenue 2016-2017	Revenue Share of Property Tax# & Stamp Duty*	Revenue from Property
Delhi Government	311480	6.14%	19130
New Delhi Municipal Corporation	6431	84.5%	5437
North Delhi Municipal Corporation	15056	40.7%	6132
South Delhi Municipal Corporation	21773	41.4%	9010
East Delhi Municipal Corporation	6213	29.4%	182.8
Total =	360953	11.05%	39891.8

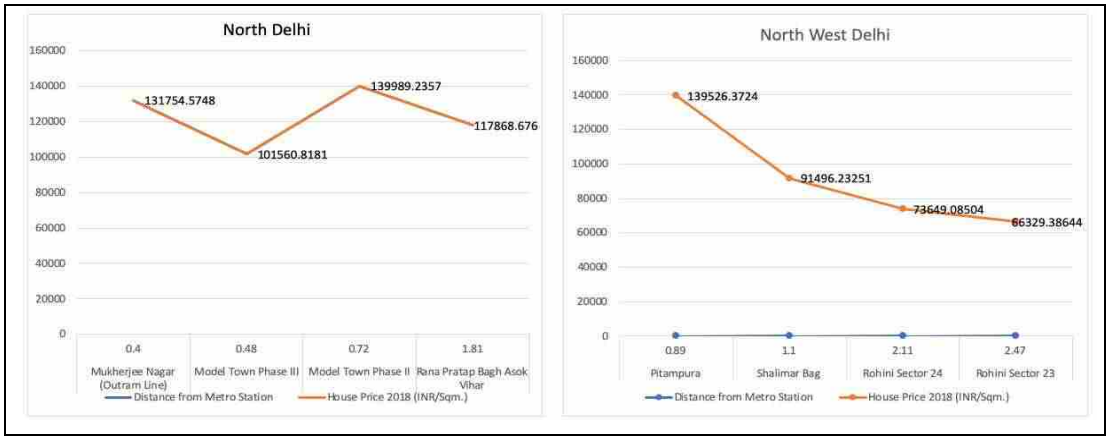
(Source: Fifth Delhi Finance Commission 2016-2021,table 5.6, page 57 & Table 6.4 page 90)
***Delhi government earn revenue from stamp duty**
#Municipal Corporations earn revenue from property tax

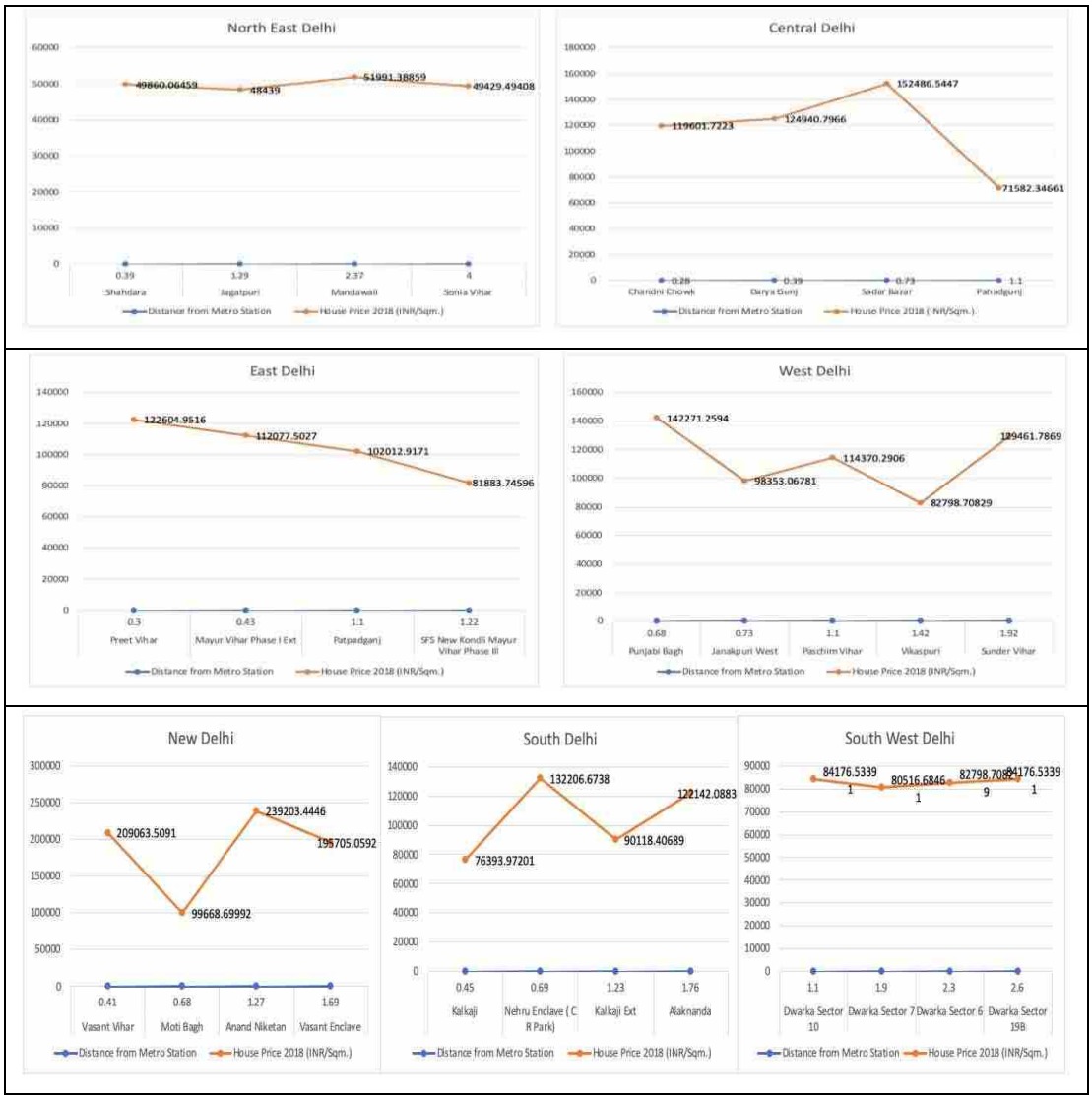
The data suggest that the total revenue earning from property tax and stamp duty was INR 39891.8 million out of total tax revenue of INR 360,953 million collected in Delhi during 2016-2017.

4.4 Data for Dummy Variable Identification:

The distance from the metro station of urban area centroids of each district is used to estimate the influence zone distance of the metro network for each district. The study of available literature suggests that the slope of the house price trend changes abruptly after the influence area of the metro network. This change in slope has been captured by plotting the house price trend in each district with respect to distance from the metro network. The influence zone distance of the metro network is the distance where the house price slope changes. **Figure 4.4** describes the graphs plotted to determine influence zone distance of nine districts of Delhi**.**

Fig 4.4: House Price Trend in districts and influence zone distance





The influence zone distance of the metro network for each district observed in each district of Delhi. The pattern suggests that the house price falls after a certain distance from the metro station in seven districts, namely North Delhi, North West Delhi, North East Delhi, East Delhi, West Delhi, New Delhi, and South West Delhi. In other words, the distance from the metro station affects the average house price of the urban area. The average house price near the metro network is lower in North Delhi, North East Delhi, Central Delhi, New Delhi, and South Delhi districts. High average house price near the metro network observed in North West Delhi, East Delhi, West Delhi, and South West Delhi district.

The influence area distance of the metro network is the distance where the change in the slope of the average house price trend observed. The influence area distance for each district tabulated below based on the above graphical analysis. **Table 4.12**

estimates the median distance of 0.730 kilometers for nine districts of Delhi. This median influence zone distance is the identification criteria for dividing the urban areas into two categories, that is the urban areas situated within and outside the influence zone distance of the metro station.

Table. 4.11: Influence Zone distance of metro network

District	Influence area distance (kilometres)	Median Distance (kilometres)
North Delhi	0.48	**0.73**
North West Delhi	1.1	
North East Delhi	1.29	
East Delhi	1.1	
Central Delhi	0.39	
West Delhi	0.73	
New Delhi	0.68	
South Delhi	0.69	
South West Delhi	1.9	

The binary value of the dummy variable depends on the median value of the influence zone distance. If the distance of urban area centroid from the metro station is less than 0.73 kilometers, then the binary value of the dummy variable will take the binary value 1, otherwise 0 for urban areas whose centroid situated beyond 0.73 kilometers. The dummy variable of nearness to the metro will provide a comparison of house price movement in the area situated within influence zone distance with those urban areas situated beyond that distance.

Two dummy variables introduced in research design 2. Treatment year dummy will take the value of 1 for the panel year 2005, 2012 and 2018, and binary value 0 for the years 1992 and 1998 because there was no metro network during these panel years. Another dummy variable in research design 2 represents metro rail density estimated as the metro route kilometers per square kilometer of the district area. The median value of the metro rail density of nine districts has taken as the identification criteria to divide the nine districts into treatment and control groups of districts. The Median value of the percentage area covered within the influence zone of each district (2 x influence zone distance x metro route length) gives another identification strategy to divide nine districts into treatment and control groups of districts. Table 4.12 gives the median value of the metro rail density and the percentage of influence area of the metro railway in each district:

Table. 4.12: Metro Density and Percent Metro Influence Area

District name	District Area (Sq.km)	Influence Area Distance (km)	Metro Route Length 2018 (km)	Percentage Metro Influence Area	Metro Density (km./Sq. km.)
	1	2	3	4 = (2*2*3)*100/(1)	6 = 3/1
North Delhi	289	0.48	15.09	5.01%	0.05
North West Delhi	151	1.1	17.19	25.05%	0.11
North East Delhi	60	1.29	18.68	80.32%	0.31
East Delhi	64	1.1	25.57	87.90%	0.40
Central Delhi	85	0.39	15.44	14.17%	0.18
West Delhi	129	0.73	48.15	54.50%	0.37
New Delhi	93	0.68	64.38	94.18%	0.69
South Delhi	250	0.69	58.28	32.17%	0.23
South West Delhi	362	1.9	14.18	14.89%	0.04
			Median Value =	**32.17%**	**0.23**

The treatment group of districts and control groups of districts has been grouped based on the median values of Metro Railway Density. North Delhi, North West Delhi, Central Delhi, and South West Delhi have grouped under Control Group districts because metro rail density in these districts is less than the median value of metro rail density. The remaining five districts, North East Delhi, East Delhi, New Delhi, West Delhi, and South Delhi, have grouped under Treatment Group Districts. This grouping of these districts will help us to estimate the difference in residential price trends in the treatment and control group districts using Difference in Difference (DiD) regression model.

CHAPTER-5
RESEARCH DESIGN

The research design will use the two-panel dataset created from the primary and secondary data collected to enquire the research questions. The first dataset of the research design is '**house_price_thesis.dta'**, which is used to estimate the effect of distance from the metro station on the house prices of urban areas. The second dataset '**res_land_price_thesis.dta**' comprises data of dependent variable residential land price for the panel years 1992, 1998, 2005, 2012, and 2018 and explanatory variables of the number of metro stations, population density, business establishment, workers, colleges, hospitals, metro length, and trips in each district..

Research design 1 used learning from the literature on the Hedonic price model for estimating the effect of metro stations on the house prices. Research design 1 employs the dummy variable of nearness to the metro station to analyze the difference in percentage change in average house prices of the urban area located within influence zone distance of 0.73 kilometers with those located between 0.73 to 4 kilometers. Research design 2 took inspiration from the literature on empirical strategies used for estimating policy treatment of infrastructure projects on welfare and economic gain. Research design 2 uses the Difference in Difference (DiD) with Generalized Least Square (GLS) regression model to estimate the difference in residential land price trends in the treatment and control group districts due to policy treatment of the introduction of the metro railway system in Delhi. Research design 2 also estimates the effect of metro stations and other control variables on the percentage change in mean residential land price from 1992 to 2018 using the Two Stage Least Square Instrument Variable (2SLS IV) Fixed Effect Regression model. Research design 3 is a graphical analysis method to estimate the correlation between the house price movement and the residential land price trends in the urban areas. **Appendix 6** details the programming codes of the research models on STATA and the regression results of three research designs**.**

5.1 Research Design 1: Effect of distance from metro network on the house price

This research design aims to estimate the effect of distance from the metro network on the average housing price of urban areas of the districts. Research design 1 uses house price movement from the years 2012, 2015, and 2018. The effect of the distance from

the metro network on the average house prices of urban areas of a Delhi falling within the influence distance of metro network and those situated away from the influence distance can be estimated simultaneously from the following regression equations:

$$\textbf{log (house\_Price)}_{it} = \beta_0 + \beta_1 \textbf{ station\_distance}_{it} + \textbf{u}_{it} \quad (\textbf{ if } \textbf{d}_{\textbf{i, near\_metro}} = \textbf{0})$$

$$\textbf{log (house\_Price)}_{it} = \beta_0 + \beta_1 \textbf{ station\_distance}_{it} + \textbf{u}_{it} \quad (\textbf{ if } \textbf{d}_{\textbf{i, near\_metro}} = \textbf{1})$$

The coefficient β_1 will give two estimates of the effect of increasing distance from the metro station on average house price change in urban areas situated within influence zone when $d_{i, near\_metro} = 1$, and effect on average house price of the urban area situated outside of influence zone between 0.730 kilometers to 4 kilometers when $d_{i, near\_metro} = 0$.

The above model will estimate the coefficients to explain the impact of distance on the percentage change in average house prices. It does not provide differences in the average house price of the urban areas situated within the influence zone (0.730 kilometers) and beyond the influence zone distance. This difference can be estimated by introducing a dummy variable 'nearness to metro'. The intercept shift due to the dummy variable is given by δ_0**.** The coefficient of interaction term of station distance δ_1 will estimate the percentage difference in the house prices of the urban areas within influence area distance and between 0.73 kilometers to 4 kilometers. The following equation gives the GLS regression model for estimating the percent difference in average house price:

$$\textbf{log (house\_Price)}_{it} = \beta_0 + \delta_0 * \textbf{d}_{\textbf{i,near\_station}} + \delta_1 * \textbf{d}_{\textbf{i,near\_station}} \textbf{ station\_distance}_{it} + \beta_1 \textbf{ station\_distance}_{it} + \textbf{u}_{it}$$

Where subscript 'i' represents the urban area of the urban area, 't' represents the year 2012, 2015, and 2018. log(house price) is the change in house prices recorded during 2012, 2015, and 2018 for urban areas, and station_distance corresponds to the distance from the metro station during the year 2012, 2015, and 2018. The distance from metro stations varies according to year as some metro stations became operation between 2015 to 2018 in the urban areas of South Delhi and New Delhi districts. It resulted in a reduction of distance from metro networks in urban areas of these districts. The dummy variable $\textbf{d}_{\textbf{i, near\_metro}}$ represents the binary value such that it takes $\textbf{d}_{\textbf{i, near\_metro}} = 1$ if urban area centroid is within 0.730 kilometers, and takes a value of 0 otherwise. Term $\textbf{u}_{it}$ represents the other extraneous variables and error term in the equation.

5.2 Research Design 2: Effect of metro railway expansion on change in residential land price

DID Method of Estimation: The difference in difference (DiD) regression model estimates the effect of the introduction of the metro railway network on the residential land prices in treatment and control group districts. The treatment year dummy divide the panel data years 1992, 1998, 2005, 2012 and 2018 into two categories such that:

$\mathbf{d_{1treated\ year\ (2005\text{-}2018)}}$ **= 1, (**If the year corresponds to treatment years 2005, 2012 and 2018 when metro stations became operational in districts.)

$\mathbf{d_{1treated\ year\ (2005\text{-}2018)}}$ **= 0, (**If the year corresponds to the year 1992 and 1998 when there was no metro stations in districts.)

The 9 districts of Delhi are further into grouped as treatment group districts and the control group of districts based on the metro railway density in a district. A dummy variable has been introduced to differentiate between the treatment and control group districts. The dummy variable representing treated districts takes a binary value equal to 1 if the district's metro rail density is more than 0.23 kilometers / Sq. kilometer area of the district, otherwise 0 as given below:

$\mathbf{d_{2treated\ \_district}}$ **= 1, (**If metro railway density is **more** than 0.23 km/ Sqkm)
$\mathbf{d_{2treated\ \_district}}$ **= 0, (**If railway density is **less** than 0.23 km/ Sqkm)

The median metro railway density of 0.23 km/Sq. KM. is the identification criteria for selection of 5 districts under Treatment Group of districts, and 4 districts under Control group of districts. The GLS DiD regression equation with explanatory variables takes the following form:

$$\mathbf{log\ (residential\_land\_price)_{it}} = \beta_0 + \delta_{0t} * \mathbf{d_{1treated\ year}} + \delta_{0d} * \mathbf{d_{2treated\ \_district}} + \delta_1 * \mathbf{d_{1treatedyear}} * \mathbf{d_{2treated\ \_district}} + \beta_1\ \mathbf{stations}_{it} + \beta_2\ \mathbf{log(Population\_density)}_{it} + \beta_3\ \mathbf{log(business\_estb)_{it}} + \beta_4\ \mathbf{log(workers)_{it}} + \beta_5\ \mathbf{log(Hospitals)_{it}} + \beta_6\ \mathbf{log(colleges)_{it}} + \mathbf{u_{it}}$$

Where, subscript 'i' represents the district ID of district of Delhi; 't' represents the panel year 1992, 1998, 2005, 2012 and 2018; β_0 is the intercept of the regression model and δ_{0t} and δ_{0d} are the intercept shift caused by dummy for treatment year $\mathbf{d_{1treated\ year}}$ and treatment group district dummy $\mathbf{d_{2treated\ \_district}}$. The Dependent variable of log of

residential land price for year 't' and district 'i' is given by **log(residential_land_price)$_{it}$**. The variable of the interest in the regression equation is **'stations $_{it}$'** which represents the number of metro stations in a district during the years 1992, 1998, 2005, 2012, and 2018. The other control variables in the equations are in logarithm form, which represents population density of the districts, number of business establishment, number of workers, number of hospitals, number of colleges in the districts recorded during the panel years 1992, 1998, 2005, 2012, and 2018.

The extraneous variable and the error term in the equation is represented by $\mathbf{u_{it}}$. The coefficients β_1 , β_2 , β_3 , β_4 β_5, β_6 represent the individual effect of explanatory variables on the log of residential land price while controlling for other variables in the equation. The variable of interest of the regression model is the number of metro stations in districts represented by variable 'stations'. The coefficient β_1 estimates the effect of variable 'stations' on the conditional mean of log of residential land prices. The coefficient of the dummy variables interaction term in the equation is δ_1 which estimates the difference in difference of percentage change of mean residential price between the treatment group districts and control group districts.

The residential land price of Delhi notified by the government periodically by revising the circle rate of the different land categories of Delhi. Therefore the difference in log of residential land price in the treatment and the control group of districts may not show a significant difference. The data of the control group districts correspond to land category D and E, whereas the data of treatment group district correspond to the land category B, C, D, and G. It is interesting to see if there is any significant difference in log residential land prices due to the metro network expansion in the treatment and control group districts.

2SLS IV Regression Method combined with Fixed Effect Model:

The DiD regression estimates the difference in difference of the percentage change in residential land price between treatment and control groups of the district. However, the estimated coefficients of the explanatory variables may be biased and inconsistent due to district level fixed effect and endogeneity caused by the residential land price on the number of stations. Some districts with high land value land categories B and C have location advantage due to nearness to the CBD. It may be a potential cause of

endogeneity because these districts are situated adjacent to the CBD hence generating and attracting more traffic, and therefore creating demand for new metro stations. The endogeneity may be controlled by introducing instrument variables of 'metro route length' and the 'trips' of districts observed during the panel years 1992, 1998, 2005, 2012, and 2018. Further, the fixed district effect may also cause biased and inconsistent estimation of the regression coefficients, which may be overcome by combining the Fixed Effect model with the 2SLS IV regression model. The Hausman test will check the relative efficiency of the estimates of the Random effect Model and Fixed Effect model. The following equation gives the regression equation of the GLS regression model:

$$\mathbf{log\ (residential\_land\_price)}_{it} = \beta_0 + \beta_1 * \mathbf{stations}_{it} + \beta_2 * \mathbf{log(Population\_density)}_{it} + \beta_3 * \mathbf{log(business\_estb)}_{it} + \beta_4 * \mathbf{log(workers)}_{it} + \beta_5 * \mathbf{log(Hospitals)}_{it} + \beta_6 * \mathbf{log(colleges)}_{it} + \mathbf{u}_{it}$$

2SLS IV regression model of Research design 2 involves three stages to estimate the unbiased and consistent effect of the number of stations on log of residential land prices. These stages are:

1. GLS Estimation of the coefficients of the explanatory variables that explain the effect of each variable on the log residential land price.
2. The explanatory variable will be checked for endogeneity and fixed effect by conducting the Hausman test.
3. 2SLS IV Fixed effect regression model estimation with the variables 'metro length' and 'trips' as instrument variables of the variable 'station'.

The endogeneity caused by the explanatory variable of interest poses a threat to an unbiased and consistent estimation of the effect of the mero station on the log of residential land price. The research design 2 will first estimate the individual effect of the variables on log residential land price. The endogeneity caused by the explanatory variable will be checked by regressing the variable of interest 'stations' on other explanatory variables. The predicted residual will be obtained from this regression, which will be included as a variable in the GLS regression equation. The z value of predicted residual on log residential land price will suggest about the significance of the endogeneity caused by the variables. The explanatory variable suffers from endogeneity if the coefficient of residual suggests a significant effect on the log of residential land price. Two-Stage Least Square (2SLS) IV regression model can control

the endogeneity in the regression equation. The Hausman test will be conducted to test the hypothesis **H0**: that the Random Effect estimates are more efficient with an alternate hypothesis **H1**: that the Fixed Effect model is more efficient. If the fixed effect model is more efficient than the Random Effect model, then 2SLS IV regression model combined with the Fixed Effect model will give unbiased and consistent estimates of the effect of the metro station on the percentage change in residential land prices.

The first stage of the IV regression model with the instrument variables of 'metro_length' and 'trips' instrumented for variable of interest **'stations**' can be written in the following form:

$$\mathbf{stations}_{it} = \pi_0 + \pi_1 * \mathbf{(metro\_length)}_{it} + \pi_2 * \mathbf{log(trips)}_{it} + \pi_3 * \mathbf{log(population\_density)}_{It} + \pi_4 * \mathbf{log(business\_estb)}_{It} + \pi_5 * \mathbf{log(workers)}_{It} + \pi_6 \mathbf{log(Hospitals)}_{It} + \pi_7 \mathbf{log(colleges)}_{It} + \mathbf{v}_{it}$$

Where, $\mathbf{metro\_length}_{it}$ is the first Instrument Variable represents the length of the metro network in the districts for the panel years 1992, 1998, 2005, 2012, and 2018. The second instrument variable $\mathbf{log(trips)}_{it}$ represents the log change of total trips in districts during the panel years 1992, 1998, 2005, 2012, and 2018.

Second Stage IV Regression Equation Form: The fitted value of the variable $\widehat{stations}$ and other variables will be estimated from equation of first stage of 2SLS IV regression. The fitted values of variable 'stations' will be substituted in the main equation to derive the 2SLS IV regression equation. The 2SLS IV regression equation can be written as:

$$\mathbf{log(residential\_land\_price)}_{it} = \Upsilon_0 + \Upsilon_1 * (\widehat{stations})_{It} + \Upsilon_2 * \mathbf{log(population\_density)}_{it} + \Upsilon_3 * \mathbf{log(business\_estb)}_{it} + \Upsilon_4 * \mathbf{log(workers)}_{it} + \Upsilon_5 * \mathbf{log(Hospitals)}_{it} + \Upsilon_6 * \mathbf{log(colleges)}_{it} + \mathbf{e}_{it}$$

Where,

$\widehat{stations}$	Fitted value of variable station estimated from the reduced form of equation..
e_{it}	Error term
$\Upsilon_0, \Upsilon_1, \Upsilon_2, \Upsilon_3, \Upsilon_4, \Upsilon_5, \Upsilon_6$	Estimators of the 2SLS IV regression model represents the effect of explanatory variables on log of residential land price

The 2SLS Instrument Variable regression model will estimate the effect of the addition of metro station on the percentage increase in the residential land price in the National Capital Territory of Delhi for the period between 1992 to 2018. The model will also state the statistical significance of the variable involved in the equation on the percentage increase in the residential land prices in Delhi. These estimate may suffer district fixed effect because the error term e_{it} may contain district fixed effect a_i. Therefore, the fixed effect model will be combined with 2SLS IV regression model to overcome the effect of district fixed effect.

First Stage of IV regression equation (FE Model): The time demeaned equation for fixed effect regression model can be written as :

$$\ddot{stations}_{it} = \pi_0 + \pi_1 * \ddot{metro\_length}_{it} + \pi_2 * \ddot{log(trips)}_{it} + \pi_3 * \ddot{log(population\_density)}_{it} + \pi_4 * \ddot{log(business\_estb)}_{it} + \pi_5 * \ddot{log(workers)}_{it} + \pi_6 * \ddot{log(hospitals)}_{it} + \pi_7 * \ddot{log(colleges)}_{it} + v_{it}$$

Second Stage of IV regression equation (FE Model): The time demeaned equation of second stage of 2SLS IV regression equation can be written as :

$$\ddot{log(residential\_land\_price)}_{it} = \Upsilon_0 + \Upsilon_1 * \ddot{\widehat{stations}}_{It} + \Upsilon_2 * \ddot{log(population\_density)}_{it} + \Upsilon_3 * \ddot{log(business\_estb)}_{it} + \Upsilon_4 * \ddot{log(workers)}_{it} + \Upsilon_5 * \ddot{log(hospitals)}_{it} + \Upsilon_6 * \ddot{log(colleges)}_{it} + e_{it}$$

The Fixed Effect with 2SLS IV Regression will estimate intercept Υ_0 and coefficients of the regressor Υ_1, that is effect of fitted value of stations on the percentage change in residential land price. Other coefficients Υ_2, Υ_3 , Υ_4 Υ_5, Υ_6 are the estimates of the individual effect of the control variables on the percentage change in residential land price after eliminating district fixed effect using time demeaned data of the variables for panel period between 1992 and 2018.

5.3 Research Design 3 : Correlation analysis of Housing price in urban area of a district and Residential Land price:

Research design 3 analyses the trend of the house price movement of the urban areas of districts with the residential land prices of the same land category during the years

2012, 2015, and 2018. The trend analysis of house price movement and the residential land prices between 2012, 2015, and 2018 will suggest the similarity between the house price change and the residential land price change from 2012 to 2018. Research design 3 will also estimate the correlation coefficient of the average house price of urban area within and outside of the influence zone by using dataset '**rd3_thesis.dta'.** The aim of research design 3 is to analyze how residential price movement correlation with average house price movement from 2012 to 2018 within and outside the influence zone of the metro network. The plot of average house prices and the residential land prices will suggest the average house buyer preferences within and outside influence zone distance of the metro network. A high average house price within the influence zone means that a buyer will give a higher premium to the houses located within the influence zone. In contrast, a lower house price within the influence zone means the buyer does not value nearness to the metro station in making his house buying preference.

CHAPTER-6
RESULTS AND INTERPRETATION

Research design 1, 2, and 3 uses the spatial data of infrastructure such as metro networks, hospitals, colleges in each district of Delhi, trips generated and attracted in districts, and secondary data such as house prices in the urban area, residential land prices in districts, population density, number of business establishments and workers in each district. This chapter explains the results of research designs 1, 2, and 3 and compares the research findings with the findings of similar studies mentioned under the literature review chapter.

6.1 Regression Result of Research Design Model 1:

The regression design 1 uses the variable of the house prices as the dependent variable and distance from the mero network as an explanatory variable to estimate the effect of distance on average house prices within and outside of the influence zone. Research design 1 uses data of 40 urban areas of nine revenue districts for the periods 2012, 2015, and 2018. The house price data of urban areas is the average house price corresponding to the second quarter, which is June to September of the financial year, available in the price trend page of real estate website 99acre.com. The total number of house price observations is 94, with the mean value of INR 106,000 / Sq. Meter and standard deviation of INR 50800/Sqm. The station distance data from the metro network has 120 observations with the mean value of 1.3573 kilometers with a standard deviation of 0.8185 kilometers as described below:

Summary of House Price of Urban Area and Distance from Metro Network

	N	Mean	St.Dev	min	max
house price	94	106000	50800	11300	413000
station dist	120	1.3573	.8185	.28	4
year	120	2015	2.4598	2012	2018

The GLS regression model has been used to estimate the effect of distance from the metro on house prices in the urban areas. The influence zone of the metro network is the median distance of 0.73 km estimated under table 4.11 for nine districts of Delhi. This estimated influence zone distance of 730 meters is less than the influence zone distance of 800 meters, as suggested in the Transit-Oriented Development Policy of Delhi notified by the Ministry of Housing and Urban Affairs in December 2019. The urban areas of Delhi grouped under two categories based on the influence zone distance.

The centroid of one group of the urban areas situated within 0.730 kilometers represents the houses situated near metro stations. The other group of house price data represents the urban areas whose centroid located between 0.730 kilometers to 4 kilometers. The regression model estimates the effect of distance from the metro network on the dependent variable of log house prices described in table 6.1. Colom 1 of the regression result suggests with 99% confidence that on average per kilometer movement within the influence zone increases the mean house price by 24.57% or each 100 meters movement within the influence zone of 730 meters explains the 2.457% increase of mean house price. Colom 2 of the model estimates the effect of distance from the metro station in the zone beyond 0.730 kilometers to 4 kilometers. The estimated coefficient (-) 0.1730 can be interpreted as each kilometer movement away from the metro network outside influence zone up to 4 kilometers causes 17.30% decrease in mean house prices in the urban area of Delhi but this estimate lacks statistical significance.

Table 6.1: Estimates from Regression of Research Model 1

Research Design 1 : Effect of Distance From Metro on House Price

	(1)	(2)	(3)	(4)
	Within_Metro_inf~e	Away_Influ_zone	Difference_metro~e	Difference_robust
station_dist	0.2457***	-0.1730	-0.1752*	-0.1752**
	(0.0644)	(0.1176)	(0.1063)	(0.0768)
d_near_station			-0.2190	-0.2190
			(0.2225)	(0.1878)
diff_near_metro			0.4896***	0.4896***
			(0.1597)	(0.0832)
_cons	11.5317***	11.6664***	11.6778***	11.6778***
	(0.0832)	(0.2107)	(0.1905)	(0.1600)
Obs.	34	60	94	94
Pseudo R^2	.z	.z	.z	.z

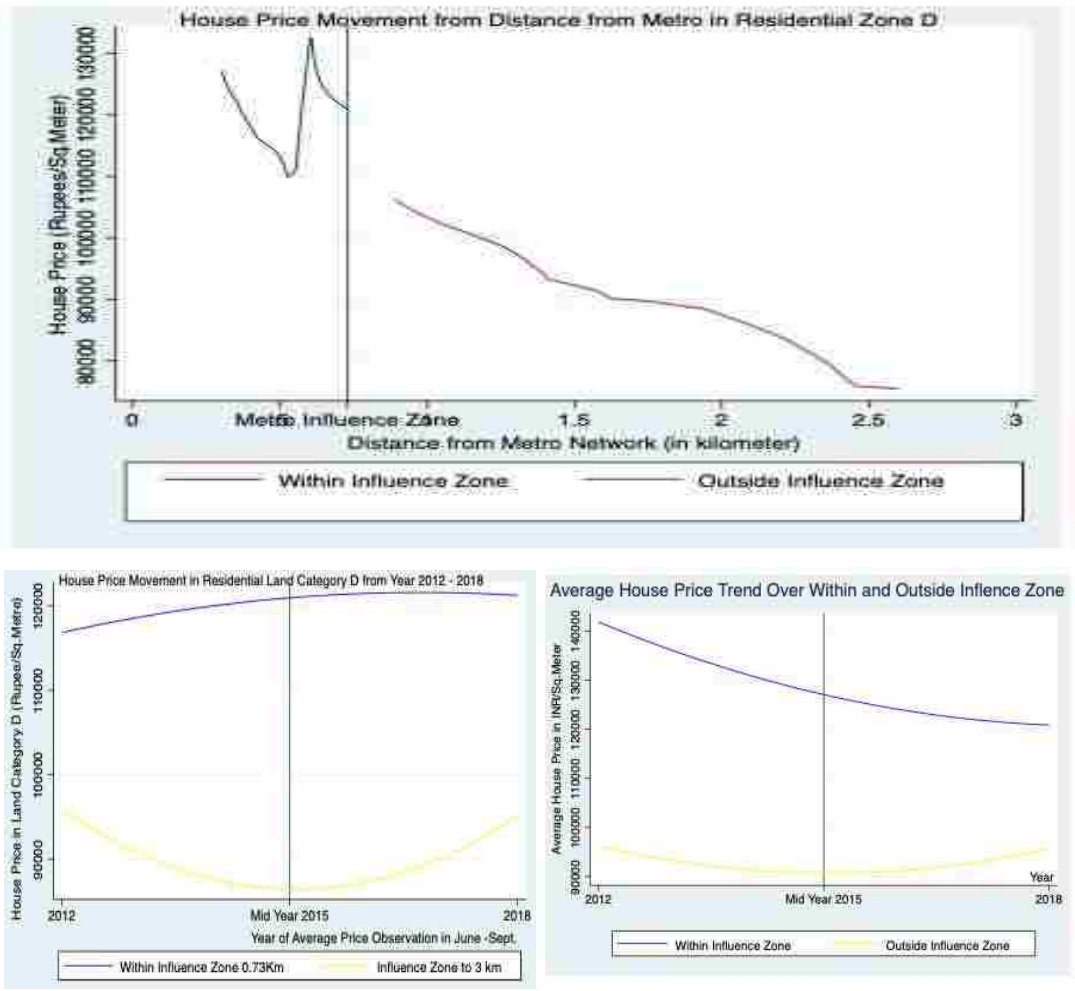
Standard errors are in parenthesis
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Colom 4 represents the robust estimate of the regression model with variables representing nearness to metro station and interaction term to estimate the percent difference in average house prices within and outside the metro influence zone. The effect of distance can be interpreted as a one kilometer movement away from the metro network causes 17.52% decrease in mean house price with statistical significance of 95% confidence level. The coefficient of dummy variable 'd_near_station' representing the urban area within the influence zone suggests 21.90% lesser average house price, but this result lacks statistical significance. The difference in percentage house price change between the urban area within and outside influence zone captured by the coefficient of dummy variable 'diff_near_station'. It suggests with very high

confidence that 48.96% difference in mean house price of urban area within the influence zone distance of 0.73 km as compared to the mean house price of the urban area situated outside the influence zone.

The average house price movement in the urban area (fig. 6.1) of residential land zone category D plotted with respect to distance from the metro network (plot1). It explains that the mean house price within the influence zone drops up to 500 meters from the metro network and increases to influence zone distance of 0.730 kilometers. After the influence zone, the mean house price declines up to 1.5 kilometers at a constant rate, and after that rate of average house price decline follows 'inverted U type' pattern up to 2.5 kilometers. The mean house price remains constant after the distance of 2.5 kilometers in residential land category type D. This inverted U type price drop within 1.5 to 2 kilometers zone is opposite to the finding of Seo et al. (2014). They found U type pattern of house price change with increasing distance from Light Railway and Highway in Phoenix, Arizona.

Fig.6.1 Average House Price in Residential land category D with distance and Year



Plot 2 of fig. 6.1 explains the house price trend in the urban area in residential land category D. Mean house price in the influence zone shows an increasing trend up to the year 2015. After that, the mean house price is constant between 2015 to 2018. Mean house prices outside the metro influence zone recorded a decline in price up to the year 2015 and after that increases to achieve price level of 2012.

Plot 3 of fig. 6.1 explains that the average house price declining trend within influence zone between 2012 to 2015. However, this declining house price trend reversed between 2015 -2018 in the houses located outside the influence zone, whereas the average house price shows a continuous declining trend for properties within the influence zone. The regression result in plot1 (fig. 6.1) is similar to Sharma (2018) findings that premium on the houses within 500 meters of metro stations is lower than the premium on the houses recorded between 500 meters to 1000 meters. Sharma (2018) also observed that noise, traffic congestion, crowding of paratransit mode of transportation causes lower property premium within 500 meters of Metro Station in Bengaluru city. The same assertion may be used for Delhi because of the traffic congestion near the metro station caused by the paratransit mode of transportation. Pan (2013) study on the impact of light Rail Transit (LRT) in Houston, Texas, also found a negative effect of immediate proximity to station up to a quarter-mile (400 meters) on properties.

The estimate of research design 1 found that the mean house price within 0.73 kilometers influence zone is 48.96% higher than the mean house price outside of the influence zone. This percentage difference in house price is very high as compared to Dubey et al. (2013) observation for Montreal city, where community railway caused 11% high premium of mean house price near the station. The 48.96% average house prices difference within and outside influence zone is similar to Pan (2018) study on the impact of LRT in Houston city wherein average house prices within 3 miles of LRT corridor is 43.60% higher than the mean house price of Harris county region.

6.2 Regression Result of Research Design Model 2:

The second research design investigates the effect of metro stations on residential prices from 1992 to 2018. The regression model is GLS regression based on difference in difference (DiD) method and Two-Stage Lease Square Instrument Variable regression (2SLS IV) Fixed Effect model to evaluate the treatment of the introduction of the metro

station on the percent change in the residential land prices. The instrument variable selected for variable 'stations' is 'metro_length' and 'trips'. Control variables of the research design 2 represent population density, number of the business establishments, workers, colleges, and hospitals in the districts during the analysis period. The summary statistics of the dependent variable and explanatory and instrument variables are detailed below:

Summary of Variables of Research Design 2

	N	Mean	St.Dev	min	max
res land price	45	61500	84900	2550	420000
stations	45	8	11.4515	0	43
metro length	45	10.5429	15.9847	0	64.38
trips	45	1760000	913000	590198	5094846
population density	45	14200	10100	2217	43360
business est	45	83700	59200	4044	281705
workers	45	390000	190000	91624	895845
hospitals	45	10.4889	6.1297	2	26
college	45	12.9111	8.9235	1	34
year	45	2005	9.4436	1992	2018

The research begins with the test of endogeneity of the explanatory variable and Hausman test to select the efficient model for the estimation of the regression model. The test of endogeneity suggests that the residual '**e1**' obtained from the regression of variable of interest 'stations' on the other control variable (**Table 6.2, Colom 1)** does not have a statistically significant effect on dependent variable log residential land price (**Table. 6.2, Colom 2**).

Table 6.2: Result of Endogeneity test and Hausman Test for Model Efficiency

Result of Endogenity Test

	(1)	(2)
	Reg_Stations	Endogen_est
l_population_~y	0.9179	-0.3832*
	(2.0253)	(0.2155)
l_business_est	1.1652	0.4095
	(2.5537)	(0.2680)
l_workers	5.5021	-0.6049
	(4.0782)	(0.6036)
l_hospitals	3.1396	0.7432
	(2.8802)	(0.5161)
l_colleges	2.2484	
	(2.0866)	
stations		0.1001***
		(0.0156)
e1		0.0040
		(0.0918)
_cons	-95.9885**	14.3412
	*	
	(36.0715)	(8.7747)
Obs.	45	45
Pseudo R^2	.z	.z

Standard errors are in parenthesis
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Result of Hausman Test to check Random Effect And Fixed Effect Model Efficiency

	(1)	(2)
	Random_effect	Fixed_effect
stations	0.0909***	0.0722***
	(0.0145)	(0.0163)
l_population_~y	-0.3307*	2.0107
	(0.2000)	(1.4253)
l_business_est	0.4914*	-0.0875
	(0.2520)	(0.2592)
l_workers	-0.3146	-0.5381
	(0.4046)	(0.3835)
l_colleges	0.1419	0.3610
	(0.2060)	(0.7493)
l_hospitals	0.3708	0.7178
	(0.3078)	(0.5814)
_cons	9.7819***	-3.7859
	(3.6602)	(11.0116)
Obs.	45	45
R-squared	.z	0.8139

Standard errors are in parenthesis
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

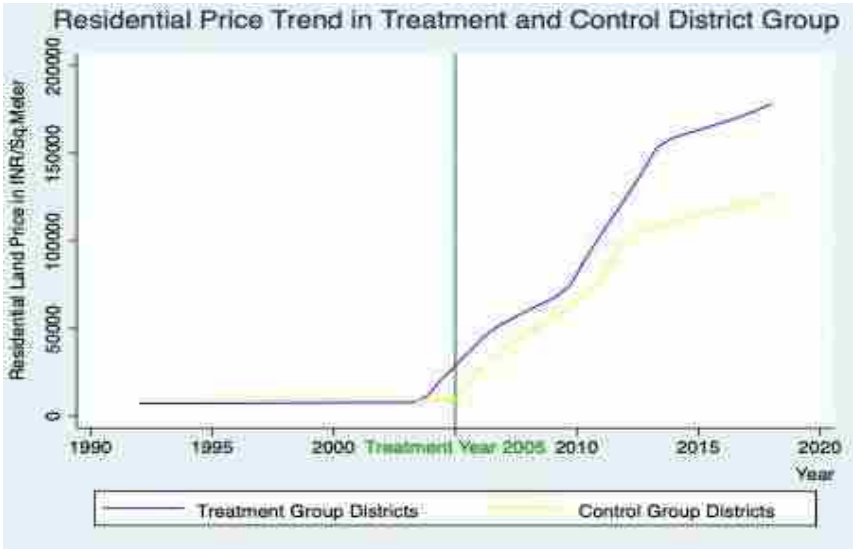
Result of Hausman Test to check Random Effect and Fixed Effect Model Efficiency

	Coef.
Chi-square test value	19.7337
P-value	.0031

The Hausman test rejects the null hypothesis that the Random Effect is an efficient model in favor of an alternate hypothesis that the Fixed Effect model is more efficient for estimating the regression model. The Fixed Effect model is the preferred regression model because the **p-value** obtain from the Hausman test is less than 0.05 (**Table 6.2**). The result suggests the existence of a time-invariant effect on the error term. The fixed effect model is therefore combined with the 2SLS IV regression model to estimate an unbiased and consistent coefficient of the explanatory variable.

Columns 1, 2, 3 of table 6.3 describe the result of the difference in difference GLS estimation due to the treatment effect of metro rail expansion in treatment and control group districts. The treatment group consists of five districts, namely North East Delhi, East Delhi, West Delhi, New Delhi, and South Delhi, which have metro rail density more than 0.23 kilometer / Sq. Kilometer district area. The Control group districts are represented by North Delhi, North West Delhi, Central Delhi, and South West Delhi, where metro rail density is less than 0.23 km/Sq.km. Fig. 6.2 plots the residential land price trend in the treatment and control group districts between 1992 to 2018 with treatment year as 2005. The plot suggests a similar residential land price trend in both treatment and control group districts before and after the treatment year, the year after 1998, when the metro network construction began, and operation of metro stations started from December 2002 (**fig. 6.2**).

Fig.6.2: Residential land price trend in Treatment and Control group districts



The GLS estimates of DiD regression are reported under Colom 1 to 3 of table 6.3. Colom 1 of **Table 6.3** presents the result of DiD regression without control variables.

The coefficient of treatment year dummy can be interpreted as the mean residential land price in control group districts increased by 178.46% or 1.78 times after the year 1998 to 2018 than the average residential land price observed during the panel years 1992 and 1998 when no metro network exist in the districts of Delhi. The coefficient of dummy variable treated_district suggests that the mean residential land price of the treatment group district is 26.69% less than the mean residential price of the control group in the absence of policy treatment from 1992 to 1998. The interaction term in first regression (Colom 1) explains difference in difference (DiD) of change in the mean residential price between treatment and control group district due to the treatment effect of high metro rail density. The policy treatment of metro network expansion has caused 33.19% change in residential land prices in the treatment group district as compared to control group districts. However, the estimate does not have statistical significance.

Table 6.3: Results of Regression Models of Research Design 2

Results of Second Research Design, DiD method have treatment Year after 1998

	(1)	(2)	(3)	(4)	(5)	(6)
	Dummy_Only	DiD_Var_of_Inter~t	DiD_All_Var	DiD_robust	IV+Fixed_Effect	2SLS_IV+Fixed_Ef~t
treated_year	1.7846***	0.9112**	0.4251	0.4251		
	(0.5643)	(0.4186)	(0.4859)	(0.5015)		
treated_distr~t	-0.2669	-0.2669	-0.7084	-0.7084		
	(0.5864)	(0.4124)	(0.4699)	(0.5746)		
interection	0.3319	-0.4251	-0.2453	-0.2453		
	(0.7571)	(0.5447)	(0.5367)	(0.4788)		
stations		0.0970***	0.0884***	0.0884***	0.0787***	
		(0.0148)	(0.0152)	(0.0115)	(0.0167)	
l_population_~y			-0.0257	-0.0257	1.6918	1.6918
			(0.2227)	(0.1337)	(1.4393)	(1.3703)
l_business_est			0.2059	0.2059	-0.0713	-0.0713
			(0.2605)	(0.1844)	(0.2600)	(0.2475)
l_workers			-0.4897	-0.4897***	-0.5319	-0.5319
			(0.3895)	(0.1793)	(0.3845)	(0.3661)
l_colleges			0.0481	0.0481	0.4861	0.4861
			(0.2002)	(0.1620)	(0.7542)	(0.7181)
l_hospitals			0.7062*	0.7062*	0.6580	0.6580
			(0.3717)	(0.4180)	(0.5838)	(0.5558)
station_hat						0.0787***
						(0.0159)
_cons	8.9547***	8.9547***	12.0744***	12.0744***	-1.2875	-1.2875
	(0.4371)	(0.3074)	(3.5468)	(1.3273)	(11.1222)	(10.5886)
Obs.	45	45	45	45	45	45
R-squared	.z	.z	.z	.z	.z	0.8304

Standard errors are in parenthesis
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

The effect of policy treatment of metro railway expansion does not have statistical significance when we introduce control variables in the regression model (Colom 3). The treatment year resulted in 42.51% increase in the mean residential price in the control group district before and after the treatment year 1998. The estimate of treated districts suggests that the mean residential land price of the treatment group district is

70.84% less than the control group district between 1992 to 1998. The coefficient of '**interaction**' estimates the difference in difference of the percentage change in the mean residential land price. It explains 24.53% differences in the mean residential land price between the treatment and control group districts before and after the onset of treatment of metro network expansion. However, these three estimates did not have statistical significance. The negative sign of interaction term suggests that the percentage change of residential land price in the control group district is larger than treatment group districts.

Colom 4 checks the robustness of the estimates of the regression model. The regression result of Colom 4 suggests that only three variables have effects on the log of residential land price. The regression estimate of Colom 4 reports with 99% confidence that the addition of the metro station in a district causes 8.84% change in the mean of residential land price. Also, a one percent increase in the number of workers in districts causes a reduction in the mean residential land prices by 0.49% with the statistical significance of 99%. A 1% increase in the mean number of hospitals in districts suggests 0.71% increase in mean residential land price with 90% confidence. However, these estimates of variables may be inconsistent due to district level fixed effect, the correlation among the variable (**Table 6.4**), and endogeneity suggested by Hausman test statistics..

Table 6.4 Correlation among Explanatary and Instrument Variables

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) stations	1.0000							
(2) metro_length	0.8389	1.0000						
(3) l_trips	0.6473	0.7269	1.0000					
(4) l_population_d-y	0.2703	0.0792	-0.1286	1.0000				
(5) l_business_est	0.3768	0.2229	0.2023	0.5195	1.0000			
(6) l_workers	0.4568	0.2920	0.2403	0.4918	0.7251	1.0000		
(7) l_colleges	0.3568	0.3972	0.5893	0.0051	0.0471	0.0984	1.0000	
(8) l_hospitals	0.4442	0.5639	0.7254	0.0895	0.2169	0.3261	0.6629	1.0000

The instrument variable regression strategy has been combined with the Fixed Effect model to overcome the issue of endogeneity and eliminate the district level fixed effect. Two instrument variables, namely 'metro_length' and 'l_trip' used for the variable of interest 'stations'. The High correlation between variable stations and instrument variables metro_length and l_trips (table 6.4) satisfy the condition of instrument relevance. The condition of instrument exogeneity is also satisfied because trips and metro routes do not affect the residential land price. The total trips of a district measure movement from one district to another, and it is neutral to the residential land price. The residential land price does not relate with the metro network length because the

length of a metro line depends on the underground geology and road width available for the construction of the underground and elevated metro line. The IV regression model and 2SLS IV Regression models estimate the coefficients of explanatory variables under Colom 5 and 6 of Table 6.3. Table 6.5 reports the regression result of the first stage of 2SLS IV regression. The fitted value of **station_hat** estimated from the first stage of 2SLS IV Fixed Effect regression model. This fitted value station_hat is used in the second stage of the regression model to estimates the regression coefficients of the explanatory variables.

Table 6.5 First Stage of 2SLS IV regression with Fixed Effect

First Stage of Two Stage Instrument Variable Regression

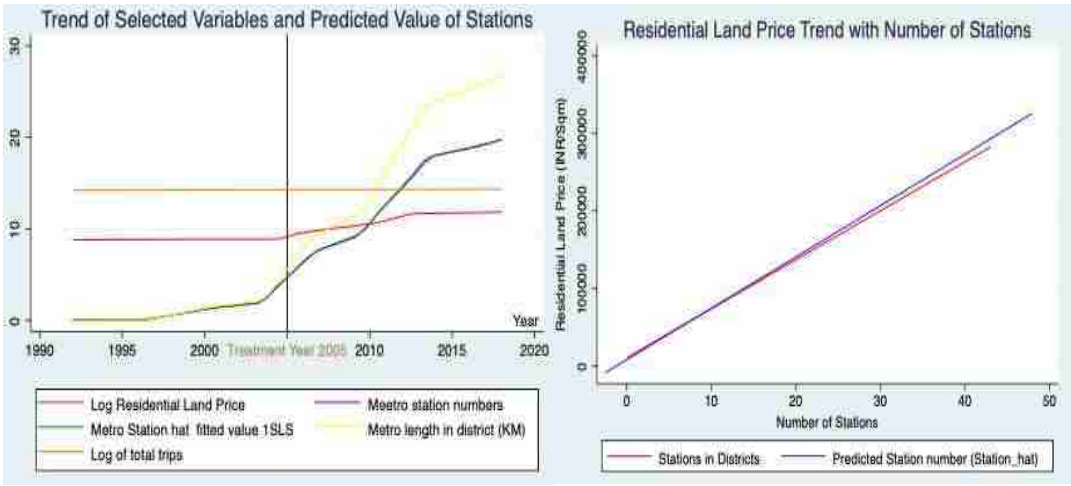
stations	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
metro_length	0.6525	0.0355	18.39	0.000	0.580	0.725	***
l_trips	3.8936	3.2369	1.20	0.239	-2.727	10.514	
l_population_density	-0.8217	4.4327	-0.19	0.854	-9.888	8.244	
l_business_est	-0.7763	0.6161	-1.26	0.218	-2.036	0.484	
l_workers	-0.6573	0.9164	-0.72	0.479	-2.531	1.217	
l_colleges	-1.1103	1.8071	-0.61	0.544	-4.806	2.586	
l_hospitals	1.4022	1.5998	0.88	0.388	-1.870	4.674	
Constant	-30.3397	30.9717	-0.98	0.335	-93.684	33.005	

Mean dependent var	8.0000	SD dependent var	11.4515
R-squared	0.9808	Number of obs	45.0000
F-test	211.8062	Prob > F	0.0000
Akaike crit. (AIC)	178.5029	Bayesian crit. (BIC)	192.9562

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

The instrument variable 'metro_length' has a significant effect on the variable of interest 'stations'. The Fitted value of variable '**station_hat'** estimates unbiased and consistent estimates of explanatory variables in Colom 6 of **table 6.3**. The fitted value of variable 'stations' is represented by 'station_hat' in Fig.6.3. It suggests a minor deviation between the fitted and the actual value of the mean number of metro stations for the period of analysis between 1992 to 2018..

Fig.6.3: Trend Analysis of fitted Station_hat and Selected Variables



The IV regression and 2SLS IV Fixed Effect regression model estimates the same average effect of the explanatory variables; however, the standard error of estimated coefficients are less in 2SLS IV Fixed Effect regression results. Both models have found that the number of stations has a significant effect on the mean residential land price in districts of Delhi (Colom 5 & 6, Table 6.3). The coefficient of variable stations suggests that the addition of station from 1992 to 2018 caused 7.87% increase in the mean residential land prices with a statistical significance of more than 99%.

The variables population density, number of colleges, and number of hospitals have the positive effect on the residential land price as 1% increase in the mean value of these variable explain 1.69%, 0.48% and 0.66% increase in mean residential price respectively; however, the estimates of these variable lack statistical significance. The variable of the number of business establishments and the number of workers in districts has a negative effect on the mean residential land as 1% increase in the mean number of these variables explains 0.07% and 0.53% decrease in the mean residential land price, but the estimates lack statistical significance (Colom 5 & 6, Table 6.3).

The main objective of research Design 2 is to estimate the effect of the expansion of the metro network on residential land prices in Delhi. The DiD regression (Colom 4) found no significant difference in mean residential prices in the treatment and control group districts of Delhi before and after the introduction of the metro railway. The residential land prices in both treatment and control groups of districts have a similar residential land price trend from 1992 to 2018 (Fig.6.2). The 2SLS IV Fixed Effect regression model (Colom 6) found the significant effect of metro stations in the National Capital Territory of Delhi on the mean residential land price increase from 1992 to 2018 as metro station addition in districts can explain 7.87% increase in mean residential land price with statistical significance of more than 99%.

6.3 Result of Research Design 3: Correlation Analysis of House Price and Residential Land Price

Trend of house price and residential land prices of urban area of Delhi has been plotted for period 2012 to 2018. The data of house price and residential land price of same land category corresponds to year 2012, 2014, 2015 and 2018. The graphical representation of house price and residential land price trend are represented under Fig.6.4.

Fig.6.4 Trend of House Price and Residential Land Price in Districts of Delhi

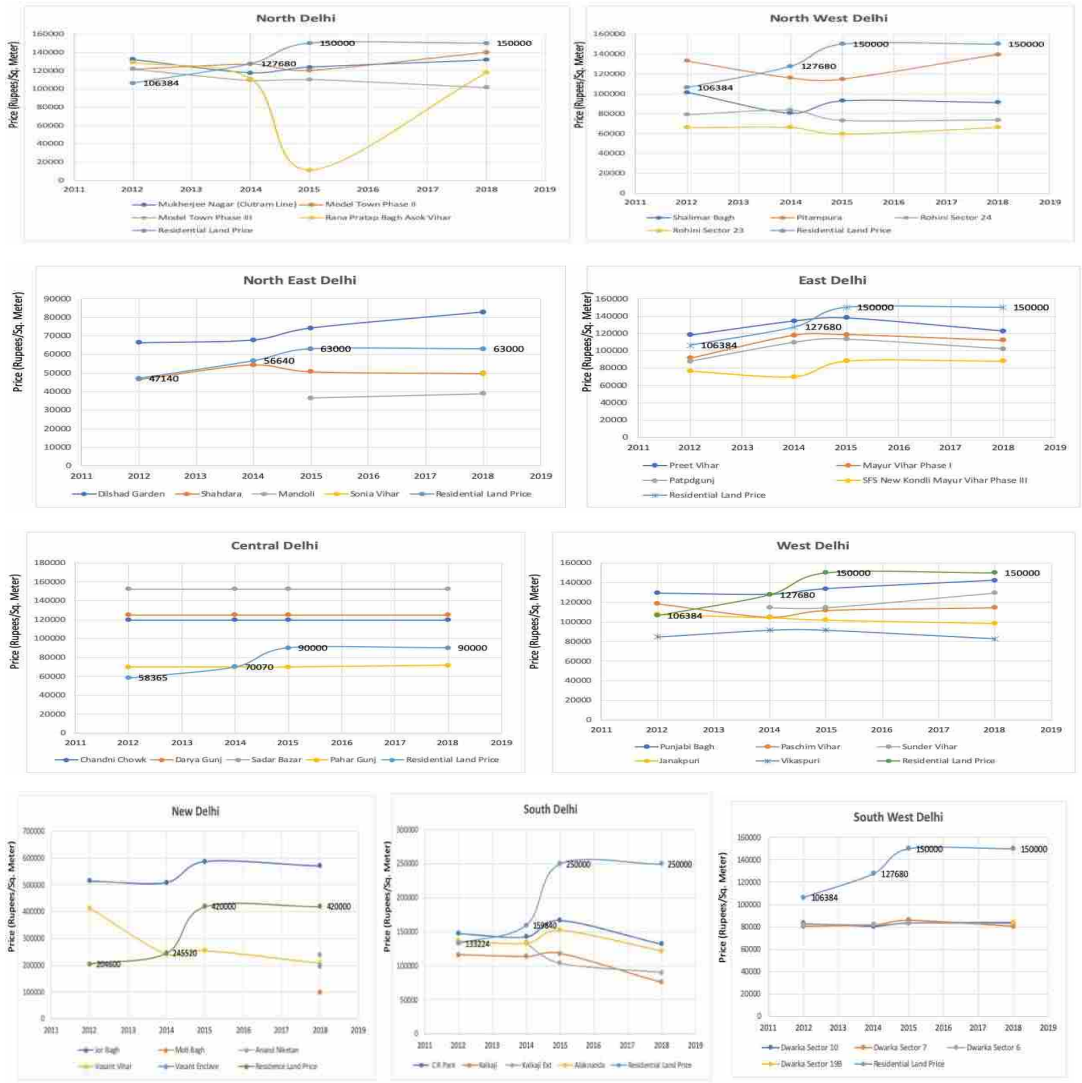


Figure 6.4 is the plot of the house price data and residential land price data of the same land category for the years 2012, 2014, 2015, and 2018. The house price trend is relatively flat and remains unaffected with residential land price movement in Central Delhi district because a significant portion of Central Delhi district falls under the fort city where construction regulations are strict. The house price and residential land price trend is not identical for most districts. However, similar average house prices and residential land prices observed in the urban area of Mukherjee Nagar (North Delhi), Shalimar Bagh (North West Delhi), Dilshad Garden (North East Delhi), Mayur Vihar Phase III New Kondli (East Delhi), Punjabi Bagh (West Delhi), Jor Bagh (New Delhi), C.R. Park (South Delhi) and Dwarka Sector 7 (South West Delhi). These urban locations have one similarity that the centroid of these urban areas falls within the metro

influence zone. More convincing interpretation about house price and residential land price correlation can be made from the correlation coefficient estimate of the average house price trend and residential land price trend within and outside influence zone for the years 2012, 2015, and 2018 (**Fig.6.5**).

Fig. 6.5 Correlation Between House Price and Residential Land Price

Correlation of Residential Land Price and House Price Within Influence Zone 0.73 Kilometer from metro

Variables	(1)	(2)
(1) res_land_price	1.0000	
(2) house_price	0.4162	1.0000

Correlation of Residential Land Price and House Price Outside Influence Zone 0.73 – 4.0 Kilometer from metro

Variables	(1)	(2)
(1) res_land_price	1.0000	
(2) house_price	0.6398	1.0000

The correlation analysis suggests that the mean house price of the urban area situated outside the influence zone has high correlation of 63.98% with the mean residential land price. In contrast, the low correlation score of 41.62% estimated between the average house prices and residential land price within influence zone distance. The correlation estimates suggest that the average house price of the properties of high residential land is lower if situated within the influence zone of the metro network. It also suggests that the average house price is higher within the influence zone for low land value properties up to the residential land price value of INR 20000 / Sq. Meter. A similar finding was observed in Freddie Mac Report (2019) on the effect of metro stations in the house prices in Washington, D.C. The Report suggests that the proximity to the metro station has the smallest effect on the high-value properties and high premium observed for the low-value properties in the proximity of the metro station in the Washington DC metropolitan. The correlation analysis also suggests that the average house price outside the influence zone shows a linear increase in average house prices with the increase in residential land prices in Delhi. We can infer the house buying preferences from the plot of housing and residential land price. The plot in Fig. 6.5 suggests that the house buyers of high property value do not value nearness to metro station, whereas the house buyers of low property value prefer to pay a higher price if the house is located within the influence zone of the metro network because they prefer metro network over private vehicles for commuting to their workplaces, business establishments, and other destinations.

CHAPTER 7
POLICY IMPLICATIONS AND RESEARCH OUTCOME

The motivation of this research thesis is to estimate the effect of metro railway expansion on the residential land price in the National Capital Territory of Delhi and propose value capture finance (VCF) amount that can be utilized to finance Metro projects of Delhi. Metro Policy 2017 has a provision that the state government should adhere to the adoption of Value Capture Financing (VCF) guidelines, and the financial benefits accrue due to VCF should be transferred directly to the Special Purpose Vehicle (SPV) agencies implementing the metro railway projects. This thesis research has estimated that the expansion of the metro network in Delhi has caused 7.87% increase in the mean residential land price in Delhi from 1992 to 2018 while controlling for other variables. The primary beneficiaries of this increase in land prices are the Government of National Capital Territory (NCT) of Delhi and Municipal Corporations of Delhi as they receive a large portion of their tax revenue from stamp duty on the transaction of the properties and the property tax. The residential land prices are the basis for the assessment of the property tax and stamp duty value. This chapter has assessed the amount of VCF that should be transferred to Delhi Metro Rail Corporation Limited because of additional land revenue due to the expansion of the metro network in Delhi.

7.1 Public Policy Implications:

The regression estimates of research design 1, 2, and 3 have implied that the State Government and Delhi Division of Ministry of Housing and Urban Affairs, Government of India should make provisions regarding the following:

1. The additional surcharge of 48.96% should be levied on the stamp duty and property tax of houses of the urban area situated within 0.730 kilometers influence zone of the metro network. The levy of 48.96% surcharge on stamp duty and property tax of urban area houses situated within the influence zone will capture the increased house price value within the influence zone.
2. Planning of traffic decongestion, noise reduction, and passenger-friendly movement should be priorities within 500 meters of the influence zone to improve the surrounding environment of metro stations and to enhance the property value of the nearby area.

3. Transfer of 7.87% revenue receipt of annual property tax and stamp duty collection of Municipal Corporations and Government of NCT of Delhi on Value Capture Finance (VCF) account to finance upcoming metro projects or supplement the annual revenue of Delhi Metro Rail Corporation Limited.

The additional amount from the VCF will help Delhi Metro Rail Corporation (DMRC) to finance the Phase-IV of Delhi Metro Project or supplement the revenue of Delhi for sustainable metro operation by keeping the metro railway travel fare as low as possible.

7.2 Assessment of Value Capture Finance (VCF) Amount:

The Value Capture Finance (VCF) amount has been assessed based on research design 2 findings that metro railway expansion has caused an average 7.87% increase in residential land price from 1992 to 2018. The VCF amount is derived from taking 7.87% of actual audited revenue receipts from the property tax and stamp duty collections of Municipal Corporations of Delhi and Government of NCT of Delhi during the financial Year 2016-17 as detailed under Table.7.1.

Table.7.1: Assessment of Value Capture Finance Amount

(Values in million INR, US$ value in parenthesis)

Tax Collection Authorities of Delhi	Total Own Tax Revenue 2016-2017	Revenue from Property Tax and Stamp Duty 2016-17	Value Capturing Finance Rate	Annual Value Capturing Finance Amount
(1)	(2)	(3)	(4)	(5) = (3) X (4)
Government of NCT of Delhi, Municipal Corporations of New Delhi, North Delhi, South Delhi and East Delhi	360,953 ($4759.97 million)	3,9891.8 ($526.06 million)	7.87%	3139.48 ($41.40 million)

(*1US$ = 75.83 Indian Rupees as on May 2, 2020)

The base year of 2016-17 has been taken for assessment of value capture amount because the revenue data of the year 2016-17 is the latest audited actual revenue data of the Government of Delhi and Municipal Corporation of Delhi. The assessment of value capture finance in Table 7.1. suggest that the Government of Delhi and Municipal corporation of Delhi should collectively transfer INR 3139.48 million annually for Value Capture Finance of upcoming metro railway projects in Delhi.

7.3 Value Capture Financing (VCF) effect on Project Financing and Metro Operations

The Government of Delhi and Government of India is implementing 103.94 kilometers route length with 76 metro stations under Phase-IV of Delhi MRTS Project at the estimated cost of INR 468,450 million. Out of this total 103.94 kilometers route length, three priority corridors of 61.68 kilometers with 45 metro stations have been approved by the Government of India, with the total cost of INR 249,486.5 million. Table 7.2 provides the assessment of the potential contribution of the VCF amount to the Delhi Metro Phase IV project cost.

Table.7.2: Assessment of Percentage Share of VCF on Phase-IV Project Cost

DMRC Phase IV Project	Total Cost (INR Million)	Completion Period* (Years)	Annual VGF Amount	Total VCF Amount (INR, Million)	VCF Contribution (Percent of Total Cost)
(1)	**(2)**	**(3)**	**(4)**	**(5) = (3) X(4)**	**(6) = 100X (5)/(2)**
Three Priority Corridor (61.68KM)	249486.5	4 (Year 2024)	3139.48	**12557.92**	**5.03%**
Six Corridor (103.94 KM)	468450	6 (Year 2026)	3139.48	**18836.88**	**4.02%**

- **Completion period counted from Year 2020-2021.**

The financing structure of the approved phase-IV project has a provision that 51.83% of the project cost will be financed through the sovereign debt from the multilateral agency and subordinate debt of Government of Delhi and Government of India. The VCF amount reduces the sovereign and subordinate debt burden as estimated below:

DMRC Phase IV Project	Total Cost (INR Million)	Loan Amount (@ 51.83% of Total Cost)	Total VCF Amount (INR Million)	VCF to Sovereign and Subordinate Loan Ratio
(1)	**(2)**	**(3)**	**((4)**	**(5) = 100(4)/(3)**
Three Priority Corridor(61.68KM)	249486.5	129309.14	**12557.92**	**9.71%**
Six Corridor (103.94 KM)	468450	242798.17	**18836.88**	**7.75%**

The assessment of Value Capturing Financing suggests that the transfer of 7.87% of total property tax and stamp duty collection on account of increased residential land

value can finance 5.0% of Delhi Metro Phase-IV project cost with three priority corridors. This additional VCF amount has the potential to reduce the sovereign and subordinate debt burden of Delhi Metro Rail Corporation by 9.71% and 7.75% for the phase-IV project with three priority corridors and six corridors respectively.

The profit and loss statement of Delhi Metro Rail Corporation Limited (DMRC) suggests continuous loss during 2016-17, 2017-18, and 2018-19. Delhi Metro Rail Corporation increased the fare of metro travel to recover these losses in the year 2017-18. The maximum fare was increased from INR 30 to INR 60 from May 2017. It resulted in the reduction of the daily passenger ridership of Delhi Metro during 2017-18 and 2018-19. An alternate mechanism to recover the operational loss of Delhi Metro Rail Corporation is to use the VCF amount and to keep the travel fare amount at a minimum. It will make the operation of metro railway sustainable in the long run as the revenue loss of Delhi Metro will be compensated by the VCF amount transfer by the Government of NCT of Delhi and Municipal Corporation of Delhi.

Table 7.3: Estimate of Net Profit /Loss of DMRC after transfer of VCF Amount

(Values in million Indian Rupees)

Year	DMRC Total Income	DMRC Total Expenses	Profit / Loss (After Tax)[#]	Annual VCF Amount*	Net Profit / Loss after VCF
2016-17	53879.85	57361.39	(-)2293.54	3139.48	(+) 845.94
2017-18	62110.52	63560.35	(-)949.88	3139.48	(+) 2189.60
2018-19	64615.22	72258.45	(-) 4640.39	3139.48	(-) 1500.91

[#] Profit / loss After Tax is calculated as = Total Income – Total Expense + Deferred Tax
***VGF amount is corresponding to estimate of year 2016-17, considered same for 2017-19.**

The profit / Loss estimate at table 7.3 suggests that fixed annual VCF amount of INR 3139.48 million has turned the losses of DMRC into the profit of INR 846 million and INR 2190 million during 2016-17 and 2017-18, while the loss during the year 2018-19 is manageable due to previous years surplus. The outbreak of COVID-19 disease will further discourage the use of public transportation in Delhi. It is expected that the ridership of Delhi Metro will remain lower in the coming years. The annual VGF amount transfer equal to 7.87% of property tax and stamp duty collections of Municipal Corporations of Delhi and Government of NCT of Delhi should be transferred to Delhi Metro Rail Corporation to make the metro operation sustainable in the long run.

7.4 Research Outcome

The outcomes of the research have been summarised against the research questions put forwarded in Chapter-1. The findings of the research design 1, 2, and 3 are summarised below in the form of answers to the research questions:

Research Questions	Research Findings
1. Estimate the effect of metro railway network expansion in Delhi on the residential land value and house price of Delhi?	The expansion of the metro network in Delhi has a significant impact on the mean residential land price increase. It explains 7.87% increase in mean residential land price from 1992 to 2018 with very high statistical significance while controlling other variables. Research design 1 estimated 48.96% difference in mean house prices of the urban areas situated within the influence zone of the metro network than the urban areas situated between 0.730 kilometers to 4 kilometers..
2. What is the influence zone distance of the metro network and estimate the effect of the influence zone on house prices of the urban area of Delhi?	The estimated influence zone distance of the metro network is 0.730 kilometers. This estimated influence zone distance is lower than the 0.8 kilometers influence zone mentioned in the TOD Policy of Delhi, 2019. In the residential land category D, the average house price decline from the metro network to 0.5 kilometers. After that, the average house price increases to the outer limit of the influence zone that is 0.730 kilometers. Overall, the distance from the metro network causes an increase in the average house price at the rate of 24.57% per kilometer. The average house price decreases at the rate of (minus) 17.30% per kilometer outside the influence zone between 0.730 to 4 kilometers.

3. Estimate difference in residential price trend in the treatment and control group of districts after the policy treatment of the introduction of the metro railway in Delhi?	The difference in difference estimate of before and after analysis of Research Design 2 did not find a statistically significant difference in land price increase trend in the treatment and control group of districts.
4. Does social infrastructure, demographical and economic factors affect residential land prices of Delhi's districts from 1992 to 2018?	Research design 2 estimates do not suggest any statistically significant effect of these variables on the percentage change of mean residential land price from 1992 to 2018. The social infrastructure and demographic variables have a positive effect on the percentage change of mean residential land prices. The economic variables represented by the number of business establishments and workers in districts have a small negative effect on the percentage change in the mean residential land price.
5. Assess the effect of the expansion of the metro network in Delhi on value capturing from increased land price and examine public policy relevance of the research findings?	The addition of metro stations explains 7.87% increase in residential land prices in districts from 1992 to 2018. The Government assesses the property tax and the stamp duty value based on the prevailing residential land price. Hence, 7.87% amount of the annual property tax revenue receipt and stamp duty can be transferred to Value Capture Finance account by the Municipal Corporation of Delhi and Government of Delhi to support the upcoming metro projects of Delhi.. This is also in line with the Metro policy 2017 of Government of India, which makes it mandatory for the state government to accrue the benefit of value capturing of land to metro project implementing agencies such as Delhi Metro Rail Corporation Limited.

In addition to the above outcomes, the findings of research design 1, and 2 validate the first research hypothesis that expansion of the metro network has a significant positive effect on the residential land price increase and the average house prices in Delhi. However, The findings of Research design 3 provide partial support in favor of the research hypothesis because the higher house price within the influence zone observed for houses with a low land value up to INR 200000/Sq. Meter. The average house price of high property land value has lower house prices within the metro influence zone.

The findings of research design 2 do not find a significant effect of demography, social infrastructures, and business establishments on the residential land price increase from 1992 to 2018. The findings do not provide support in favor of research hypothesis no. 3 that states residential land price is affected by the demographic changes, number of educational and health institutions, and business establishments in a city.

Delhi Metro Phase-IV approved corridor and the Network map is included here for reference.

Corridors	Total Length	Underground Length	Elevated Length	No. Of Stations
Aerocity to Tughlakabad	20.201	14.619	5.582	15
R. K Ashram to Janakpuri West	28.92	7.74	21.18	22
Maujpur - Majlis Park	12.558	00	12.558	08
Total	**61.679**	**22.359**	**39.320**	**45**

*Updated as on 31.12.2019

(Source: Delhi Metro Rail Corporation Limited website)

CHAPTER-8
CONCLUSION

This thesis report is probably the first empirical research on Delhi and perhaps first city-level empirical research in India to analyze the impact of the metro railway network on the mean residential land price in districts. The before and after analysis in this research finds no significant difference in the residential land price increase between the treatment and control group districts. This thesis also investigates the effect of distance from the metro network on the average housing price in Delhi's urban area. The primary data for the research was created using Google Earth Pro to measure the distance of metro route length and distance of urban area centroid from the metro network using the measurement tool of Google Earth Pro.

The house prices data for years 2012, 2014, 2015, and 2018 was collected from the real estate website 99acre.com. The research estimated the influence zone distance as median distance from the metro stations where changes in the house price trend observed in districts of Delhi. This thesis estimates that the influence zone limit of the metro network is 0.730 kilometers, which is lesser than the distance of 0.800 kilometers mentioned in the Transit Oriented Development Policy for Delhi notified in December 2019. The regression model of research design 1 uses GLS regression with the dummy variable representing the centroid of urban area within 0.730 kilometer to estimate the difference in mean house price within and outside influence zone. The regression model finds 48.96% higher mean house prices within the influence zone than those situated outside influence zone up to 4 kilometers from the metro network. The research also finds a trend of mean house prices in residential land category D. It observes that the mean house price decreases up to 500 meters within the influence zone and then a sharp increase in mean house price observed up to the influence zone limit. The decline in mean house prices within the influence zone can be attributed to noise and traffic congestion near the metro station. An increasing trend of the mean house price is observed within the influence zone distance 0.730 kilometers for residential land category D, whereas a declining mean house price trend observed outside the influence zone up to 3 kilometers from the metro network. Overall, the mean house price of the properties is higher near the metro network. The mean house price declines by 17.52% after every kilometer from the metro network.

Research design 2 of this thesis used unique identification criteria of metro rail density to divide the districts of Delhi into the treatment and control group districts. The treatment group districts have five revenue districts with metro railway density higher than 0.23km/Sq. kilometers district area, namely North East Delhi, East Delhi, West Delhi, New Delhi, and South Delhi. The control group of districts consists of four revenue districts, namely North Delhi, North West Delhi, Central Delhi, and South West Delhi, where metro rail density is less than 0.23km/Sq.km. Research design 2 uses the difference in difference (DiD) method and found that that there is no significant difference in the residential price trend between the treatment and control group of districts of Delhi between 1992 to 2018. The empirical analysis using the 2SLS IV regression Fixed Effect Model predicts that the addition of metro stations in the districts caused 7.87% increase in the mean residential land price between 1992 to 2018. The instrument variables of 2SLS IV regression are metro route length and total trips in each district to control endogeneity. The Fixed Effect model is used to eliminate district-level fixed effects. The research did not find a statistically significant effect of other demographic and social infrastructure variables on the mean residential land price from 1992 to 2018. The other variables in the regression model represent population density of district, number of colleges, hospitals, number of business establishment, and number of workers in nine revenue districts of Delhi. The empirical analysis under research design 3 found a high correlation between residential land price and house price outside the influence zone. The correlation between the residential land price and average house price within the influence zone is lower than that of the estimated outside the metro influence zone. The findings of Research design 3 suggest house buyer preference that high property value buyers do not value nearness to metro stations. In contrast, the house buyers of low property value pay high average house prices if the property is located within the influence zone of the metro network because they use the metro railway over private transportation mode.

The Metro Policy 2017 encourages state governments to adopt Value Capturing Financing (VCF) by transferring the financial benefits of increased land prices to the authorities implementing the metro projects. The thesis proposes a levy of additional surcharge 48.96% on stamp duty and property tax of the house property falling within the influence zone of the metro network. The thesis estimated the annual Value Capture

Finance (VCF) amount equal to 7.87% of the total revenue accrue by the Government of NCT of Delhi and four Municipal Corporations from stamp duty and property tax revenue. The VCF amount transfer to Delhi Metro Rail Corporation Limited (DMRC), project implementation agency, can finance 5% of the Delhi Metro Phase IV Project cost with three priority corridors and reduce 9.71 % sovereign and subordinate debt requirement. The research also estimates that the annual VCF amount transfer can turn DMRC net annual loss into profit. It will provide DMRC adequate cushion to keep the metro travel fare and make the metro operation sustainable in the long run.

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Appendix 1

Concepts and Theory of Econometric Methods for Policy Evaluation

This appendix presents a compilation of the concepts, theory, methods, and program evaluation techniques to estimates the effect of the independent variable on the dependent variables in the field settings.

Concepts and Theory of Econometric Methods of Time Series Data:

The time-series data have both the cross-section and time dimensions that are widely used in empirical researches. The data set contains time series, and cross-section dimensions are called the Panel data set. Panel data sets are relatively easy to collect for the city, districts, states, and a country based on the scale of the analysis. If the scale of analysis is country or prefecture, then we may call it macroeconomic analysis, whereas the regional studies often use microeconomic analysis. The microdata of a region or firm is collected through surveys with caution to reduce the measurement error and biases in collecting the data during sample data collection. The unbiased data that is free from measurement error gives an unbiased estimate and helps the policy researchers to interpret the causal effect using these data in various econometric and statistical models.

Criteria for data quality for policy research:

The data of the variables should meet six criteria, namely consistency, validity, uniqueness, accuracy, timeliness, and completeness. A brief description of these properties are as under:

1. Consistency: The data should be representative of the real-world situation, and it should not contain an element of arbitrariness while collecting the data for policy research. In other words, data should have a high degree of reliability.
2. Validity: The data should come from the legitimate source and should meet the definition of the variable for which the data is collected.
3. Accuracy: The effort should be made to record the data with a high degree of accuracy. Errors in recording or measuring elements of data such as route length, population density, etc. will lead to inconsistent estimation of the results.
4. Timeliness: The data should correctly represent the time when it was first recorded. The care should be taken while collecting data from the government published reports. These reports often use provisional data or projected data for a particular year, which may not correctly represent the data with a particular time in question.

5. Uniqueness: The data recorded for a variable for a specific period of time should be unique, and there should be no two values for the same data for the same variable in the same period of time.
6. Completeness: The data recorded should be complete, and it should avoid the gaps in the data recording. The researcher may increase the number of observations to overcome the problem of data incompleteness or overcome the issue of missing value in the data set.

Selection of Econometric Model for Policy Analysis:

The effect of certain events on the outcome variable is contingent upon the experimental design chosen to make causal inferences. Some experiments prefer natural settings where an event occurs naturally in isolation and without any control of other variables. The experiment research carried on such natural conditions is the example of **natural experiments**. The natural experiments have a control group, exogenous to the effect of policy change or event of interest, and a treatment group affected by the event of policy change. Another form of experiment design is the **quasi-experimental** design to ensure exogeneity among the variables by employing sample selection techniques and econometrics methods to get unbiased and consistent estimates to predict causal relations among dependent and independent variables.

The policy analysis of pooling cross-section data across time may employ the following econometrics method to set quasi-experimental settings to find a causal relationship among the dependent and independent variables. These are:

1) **Dummy variable Regression model:** It is the simplest form of econometrics model used to estimate the causal relationship among dependent and independent variables in case of the presence of an event. The dummy variable takes binary value zero or one based on without or with the occurrence of the event. The dummy variable regression measures qualitative change over the outcome effect by comparing the results in case of the presence of the event and the absence of it. The dummy variable may represent a particular year e.g. year 2005 or particular space that is "Tokyo City' if year or location are considered to affect the policy outcome. Let any outcome event is described by variable Y , and the independent variables are explain by X_1, and X_2. The simple regression equation can be written in the form as

$$\mathbf{Y_{it} = \beta_0 + \beta_1 X_{it} + u_{it}}$$

Suppose if we want to measure the occurrence of a certain event after the year 2005, then we may introduce a year dummy variable $D_{1,\text{ year 2005}}$ to measure the effect due to year 2005 from the following equation:

$$\mathbf{Y_{it} = \beta_0 + \Upsilon_1\ D_{1,\,year\ 2005} + \beta_1\ X_{it} + u_{it}}$$

Where, coefficient of dummy variable Υ_1 will estimate the effect of policy X_{it} on variable Y_{it} due after the year 2005. The statistical significance of this estimate will be derived from the z value if it is more than 1.96 and the p value is more than 0.05 at 95% significance level or 0.10 at 90% significance level.

2) Difference in Difference method of Policy Evaluation:

Difference in Difference (DiD) method is also known as Before and After analysis of a policy outcome. The group of the variables where the policy is applied is divided into the Control group and Treatment group. The treatment group receives the policy treatment, whereas no policy intervention is applicable in the control group. The treatment in the DiD approach represented by a dummy variable, a binary variable that takes value either 1 or zero. The sample group is broken down into four groups to estimate their effects:

1. Control group before the policy treatment year
2. Control group after the policy treatment year
3. Treatment group before the policy treatment year
4. Treatment group after the policy treatment year

The difference in difference estimate method takes the difference between changes in the averages over time between the control group ($\overline{Y}_{2,C} - \overline{Y}_{1,C}$) and average changes over the period between the treatment group ($\overline{Y}_{2,T} - \overline{Y}_{1,T}$). The difference between the two differences will give the measurement effect of policy treatment as represented by the following equation:

$$\widehat{\delta 1} = (\overline{Y}_{2,T} - \overline{Y}_{1,T}) - (\overline{Y}_{2,C} - \overline{Y}_{1,C})$$

The difference in difference method can be explained graphically as the change in the slope and intercept observed for Control and Treatment group between two periods that is before the treatment and after the treatment year. The difference between the regression line slope of the Control and Treatment group will be the treatment effect $\delta 1$.

Let the coefficient estimated from a regression model on outcome variable Y_{it} of the control group before treatment year is given by β_0, and the coefficient for treatment group is given by $\beta_0 + \beta_1$.

Let consider that the policy treatment is given to treatment group after the period T. At this period the average change in coefficient of the Control group will be $\beta_0 + \delta_0 + \beta_1 + \delta_1$. Then the estimator δ_1 will represent the changes due to policy treatment effect.

The following equation gives the general form of the equation for estimation of difference in difference estimator:

$$\mathbf{Y_{it} = b0 + \delta_0\, d2 + \beta_1\, dT + \delta_1\, d2\, dT + other\ factors,}$$

Where, dT is the dummy variable for treatment effect = 1 if the treatment is given or zero otherwise, and d2 is the dummy variable for the time period (in years or months) when the treatment started.

The DiD method of estimation of the treatment effect is a very popular tool in development economics where quasi-experiments are set up to estimate the effect of policy interventions on the desired outcome through Randomized Control Trial (RCT) methods.

3) Fixed Effect (FE) or Unobserved Effect Model for controlling time invariant errors:

The panel data may view the unobserved factors that affect the dependent variable due to the **time-invariant constant** and constants varies with the time for a particular variable. This time-invariant constant is also called the **fixed effect** of the variables such as city, schools, hospitals, colleges, universities, etc. These unobserved fixed effects are **idiosyncratic errors** of the variables. The errors caused by the fixed effect are taken care of by the **Fixed Effect (FE) regression model** by creating an individual dummy for each of the variables to compute the average effect of each variable before and after the treatment year to eliminate the heterogeneity bias from the estimates. The fixed effect regression model can be written in the form of linear equation with a single observed variable as:

$$\mathbf{Y_{it} = \beta_0 + \delta_0\, d2 + \beta_1\, X_{it} + a_i + u_{it},} \quad \mathbf{t = 1, 2}$$

Where notation $\mathbf{Y_{it}}$ denotes the dependent variable such as residential land price in district, X_{it} denotes the independent variable which is variable of interest, t denotes the time period, and d2 is the dummy variable when treatment was introduced in the sample variable. The time invariant constant is given by notation $\mathbf{a_i}$, which is the fixed effect that affects the dependent variable such as residential land price; the time variant constant is denoted by term $\mathbf{u_{it}}$, which varies with time. The intercept for the time period t =1 is β_0, and the intercept for period t = 2 is given by $\beta_0 + \delta_0$ (because d2 =1 when t=2).

The fixed effect model introduces n-1 dummy in the regression equation; for example, a set of dataset of 9 districts will have 8 dummy variable, one each for two observation of each variable. We are essentially estimating the following equation form:

$$\boldsymbol{Y_{it} = \beta_0 + \delta_0 d2_t + \beta_1 x_{it1} + \ldots + \beta_9 x_{9tk} + a_1 d(i=1) + a_2 d(i=2) + \ldots + a_9 d(i=9) + u_{it}}$$

Where, $\hat{a}_i$ is the fitted value of term $a_1 d(i=1) + a_2 d(i=2) + \ldots + a_9 d(i=9)$. The estimate $\hat{a}_i$ is the slope coefficients on these dummy variables which is the estimated fixed effect.

The Fixed Effect model estimates by demeaning the data of the explanatory variable if time period T > 2. The demeaning process involves taking an average of the sample data and subtracting it from the individual data of interest. The derivation of the demeaned form of regression equation for more than two time period is given below:

$$\mathbf{Y_{it} - \overline{Y}_i = \beta_1 (x_{it1} - \overline{X}_{it1}) + \ldots + \beta_9 (x_{itk} - \overline{X}_{itk}) + u_{it} - \overline{u}_i}$$

$$\rightarrow \ddot{Y}_{it} = \beta_1 \ddot{X}_{it} + \ddot{u}_{it} \quad ,$$

$$(\text{where, } \ddot{Y}_{it} = Y_{it} - \overline{Y}_I ; \ \ddot{X}_{it} = x_{itk} - \overline{X}_{itk} \ \text{ and } \ddot{u}_{it} = u_{it} - \overline{u}_i)$$

The estimates obtained from the demeaning form of the equation is also called **'within estimator'** because it uses the variation within the individual entity over time. The within estimator is different than between estimator because later is just the means of the variation over time and given by equation $\overline{Y}_i = \beta_1 \overline{X}_{i1} + \overline{u}_i$.

4) First Difference (FD) Model for controlling time invariant errors:

We can also eliminate the effect of fixed effect by differencing the data across two years. The equation derived from subtracting of the equation of t=1 from t=2 will give us the first difference equation as illustrated below:

$$Y_{i2} = \beta_0 + \delta_0 d2 + \beta_1 X_{i2} + a_i + u_{it} \quad (t = 2)$$

$$Y_{i1} = \beta_0 + \beta_1 X_{i1} + a_i + u_{it} \quad (t = 1)$$

If we subtract the second equation from the first equation, then we get

$$\Delta \hat{Y}_i = d_0 + \beta_1 \Delta x_i + \Delta u_i$$

This equation represents the first difference equation of single cross section with each variable are differenced over time. The estimator β_1 obtained from the regression of this equation is called the **first differenced estimator**. When the time period T > 2 then the first linear equation may be written in the following form:

$$Y_{it} = \delta_1 + \delta_2 d2_t + \delta_3 d3_t + \ldots\ldots + \delta_k dk_t + \beta_1 x_{it1} + \ldots\ldots\ldots + \beta_1 \Delta x_{itk} + a_i + u_i$$

Where, T = k i.e. t = 1,2……k, and number of observation for the model will be NT or kT. The above equation includes k-1 numbers of the dummy in addition to an intercept δ_1. The base period for the above equation is t = 1, and the intercept for the second time period will be $\delta_1 + \delta_2$. The first difference equation may be obtained by differentiating two adjacent time periods such that when t =3, then data will be deducted for time period t = 3 and t =2 . The first difference equation of more than two time period may be written as:

$$\Delta \hat{Y}_{it} = \delta_2 \Delta d2_t + \delta_3 \Delta d3_t + \beta_1 \Delta x_{itk} + \Delta u_{it}$$

However, the value of change in dummy for t=2, i.e. $\Delta d2_t$ $\Delta d3_t$ will be 1 and 0 whereas for t=3 the changes in dummy $\Delta d2_t$ $\Delta d3_t$ will be -1and 1 respectively.

5) Random Effect (RE) Regression Model

The Random effect model takes the form of the Fixed Effect model equation with an additional assumption that the fixed effect a_i is independent of all explanatory variable x_{it}. However, this fixed effect a_i may be serially correlated with the error term u_{it}, and therefore our estimate from the regression may be biased and

inconsistent. If we define the summation of fixed effect error and time variant error $\mathbf{u_{it}}$ as composite error $\mathbf{e_{it}} = \mathbf{a_i} + \mathbf{u_{it}}$, then the regression equation can be written as :

$$Y_{it} = \beta_0 + \beta_1 x_{it1} + \ldots + \beta_k x_{itk} + e_{it}$$

Since $\mathbf{a_i}$ is part of composite error e_{it} in each time period, the composite error may be serially correlated. This serial correlation in two time period t and s can be written as

$$\mathbf{Corr}\ (e_{it}, e_{is}) = \sigma^2 a / (\sigma^2 a + \sigma^2 u) \quad \text{, when } t \neq s.$$

Where, $\sigma^2 a = \mathrm{Var}(a_i)$, and $\sigma^2 u = \mathrm{Var}(u_i)$. We can use the Generalized Lease Square (GLS) transformation to solve the serial correlation problem of the composite error term; however, this procedure is effective when we have a large number of observations (N) and less panel year period (T). The GLS transformation is defined as θ and given by the following equation :

$$\theta = 1 - [\sigma^2 a / (\sigma^2 a + T \sigma^2 u)]^{1/2} \ ,$$

Where θ is between 0 and 1.

The transformed equation of Random effect model can be written as:

$$Y_{it} - \theta \bar{Y}_i = \beta_0 (1- \theta) + \beta_1 (X_{it1} - \theta \bar{X}_{it1}) + \ldots + \beta_k (X_{itk} - \theta \bar{X}_{itk}) + e_{it} - \theta \bar{e}_i$$

The random effect subtract the fraction of the time average, which depends upon the $\sigma^2 a$ and $\sigma^2 u$ and number of time period T. The estimators estimated from the above equation are called the random effect estimators. The random effect estimates will be close to the Fixed Effect estimator when $\theta = 1$, the equation become the same as the Fixed Effect equation. When $\theta = 0$, that is the equation become pooled OLS estimates. As the number of time period T goes large then the value of θ become closer to 1. However, in practice the value of θ never become zero or one.

6) Fixed Effect (FE) Model Vs. First Difference (FD) Model:

The Fixed Effect estimation is more common than First Differences because it is easier to do, and it can be easily implemented for unbalanced panels. Fixed Effect estimations are more efficient than the First Differencing method if there is no serial correlation in the error term $\mathbf{u_{it}}$. If there exist serial correlation in the error term over time $\Delta \mathbf{u_{it}}$ then First Difference model will be more efficient.

The estimates from the Fixed Effect model and the First Difference model are the same when time period T = 2. The relative efficiency of the estimates will be high for the Fixed Effect model if T>2; however, the estimates from both the FE and FD will be unbiased and consistent with T fixed and N -> ∞. If $\mathbf{u_{it}}$ follows the random walk and stochastic process, then it is the First Difference model that become more efficient than the Fixed Effect model.

7) Fixed Effect Model Vs. Random Effect Model and Hausman Test:

Random Effect model is more appropriate to use when there is no correlation among the independent variables or all variables are exogenous. Random Effect model is also more effective for a random sample of individuals. In contrast, the Fixed effect model is more appropriate when observations corresponds to mutually exhaustive set of units, such as 47 prefectures of Japan. If a dataset contains all 47 prefecture values, then it is not a random sample; in such cases, the Fixed effect model will be more appropriate for the estimation of the regression model.

We can choose the appropriateness of the Fixed Effect model and the Random Effect model by conducting the Hausman Test. The Hausman test in econometrics is also known as the **Durbin-Wu-Hausman test**. This test is named after James Durbi, De Min Wu, and Jerry A Hausman. The Hausman test proposes a null hypothesis **H0**: that the Random Effect estimator is an appropriate model with alternative hypothesis **H1**: in favor of the Fixed Effect estimator. If the **p-value** derived from the Hausman test is small than 0.05 then we reject the null hypothesis H0 in favor of H1 and say that the Fixed Effect is an appropriate model for estimates to be unbiased and consistent.

8) Testing for Endogeneity:

The endogeneity in any regression model can be defined as the condition in which the independent variables $\mathbf{X_{it}}$ are correlated with the error term $\mathbf{u_{it}}$. The endogeneity is serious threat to the exogeneity assumption of the variable $\mathbf{Cov\ (x_{it}, u_{it}) = 0,}$ if this condition is violated, then the estimates from the regression model will become biased and inconsistent. The statistical significance of endogeneity caused by correlation of explanatory variables with error term may be estimated by adopting the following procedure:

i. Regress the explanatory variable and find the residual by executing predict residual command in STATA.

ii. Regress the dependent variable on the explanatory variables and the predicted residual to find estimators and the z- statistics.

iii. If the estimated coefficient of residual $\neq 0$ and z statistic is significant and the p-value is less than 0.05, then we conclude that there is significant correlation between $\mathbf{X_{it}}$, $\mathbf{u_{it}}$.

The endogeneity in the regression model can be overcome by introducing an omitted variable in the equation or by choosing appropriate instrument variable (IV) for the variable of interest and estimating the regression model in 2 Stages through Two Stage Instrument Variable (IV) Regression model.

9) Two Stage Least Squares (2SLS) Instrument Variable Regression Model:

The Instrument Variable (IV) Regression should be used when there is a correlation between the explanatory variable ($\mathbf{x_{it,}}$) and the error term($\mathbf{u_{it}}$). The consistent estimation of intercept β_0 and slope coefficient β_1 is possible by introducing a new variable z which satisfy the following properties:

a) **Instrument exogeneity : Cov (z, u) = 0;**

The new variable z is uncorrelated with error term u. In other words, **z** is exogenous in the regression equation. The concept of instrument exogeneity states that variable **z** has no partial effect on y after x and omitted variables are controlled, and **z** should be uncorrelated with the omitted variables. Generally, it is not possible to test the covariance between z and u, because u is unobservable. Therefore, we must maintain that **Cov (z, u) = 0** in most of cases by providing economic intuition.

b) **Instrument Relevance: Cov (z, x) $\neq$ 0;**

The explanatory variable x is correlated with instrument variable z. The weak correlation between z and x is not desired because the estimate from such regression is biased and inconsistent.

The method for executing 2SLS Instrumental Variable Regressions are as under:

i) A common form of standard regression equation can be represented by the following equation:

$$\mathbf{y_{1it}} = \beta_0 + \beta_1\, \mathbf{y_{2it}} + \beta_2\, \mathbf{z_{1\ it}} + \beta_3\, \mathbf{z_{2it}} + \mathbf{u_{it}}$$

ii) 1SLS Equation with two instrumental variable z_3 and z_4 not present in the standard equation can be written as:

$$y_{2it} = \pi_0 + \pi_1 z_{1\,it} + \pi_2 z_{2it} + \pi_3 z_{3\,it} + \pi_4 z_{4it} + v_{it}$$

Where,

$z_{3\,it}$	Instrument variable no.1 for endogenous variable y_{2it}
z_{4it}	Instrument variable no.2 for endogenous variable y_{2it}
$\pi_0, \pi_1, \pi_2, \pi_3,$	Estimators of the reduced form of equation

iii) 2sls IV Regression Equation can be derived after substituting the fitted value of the variable $\hat{y}_{2it}$ in the standard form of the equation as:

$$y_{1it} = \Upsilon_0 + \Upsilon_1 (\hat{y})_{2It} + \Upsilon_2 z_{1\,it} + \Upsilon_3 z_{2it} + + e_{it}$$

Where, Υ_1, Υ_2, **and** Υ_3 are the regression estimates from the 2sls IV regression model. However, the IV regression estimates may differ from the GLS estimates, and the standard error may be high. If there is no much difference between the GLS and IV estimate, and if the estimates are statistically significant then we may conclude that the difference in the estimate may be due to the sampling error.

10) Regression Discontinuity (RD) Design in Econometrics Model:

Regression discontinuity (RD) design is another example of natural experiment setting. The RD design was first proposed by Donald L. Thistlethwaite and Donald T Campbell (1960), as a method to measure the treatment effect in a nonexperimental setting. The RD design exploits the precise knowledge of the treatment and control status. The RD design regression is generally used when the treatment status is a deterministic and discontinuous function of covariate $\mathbf{X_i}$. RD design can be represented graphically to represent the change in the slope of regression and effect of the treatment 'τ' once the running variable reaches the cut off value '**c**' .

RD design is a deterministic function because once we know the running variable $\mathbf{X_i}$ then we know when the cut off $\mathbf{X_0}$ such that:

$$\mathbf{d_i = 1 \text{ if } X_i > X_o, \text{ otherwise } 0 \text{ if } X_i < X_o.}$$

RD design is a discontinuous function of $\mathbf{X_i}$, because no matter how close $\mathbf{X_i}$ gets to $\mathbf{X_o}$, the treatment is not administered or remain unchanged.

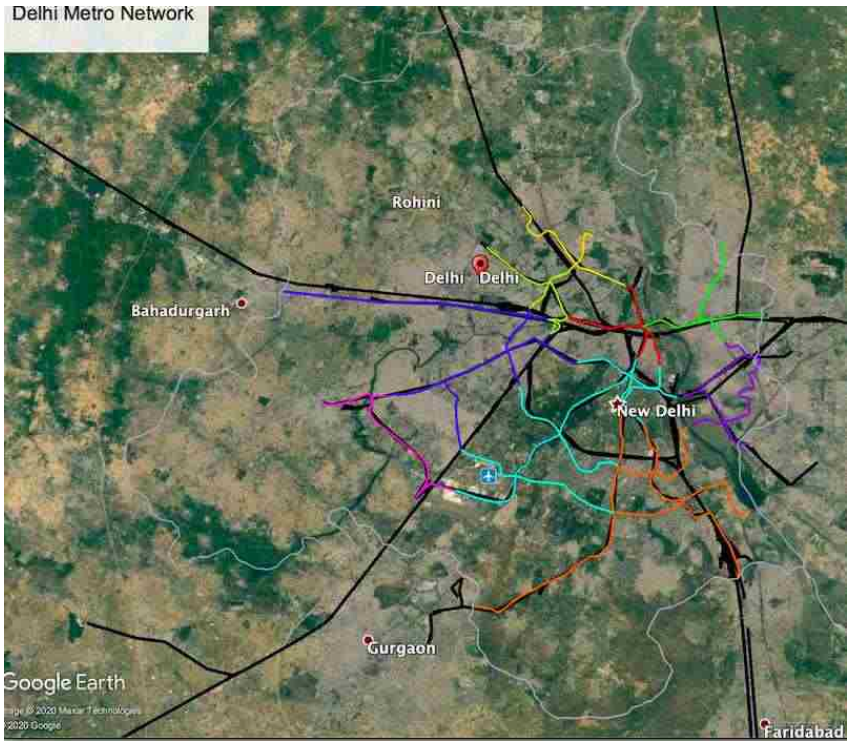
APPENDIX 2

Google Earth Pro Google Map Plots and Measurement of Plot Layers

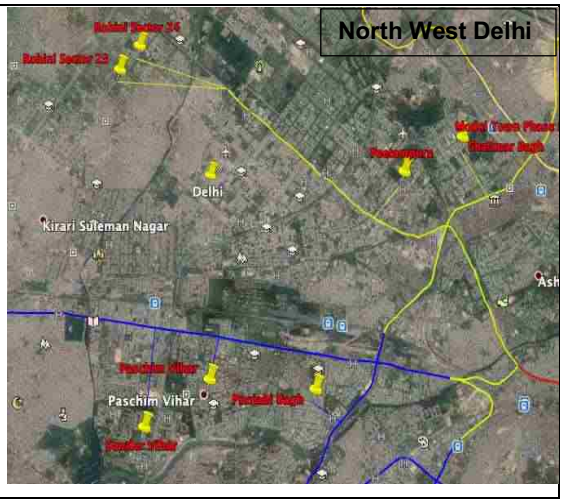
Google Earth Pro of Delhi Metro Phase-I, II, III Network and Selected Urban Area

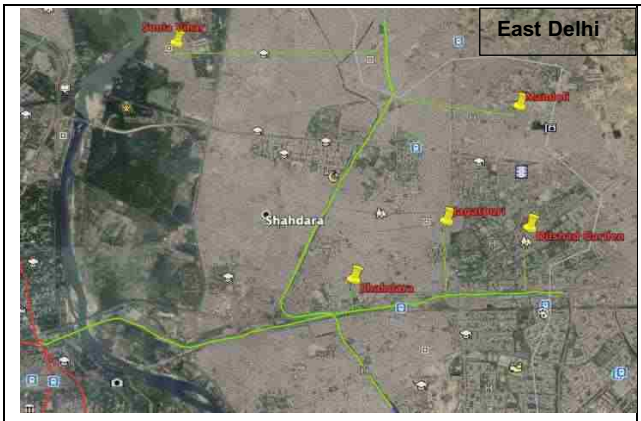
Delhi Metro Network and the selected urban area have been plotted on Google Earth Pro to measure the distance of corridors in each district of Delhi. The Google Earth Pro map of Delhi and district wise bifurcation are shown in this appendix. The corridors of each district are plotted in different colours.

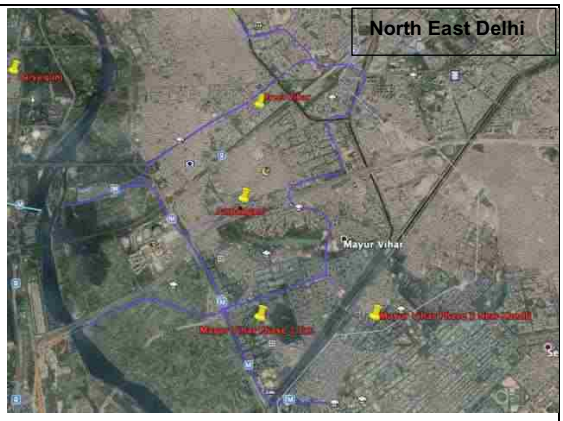
Fig. A2.1: Google Earth Plot of Metro Network

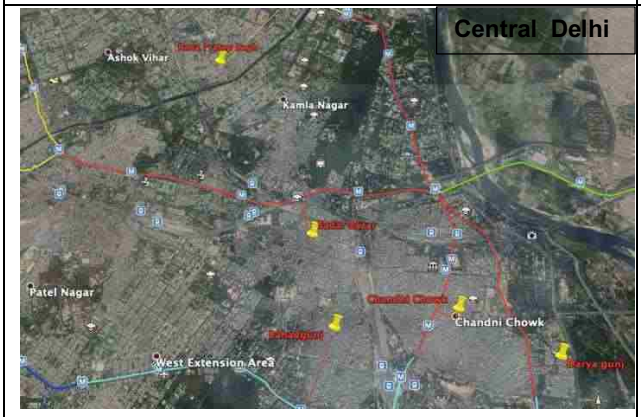


District wise plot of Delhi Metro Network and urban area selected for research are described below:

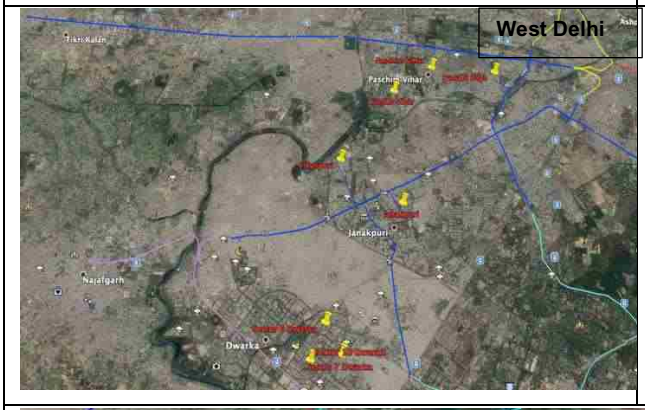



East Delhi
Shahdara

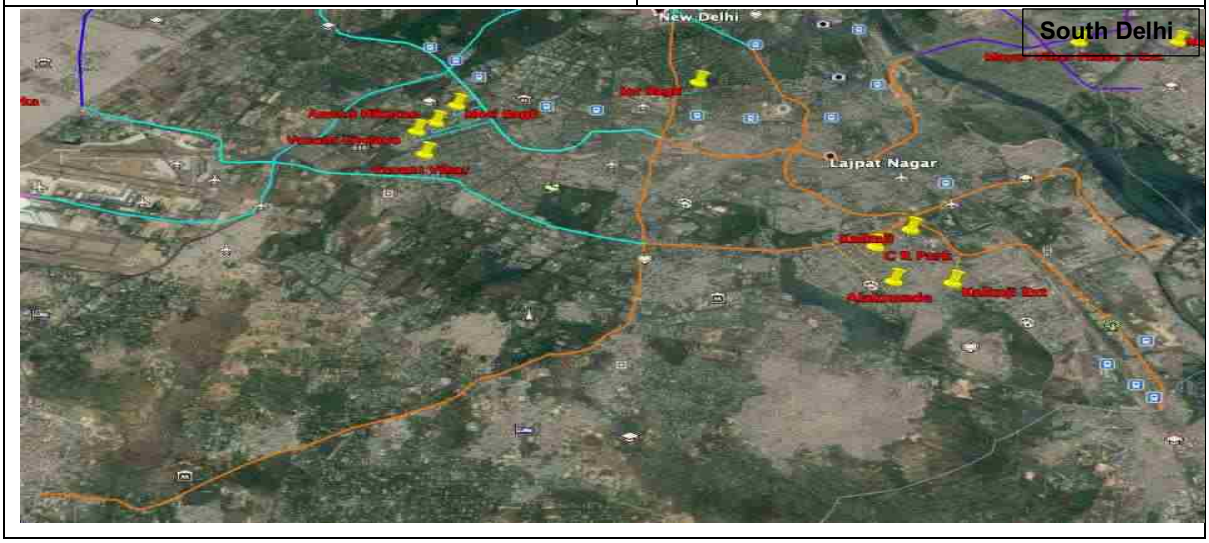

North East Delhi
Mayur Vihar


Central Delhi
Ashok Vihar
Kamla Nagar
Patel Nagar
Chandni Chowk
West Extension Area


New Delhi
Janakpuri
New Delhi


West Delhi
Janakpuri
Najafgarh
Dwarka


South West Delhi
Najafgarh
Kakrola
Dwarka

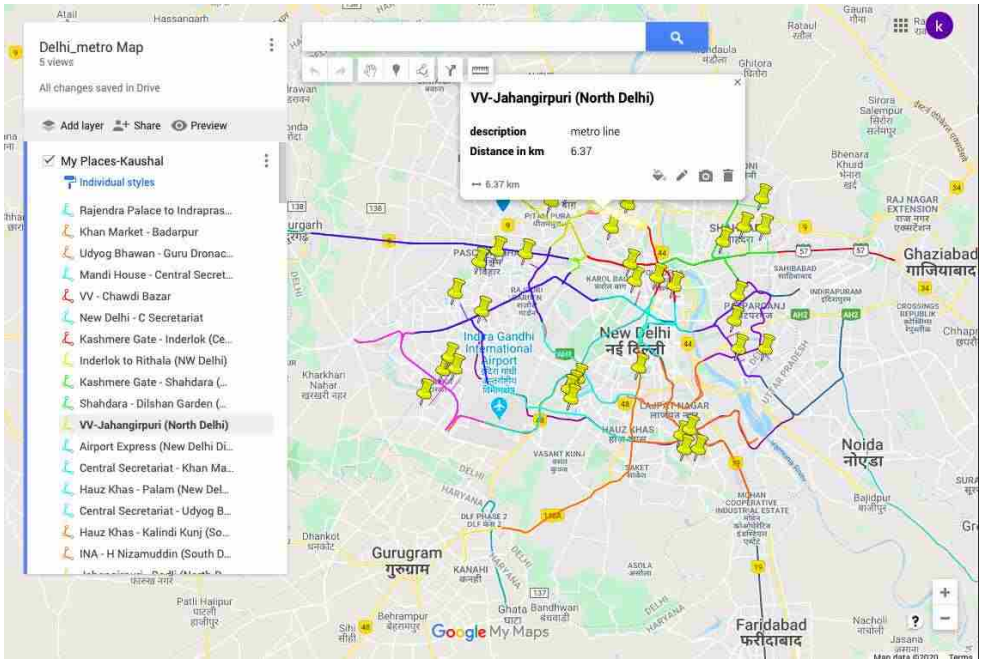

South Delhi
New Delhi
Lajpat Nagar
C.R. Park

The distances measured on Google Earth Pro are tabulated to show the district wise distances of metro network corridors and distance of selected urban areas centroid from the metro network. The distance of the layers can also be measured from Google Map using the following steps:

1. Create layers for corridors using the tool ‘ruler’ and save layers under My Places folder.
2. Mark the placemark at the centroid of the selected urban area of districts and from the ‘ruler’ tool to create a line to connect it with the nearest metro network.
3. Measure the distance of each layer from the ‘get Info’ tab by clicking on the layer.
4. Merge all corridors and places under My Place and save it as .kmz file. I have saved it as My Places-kaushal.kmz.
5. Open My Google Map and import Google Earth ‘MyPlaces.kmz’ file. Then, open the data table to add or edit the layer information. I have entered the corridor information as ‘metro line’ and urban area centroid as ‘centroid'. The distance from the metro distance are mentioned as ‘metro dist’. The new Colom of ‘distance in km’ describes the measured distance in kilometer.
6. The file was downloaded as .kmz file and converted to excel file using the online source of MyGeodata Converterwebsite https://mygeodata.cloud/converter/

My Google Earth Map provides details of the plotted metro line layers, urban places centroids, and its distance from the metro network. These layers can be depicted from the screenshot of the My Google Map as shown here:

Fig. A2.2: My Google Map with layer details



The geodata details of the layers are saved in the 'My_Places-Kaushal.xlsx' file. The geodata details of the metro lines, selected urban areas, and its distance from the metro network are described below:

x	y	gid	Name	description	tessellate	Distance_in_km
77.22181949	28.6317425	1	Rajendra Palace to Indraprastha (New Delhi District)	metro line	1	8.31
77.25553151	28.55195446	2	Khan Market - Badarpur	metro line	1	15.8
77.206245	28.54641343	3	Udyog Bhawan - Guru Dronacharya (South Delhi)	metro line	1	21.4
77.2162205	28.620785	4	Mandi House - Central Secretariat (New Delhi District)	metro line	1	2.89
77.22685397	28.66981007	5	VV - Chawdi Bazar	metro line	1	6.14
77.21886801	28.63045303	6	New Delhi - C Secretariat	metro line	1	3.66
77.18563552	28.6698635	7	Kashmere Gate - Inderlok (Central Delhi)	metro line	1	5.94
77.14199403	28.69752849	8	Inderlok to Rithala (NW Delhi)	metro line	1	8.84
77.26961443	28.67023703	9	Kashmere Gate - Shahdara (NE Delhi)	metro line	1	6.36
77.0962275	28.7241115	51	Rohini Sec 24 Distance	metro dist.	1	2.11
77.29749548	28.67478199	10	Shahdara - Dilshan Garden (NE Delhi)	metro line	1	3.15
77.174684	28.711566	11	VV-Jahangirpuri (North Delhi)	metro line	1	6.37
77.16619652	28.59677056	12	Airport Express (New Delhi District)	metro line	1	19
77.2202675	28.608666	13	Central Secretariat - Khan Market (New Delhi District)	metro line	1	2.11
77.14225297	28.56404651	14	Hauz Khas - Palam (New Delhi District)	metro line	1	12.8
77.2119835	28.6128525	15	Central Secretariat - Udyog Bhawan (New Delhi District)	metro line	1	0.533
77.26197251	28.552919	16	Hauz Khas - Kalindi Kunj (South Delhi)	metro line	1	12.5
77.260275	28.58339449	17	INA - H Nizamuddin (South Delhi)	metro line	1	8.69
77.139264	28.737711	18	Jahangirpuri - Badli (North Delhi)	metro line	1	5.17
77.181808	28.72098158	19	Azadpur - Mukundpur (North Delhi)	metro line	1	3.58
77.1543115	28.6937345	20	Shakurpur-Azadpur (North West Delhi)	metro line	1	4.75
77.16428601	28.66762596	21	SRS Marg - Inderlok	metro line	1	3.63
77.240963	28.633164	22	Mandi House - Delhi Gate	metro line	1	2.27
77.236827	28.65490601	23	Kasmere Gate - Delhi Gate (Central Delhi)	metro line	1	3.39
77.27937202	28.69135304	24	Krishna Nagar - Shiv Vihar (North East Delhi)	metro line	1	9.20
77.31162	28.629967	25	Mayur Vihar - Krishna Nagar (East Delhi)	metro line	1	13.7
77.28780801	28.60755348	26	Indraprastha-New Ashok Nagar (East Delhi)	metro line	1	7.27
77.28702047	28.63660799	27	Yamuna Bank - Anand Vihar (East Delhi)	metro line	1	4.72
77.05	28.5860785	28	Dwarka Mor - Dwarka Sector 21 (South West Delhi)	metro line	1	10.7
77.06241641	28.55619986	29	Dwarka Sector 21 - IGI Airport	metro line	1	3.48
77.0226235	28.61690347	30	Dwarka - Nangli	metro line	1	1.63
77.0052275	28.615343	31	Nangli - Najafgarh	metro line	1	2.85
77.101602	28.639132	32	Rajendra Palace - Dwarka Mor (West Delhi)	metro line	1	15.8
77.111651	28.677417	33	Punjabi Bagh East - Mundka (West Delhi)	metro line	1	13.5
76.982385	28.6864385	34	Mundka - Tikri Border	metro line	1	6.69
77.15373	28.65785449	35	Kirti Nagar - SRS Marg (West Delhi)	metro line	1	1.06
77.0870825	28.60646452	36	Palam-Janakpuri West (West Delhi)	metro line	1	5.52
77.12378999	28.65295506	37	Narain Vihar - Shakurpur (West Delhi)	metro line	1	6.58
77.16255101	28.59892899	38	INA - Naraina Vihar (New Delhi District)	metro line	1	11.5
77.2062555	28.7001555	39	Outram Line Distance	metro line	1	0.403
77.206771	28.7019791	40	Outram Line	centroid	-1	
77.18910951	28.70809782	41	Model Town Distance	metro dist.	1	0.727
77.190241	28.7111471	42	Model Town Phase 2	centroid	-1	

77.184309	28.708342	43	Model Town Phase 3 distance	metro dist.	1	0.481
77.184951	28.7106151	44	Model Town Phase 3	centroid	-1	
77.1998315	28.6921855	45	Rana Pratap Bagh Dist	metro dist.	1	1.81
77.193782	28.6860081	46	Rana Pratap Bagh	centroid	-1	
77.1622515	28.706462	47	Shalimar Bagh Dist	metro dist.	1	1.09
77.159363	28.7106271	48	Shalimar Bagh	centroid	-1	
77.142798	28.701448	49	Peetampura Distance	metro dist.	1	0.891
77.145991	28.7045111	50	Peetampura	centroid	-1	
77.085998	28.7270751	52	Rohini Sector 24	centroid	-1	
77.0940585	28.721967	53	Rohini Sec 23 Distance	metro dist.	1	2.46
77.081557	28.7227081	54	Rohini Sector 23	centroid	-1	
77.128471	28.6659985	55	Punjabi Bagh Distance	metro dist.	1	0.680
77.125437	28.6676881	56	Punjabi Bagh	centroid	-1	
77.103778	28.6734835	57	Paschim Vihar Distance	metro dist.	1	1.10
77.102499	28.6693051	58	Paschim Vihar	centroid	-1	
77.0901445	28.671341	59	Sunder Vihar Distance	metro dist.	1	1.93
77.088488	28.6615531	60	Sunder Vihar	centroid	-1	
77.0580835	28.583709	61	Sec 10 Dwarka Distance	metro dist.	1	0.532
77.059523	28.5854911	62	Sector 10 Dwarka	centroid	-1	
77.0590795	28.589123	63	Sector 6 Dwarka	metro dist.	1	1.57
77.064265	28.5949311	64	Sector 6 Dwarka	centroid	-1	
77.065365	28.58266	65	Sector 7 Dwarka	metro dist.	1	1.20
77.069346	28.5868761	66	Sector 7 Dwarka	centroid	-1	
77.0504715	28.575456	67	Sec 19B Dwarka Distance	metro dist.	1	1.83
77.044512	28.5696641	68	Sector 19B Dwarka	centroid	-1	
77.2144685	28.587763	69	Jor Bagh Distance	metro dist.	1	0.340
77.216243	28.5878171	70	Jor Bagh	centroid	-1	
77.07222	28.634381	71	Vikaspuri Distance	metro dist.	1	1.43
77.069233	28.6400691	72	Vikaspuri	centroid	-1	
77.0882685	28.630029	73	Janakpuri Distance	metro dist.	1	0.737
77.090281	28.6272471	74	Janakpuri	centroid	-1	
77.170062	28.5820935	75	Moti Bagh Distance	metro dist.	1	0.685
77.167157	28.5805601	76	Moti Bagh	centroid	-1	
77.168934	28.5778375	77	Anand Niketan Distance	metro dist.	1	1.27
77.163259	28.5753101	78	Anand Niketan	centroid	-1	
77.1674695	28.575871	79	Vasant Enclave Distance	metro dist.	1	1.69
77.159695	28.5726661	80	Vasant Enclave	centroid	-1	
77.1615655	28.564254	81	Vasant Vihar Distance	metro dist.	1	0.414
77.161864	28.5658821	82	Vasant Vihar	centroid	-1	
77.247644	28.542101	83	C R Park Distance	metro dist.	1	0.688
77.249597	28.5396681	84	C R Park	centroid	-1	
77.2550185	28.545733	85	Kalkaji Distance	metro dist.	1	0.449
77.256618	28.5443091	86	Kalkaji	centroid	-1	
77.2650715	28.5353685	87	Kalkaji Ext Distance	metro dist.	1	1.24
77.26338	28.5299761	88	Kalkaji Ext	centroid	-1	
77.2473525	28.5370165	89	Alaknanda	metro dist.	1	1.77
77.252402	28.5304171	90	Alaknanda	centroid	-1	
77.228885	28.6510605	91	Chandni Chowk dist	metro dist.	1	0.277
77.230365	28.6506191	92	Chandni Chowk	centroid	-1	
77.2424145	28.6447135	93	Darya Gunj Distance	metro dist.	1	0.387

77.244406	28.6447341	94	Darya gunj	centroid	-1	
77.2108245	28.6437275	95	Pahadgunj Distance	metro dist.	1	1.07
77.212602	28.6482961	96	Pahadgunj	centroid	-1	
77.208562	28.663498	97	Sadar Bazar Distance	metro dist.	1	0.731
77.209231	28.6603381	98	Sadar Bazar	centroid	-1	
77.314742	28.6801655	99	Dilshad Garden Distance	metro dist	1	0.973
77.315309	28.6849741	100	Dilshad Garden	centroid	-1	
77.2834055	28.674551	101	Shahdara	metro dist.	1	0.389
77.283137	28.6762861	102	Shahdara	centroid	-1	
77.302523	28.708243	103	Mandoli Distance	metro dist.	1	2.37
77.314268	28.7065391	104	Mandoli	centroid	-1	
77.2690245	28.718368	105	Sonia Vihar Distance	metro dist.	1	4.03
77.248395	28.7184321	106	Sonia Vihar	centroid	-1	
77.2941365	28.5999625	107	Mayur Vihar Phase 1 Distance	metro dist.	1	0.426
77.295989	28.6006741	108	Mayur Vihar Phase 1 Ext.	centroid	-1	
77.294072	28.6388475	109	Preet Vihar Distance	metro dist	1	0.300
77.295201	28.6379591	110	Preet Vihar	centroid	-1	
77.3125445	28.6047875	111	Mayur Vihar Phase 3 New Kondli Distance	metro dist.	1	1.22
77.316819	28.6007511	112	Mayur Vihar Phase 3 New Kondli	centroid	-1	
77.3003095	28.6808635	113	Jagatpuri Distance	metro dist.	1	1.21
77.300034	28.6861521	114	Jagatpuri	centroid	-1	
77.286655	28.6180905	115	Patparganj	metro dist.	1	1.15
77.292476	28.6203951	116	Patpadganj	centroid	-1	

APPENDIX 3

Data Source and Data Generation for Research

A 3.1 District-wise Number of metro stations and metro route length for the years 1992, 1998, 2005, 2012 and 2018 are counted by considering the completed corridor during the corresponding year.

		NDMC	North MCD			East MCD		South MCD		
Year	Metro Network	New Delhi District	North Delhi	North West Delhi	Central Delhi	North East Delhi	East Delhi	South Delhi	South West Delhi	West Delhi
1992	Metro Line	No	No	No	No	No	No	No	No	No
	Number of Stations	0	0	0	0	0	0	0	0	0
	Length of Metro Network (KM)	0	0	0	0	0	0	0	0	0
1998	Metro Line	No	No	No	No	No	No	No	No	No
	Number of Stations	0	0	0	0	0	0	0	0	0
	Length of Metro Network (KM)	0	0	0	0	0	0	0	0	0
2005	Metro Line	New Delhi to Central Secretariat (Line-2)		Inderlok - Rithala (Line-1)	Inderlok to Kashmere Gate (Line-1), Vishwavidyalaya to Chawri Bazar (Line-2)	Kashmere Gate - Shahdara (Line-1)				
	Number of Stations	4	0	8	6+6=12	4	0	0	0	0
	Length of Metro Network (KM)	3.35	0	8.82	22.06	6.36	0	0	0	0
2012	Metro Line	New Delhi - IGI Airport (Express Line), Central Secretariat - Udyog Bhawan (Line-2), Central Secretariat - Khan Market (Line-6), Rajendra Palace - Indraprastha (Line-3)	Vishwavidyalaya - Jahangirpuri (Line-2)	SRS Marg - Inderlok (Line-5)		Shahdara - Dilshad Garden (Line-1)	Indraprastha - New Ashok Nagar (Line-3), Yamuna Bank - Anand Vihar (Line-4)	Udyog Bhawan - Guru Dronacharya (Line-2), Khan Market - Badarpur (Line-6)	Dwarka Mor - Dwarka Sec 9 - Dwarka Sec 21 (Line-3), IGI Airport - Dwarka Sector 21	Rajendra Palace - Dwarka Mor (Line-3), Punjabi Bagh East - Mundka (Line-5), Kirti Nagar - SRS Marg (Line-5)
	Number of Stations	5+2+1+8 = 16	5	3	0	3	5+5 = 10	13+14 = 27	8+3+1 = 12	14+12+1 = 27
	Length of Metro Network (KM)	18.96+0.53+2.1+8.31 = 29.9	6.36	3.60	0	3.15	7.26+4.71 = 11.97	11.4+15.7 = 27.1	10.7+1.63+2.80 = 14.18	14.8+12.5+1.1 = 28.4
2018	Metro Line	Delhi Gate - Mandi House, Mandi House - Central Secretariat (Line-6 Ext), INA - Naraina Vihar (Line-7), Hauz Khas - Palam (Line-8)	Jahangirpuri - Badli (Line-2 Ext), Azadpur - Mukundpur (Line-7)	Shakurpur - Azadpur (Line-7)	Kashmere Gate - Delhi Gate (Line-6 Ext.)	Krishna Nagar - Shiv Vihar (Line-7)	Mayur Vihar - Krishna Nagar (Line-7)	INA - H. Nizamuddin (Line-7), Hauz Khas - Kalkaji (Line-8)		Mundka - Tikri Border (Line-5 Ext.), Naraina Vihar - Shakurpur (Line-7), Palam - Janakpuri West (Line-8)
	Number of Stations	1+3+7+7 = 18	3+2 = 5	1	4	7	8	5+11 = 16	0	3+5+4 = 12
	Length of Metro Network (KM)	2.27+2.38+11.5+13.31 = 29.46	5.16+3.57 = 8.73	6.34	3.38	9.17	13.6	8.68+12.5 = 21.18	0	6.09+6.56+1.1 = 13.75

A 3.2 District wise list of major hospitals of Delhi

S.No.	Hospital	District	Year of Operation
1	MaulanaAzad Medical College Bahadur Shah Zafar Marg	New Delhi	1956
2	Ram Manohar Lohia Hospital Connaught Place		1932
3	Maulana Azad Institute of Dental Sciences Jawahar Lal Nehru Marg		1958
4	Lady Hardinge Medical College Connaught Place		1916
5	Lok Nayk Hospital Jawahar Lal Nehru Marg		1956
6	G B Pant Hospital Delhi Gate Asaf Ali Road		Before 1991
7	B.R. Ieva Ram Hospital		1953
8	St. Stephens Hospital		Before 1991
9	Dr. B.L. Kapoor Memorial Hospital		1953
10	BLK Super Epeciality Hospital Pusa Road		1959
11	Delhi Heart and Lung Institute Panchkuian Road		2003
12	Sardar Vallabh Bhai Patel Hospital East Patel Nagar		1991-1999
13	SR Ganga Ram Hospital Old Rajinder Nagar		1954
14	Ayurvedic and Unani Tibbia College and Hospital Karol Bagh		1921
15	Birla Center for Medical Research		1992
16	Army College of Medical Sciences Delhi Cantt		2008
17	Dr B R Ambedkar Institute Rotary Cancer Hospital Ansari Nagar		1956
18	Delhi Pain Management Center Safdarjung Enclave		2006
19	Dr B R Super Homoeopathic Medical College and Hospital Moti Bagh west		1980
1	Laxmipat Singhania Medical Foundation	South Delhi	1997
2	Venu Charitable Society (Eye Hospital)		2000
3	Sondhi Charitable Trust		2000
4	Devki Devi Foundation		2007
5	Vikrant Children Medical Foundation		2008
6	Gujarmal Modi Hospital & Research Center		1980
7	Delhi Cheshire Home (Hospital For Disabled Person)		1978
8	Delhi E.N.T. Hospital & Research Center (E. N T. Hospital & Research Center)		2008
9	Madhukar Multi?Specialty Hospital		2017
10	National Heart Institute		2013
11	Lions Kidney Hospital and Urology Research Institute New Friends Colony		2000
12	Mata Gujri Medical Cirre Greater Kailash I		2002
13	Max Super Speciality Hospital Saket		2006
14	Rams Hospital and Medical Research Centre Badarpur Road		Before 1991
15	Fortis Escort Heart Institute New Friends Colony		Before 1991
16	Hamdard Medical College Hamdard Nagar		Before 1991
17	Pt Madan Mohan Maviya Hospital Malviya Nagar		2007
18	Pushpawati Singhania Research Institute Sheikh Sarai II		1998
19	Moolchand Hospital Lajpat Nagar III		Before 1991
20	VIMHANS Nehru Nagar		1998
21	AIIMS Ayurtendo Marg		1956
22	National Institute of TB and Respiratory Diseases Near Qutub Minar		1952
23	Shanti Memorial Society		2005
24	Indian Spinal Injuries Center		1993-1996
25	Foundation of Applied Research in Cancer		1998
26	Sagol Heart Centre Chhatarpur		1995
1	Akash Healthcare Super Speciality	South West Delhi	2005-2012
2	Ayushman Hospital Dwarka Sector 10		2005-2012
3	Ayushman Hospital Dwarka Sector 12		2005-2012
4	Bala Sahib Gurudwara (DSIIMPC)		2010
5	Medeor Hospital Dwarka Sector 12 Dwarka		2012
6	Venkateshwar Hospital Dwarka Sector 18A		2016
7	Artemis Hospital Dwarka Sector 20		2007
8	Chamundevi Hospital Qutub Vihar		1989
9	Bharoda Kala Base Hospital		Before 1991
10	Rao Tularam Memorial Hospital		1986
11	Chaudhary Brahma Prakash Ayurved Charak Sansthan		2009
12	Tarak Hospital Dwarka Mor		2014
13	Human Care Medical Trust		2003
1	Madam Chanan Devi Eye Hospital	West Delhi	Before 1991
2	Mai Kamali Wali Jan Kalyan Ch. Trust		1991-1993
3	Manav Sewarath Trust		2002
4	Lala Munni Lal Mange Ram Ch. Trust		2005
5	Arbon Cancer Hospital Paschim Vihar		2010
6	Mata Chanan Devi Hospital Janakpuri		Before 1991
7	Delhi State Cancer Institute Janakpuri		2006
8	Dean Dayal Upadhyay Hospital Hari Nagar		1970
9	Guru Gobind Singh Hospital Rajouri Garden		Before 1991
10	The Bone and Joint Clinic Paschim Vihar		Before 1991
11	Maharaja Agrasen Hospital Punjabi Bagh		1991

12	SR Krishna Hospital Uttam Nagar		2007
13	Amar Leela Hospital Janakpuri		1995
14	World Brain Centre and Research Institute Pankha Road		2012-2015
1	St. Stephens Hospital	Central Delhi	before 1991
2	Aruna Asaf Govt Hospital		before 1991
3	Hindu Rao Hospital		1997
4	Sant Parmanand Hospital		1997
5	Delhi Institute of Trauma and Orthopaedic		2001-2005
6	Karuna Hospital		before 1991
1	Balak Ram Hospital	North Delhi	before 1991
2	Infectious diseas Hospital		before 1991
3	MVTD Hospital		1997
4	Sundar Lal Jain Hospital		2001
5	Dr Bhim Rao Ambedkar Hospital		2016
6	Burari Hospital		2001
7	R G Hospital Bhalswa		2014
8	N K S Super Specialty		2009
9	Maha Durga Ch. Trust		2011
10	Asthma & Bronchitis Foundation (Delhi University)		before 1991
1	Mahavir Mohan Devi Jain Shikshan Samiti (Bhagwan Mahavir Hospital)	North West	1991-97
2	Khosla Medical Institute & Research Center		1991-97
3	Jivodaya Hospital		before 1991
4	Sunder Lal Jain Ch. Trust		before 1991
5	Jaipur Golden Ch. Trust		1991-1997
6	Ganesh Das Chawala Ch. Trust		1991-1997
7	Parmarath Mission Hospital		1991-1997
8	Lala Gela Ram Memorial Medical Research Center (Dental Hospital)		2005
9	V.N. Gupta Ch. Trust		1991-1997
10	Multan Sewa Samiti		2005
11	Sarvodaya Health Foundation		2006
12	Rajiv Gandhi Cancer Institute and Research Center Rohini		1996
13	Fortis Hospital Shalimar Bagh		2010
14	Satyawadi Raja Harish Chandra Hospital		2018
15	Babu Jagjivan Ram Memorial Hospital		1993
16	Maharishi Balmiki Hospital		1994
17	Max Super Specialty Shalimar Bagh		2011
18	Sanjay Gandhi Memorial Hospital		1986
19	Max Hospital Pitampura		2002
1	Dr Hedgewar Arogya Sansthan	North East Delhi	2001
2	Guru Teg Bahadur Hospital		1979
3	Karuna Hospital		2011
4	Chandiwala Hospital Shahdara		2005
5	Indira IVF Shahdara		After 2011
6	Swami Dayanand Hospital		1962
7	Institute of Human Behavior and Allied Sciences		1993
8	Delhi State Cancer Institute		2002
9	Rajiv Gandhi Super Specialty		2013
10	Indraprastha Dental college and Hospital		2006
11	TLM Community Hospital		1984
12	Sai Retina Foundation		2008
1	Amar Jyoti Charitable Trust	East Delhi	before 1991
2	Flt. Lt. Rajan Dhall Ch. Trust		before 1991
3	Deepak Gupta Memorial Ch. Foundation		1994
4	All India Society for Health And Education Research		1991-1997
5	National Society for Prevention of Blindness (Small Hospital)		1991-1997
6	Aruna Vaidsala Rattaiya		2001-2005
7	Walia Charitable Trust		2005-2012
8	Apex City Hospital (P Extension		2010
9	Cosmos Institute of Mental Health and Behavioral Sciences (CIMBS) Preet Vihar		1987
10	Dharmashila Cancer Hospital and Research Center Vasundhara Enclave		1994
11	Health Centre Maternity Hospital Ram Nagar		2008
12	Jag Parvesh Chander Hospital Shastri Park		2003
13	University College of Medical Science Dilshad Garden		1971
14	Lal Bahadur Shastri Hospital Khichripur Mayur Vihar Phase-II		1998
15	Max Hospital Patparganj		2005
Total Number of Major Hospitals of Delhi = 134			

A 3.3 District wise list of Universities and major colleges and educational institutes of Delhi

S.No.	Universities / Educational Institutes	District	Year of Operation
1	Mukherjee Nagar Education Hub	North Delhi	1998-2005
2	Swami Shraddhanand College Alipur		1967
3	Delhi Institute of Rural Development G.T Karnal Road		2003
1	Lokmanya College Rana Pratap Bagh Azad Vihar	North West Delhi	1965
2	Satyawati College Azad Vihar		1972
3	IIIT Noida Delhi Campus		1998
4	Ansal Institute of Technology		1963
5	Guru Teg Bahadur Institute of Management		2008
6	Delhi Institute of Tool Engineering		1957
7	Shaheed Sukhdev College of Management Studies		1987
8	Dr Baba Sahib Ambedkar Medical College		2016
9	Delhi School of Professional Studies		1999
10	Aastha College		1997
11	Guru Nanak Dev Institute of Technology		1995
12	Vivekanand Institute of Professional Studies		2006
13	Bhagwan Parshuram Institute of Technology		2003
14	Maharaja Institute of Technology		2007
15	Delhi Technology University		1941
16	Glanetium International Business School		2004
17	Loknayak Jayprakash Narayan National Institute of Criminology and Forensic Science		1972
18	Jagan Institute of Management		1989
19	ACME Group of College		2002
20	Shri Guru Gobind Singh College		1984
21	Bastuda Institute of Technology		1986
22	Keshav Mahavidyalayaa		1984
23	Venkteshwara Open University		2012
1	Hindu College Delhi University	Central Delhi	1917
2	Hansraj College Delhi University		1948
3	Miranda House University of Delhi		1948
4	St Stephenes College		1881
5	Sri Ram College of Commerce		1926
6	Khalsa College University of Delhi		1954
7	Ramjas College		1917
8	Vallabhbhai Patel Chest Institute		1946
9	Delhi School of Journalism		2017
10	Siddhanta College		1958
11	Faculty of Science Delhi University		1922
12	Daulat Ram College		1960
13	Delhi School of Economics		1949
14	Zakir Hussain College Daryia Ganj		1792
15	Indraprastha College for Women		1924
16	Sri Guru Teg Bahadur Khalsa College University of Delhi		1951
1	Bharti Vidyapeeth Deemed University	West Delhi	1964
2	Shyama Prasad Mukherjee College for Women		1969
3	Shivaji College University of Delhi		1961
4	Rajdhani College University of Delhi		1964
5	Ambedkar University Kalampura		2007
6	Guru Nanak Institute of Management		1996
7	Rai Global University		2015
8	Panjab University Khayala		1947
9	Shikshapeeth College of Management		2009
10	Madural Kamraj University		1965
11	Bhatti College		1971
12	Maharaja Surajmal Institute of Technology		1999
13	Indira Gandhi Institute of Physical Education and Sports		1987
14	IITM Janakpuri		1999
15	Bhaskaracharya Institute of Applied Science		1995
16	Rishiraj Samiksh Sansthan		1970
17	Indraprastha Institute of Technology and Management		2002
1	Netaji Subash Institute of Technology	South West Delhi	1983
2	Deen Dayal Upadhyay College		1960
3	Lal Bahadur Shastri Institute of Management		1995
4	National Law University Delhi		2008
5	Integrated Institute of Technology		2008
6	Apeejay School of Management		1993
7	Chaudhary Ranbir Singh University		2014
8	Guru Gobind Singh Indraprastha University		1998
9	Bhagini Nivedita College University of Delhi		1993
10	R C Institute of Technology		2003
11	Ch Brahm Prakash Government Engineering College		2007
12	Trinity Institute of Professional Institute		2007
13	Subharti University		2008
14	Vedel Management Institute		2014

15	Banarsidas Chandiwala Professional Studies		2008
16	Indira Gandhi National Open University		2008
17	Maharshi Dayanand University Dwarka		1976
18	MBS School of Planning and Architect		2009
1	Dayal Singh College	South Delhi	1950
2	PGDAV College		1967
3	Rajkumari Amrita Kaur College of Nursing		1948
4	South Delhi Polytechnic for Women		1963
5	Nehru Homeopathic Medical College		1967
6	Vardhman Mahavir Medical College		2001
7	Ramjas Nehru College		1964
8	Institute of Home Economics		1961
9	Gargi College		1967
10	Indraprastha Institute of Information Technology		2008
11	Acharya Narendra Dev College University of Delhi		1993
12	Deshbandhu College University of Delhi		1952
13	Shaheed Bhagat Singh College		1967
14	Delhi Pharmaceutical Institute of Science and Research University		1964
15	Jamia Hamdard University		1989
16	Jamia Millia Islamia University		1920
17	Indira Gandhi National Open University		1964
1	Shyam Lal College	North East Delhi	1964
2	University College of Management Science		1995
3	Dr Bhim Rao Ambedkar College Yamuna Vihar		1991
4	Krishna Engineering College		2004
5	Delhi Institute of Technology and Research		2004
6	Guru Ramdas College of Education		2006
1	Punjab Technological University	East Delhi	1997
2	Polytechnic College Delhi Pataudi(Gol)		1986
3	Maharaja Agrasen College University of Delhi		1958
4	Bhai Parmanad Institute of Business Studies		1963
5	Vivekanand College University of Delhi		1970
6	Shaheed Rajguru College of Applied Science for Women		1989
7	Laxmi Nagar Education Hub		2002
8	Amar Jyoti Institute of Physiotherapy		1999
1	ICFAI University Delhi	New Delhi	1984
2	Jawaharlal Nehru University Delhi		1969
3	Indian Institute of Technology Delhi		1961
4	TERI School of Advanced Studies		1998
5	Hindustan Institute of Technology		1985
6	Amity School of Engineering and Technology Bijwasan		1999
7	Delhi University South Campus		1922
8	International Management Institute		1981
9	National Institute of Education Planning		1961
10	Indian Council of Social Science Research		1969
11	Indian Institute of Mass Communication		1965
12	Shri Aurobindo Centre of Arts and Communication		2003
13	Anushtha College		1973
14	Ras Tutoram College		1970
15	Motilal Nehru College		1960
16	Ram Lal Anand College		1964
17	Aatma Ram Sanatan Dharm College		1950
18	Shiva Vishveshwara College		1961
19	Maitreyi College University of Delhi		1967
20	South Asian University		2010
21	Delhi College of Arts and Commerce		1987
22	Arya and Maity College		1968
23	Air Force Vocational College		1984
24	Ashoka Institute of Hospitality and Tourism		1971
25	School of Aviation Science and Technology		1987
26	Tilya Merchant Navy Institute		2010
27	National Defence College		1960
28	Indian Law Institute		1956
29	Al Mustafa International University		1979
30	Lady Irwin College		1932
31	School of Planning and Architecture		1941
32	Lady Harding Medical College		1914
33	Kalindi College University of Delhi		1967
34	Ayurvedic and Unani Tibbia College		1982
		Total =	142

A 3.4 District wise Trips Attracted and Generated in Delhi

Trip estimate for Delhi between 1992-2018

Assumptions: Study area 10 districts (1154.17 sq km) and peripheral zones combined
Average population density /sq km 6507(1991), 9456 (2001)
One way home based vehicular per capita trip rate 0.538 (1991)
Population projected from 1991 and 2001 census

TRIPS PRODUCED
One way vehicular trip

NO	DISTRICT	1992	1998	2005	2012	2018
1	NORTH WEST	670704	835439	1078386	1391941	1733658
2	SOUTH EAST	650244	824163	1085638	1430026	1812342
3	NORTH EAST	276509	377798	543229	781074	1067094
4	EAST	377524	510727	725915	1031740	1395642
5	NEW	204968	235653	277038	325680	374402
6	CENTRAL	217248	232730	251948	272745	292155
7	NORTH	613016	750784	950190	1202521	1472634
8	WEST	378035	474968	619297	807457	1014405
9	SOUTH WEST	383415	465712	583741	731659	888622
10	SOUTH	374376	506468	719863	1023137	1384004
11	EXTERNAL	1082116	1376613	1825010	2429454	3121744
		5228154	6591054	8660256	11427434	14556703

TRIPS ATTRACTED
One way vehicular trip

NO	DISTRICT	1992	1998	2005	2012	2018
1	NORTH WEST	156845	197732	259808	342823	436701
2	SOUTH EAST	522815	659105	866026	1142743	1455670
3	NORTH EAST	313689	395463	519615	685646	873402
4	EAST	418252	527284	692820	914195	1164536
5	NEW	914927	1153435	1515545	1999801	2547423
6	CENTRAL	967209	1219345	1602147	2114075	2692990
7	NORTH	365971	461374	606218	799920	1018969
8	WEST	444393	560240	736122	971332	1237320
9	SOUTH WEST	392112	494329	649519	857058	1091753
10	SOUTH	731942	922748	1212436	1599841	2037938
11	EXTERNAL	NA	NA	NA	NA	NA
	TOTAL	5228154	6591054	8660256	11427434	14556703

FOR TOTAL TRIPS RETURN HOME TRIP (100%) AND NON HOME BASE TRIPS ARE TO BE ADDED. (5%)

A 3.5 Data of Variables used in Research Design 1 & 3 – Estimation of the effect of distance from metro railway network on average house Prices of the urban area of Delhi

District	urban_area	year	house_price INR/Sq.M	Residential Price INR/SqM	station_dist KM	D_near_station	D_Res_Zone_D
North Delhi	Mukherjee Nagar (Outram Line)	2012	1134381.4306	106384	0.4	1	1
North Delhi	Mukherjee Nagar (Outram Line)	2015	123789.0205	150000	0.4	1	1
North Delhi	Mukherjee Nagar (Outram Line)	2018	131754.5748	150000	0.4	1	1
North Delhi	Model Town Phase II	2012		106384	0.72	1	1
North Delhi	Model Town Phase II	2015	120912.1936	150000	0.72	1	1
North Delhi	Model Town Phase II	2018	139589.2357	150000	0.72	1	1
North Delhi	Model Town Phase III	2012	121689.9893	106384	0.48	1	1
North Delhi	Model Town Phase III	2015	110247.578	150000	0.48	1	1
North Delhi	Model Town Phase III	2018	101560.8181	150000	0.48	1	1
North Delhi	Rana Pratap Bagh Asok Vihar	2012	129117.3826	106384	1.82	0	1
North Delhi	Rana Pratap Bagh Asok Vihar	2015	11254.0964	150000	1.82	0	1
North Delhi	Rana Pratap Bagh Asok Vihar	2018	123898.676	150000	1.82	0	1
North West Delhi	Shalimar Bagh	2012	101560.8181	106384	1.75	0	1
North West Delhi	Shalimar Bagh	2015	93865.25986	150000	1.75	0	1
North West Delhi	Shalimar Bagh	2018	91496.23251	150000	1.29	0	1
North West Delhi	Pitampura	2012	133121.6061	106384	0.89	0	1
North West Delhi	Pitampura	2015	134822.3897	150000	0.89	0	1
North West Delhi	Pitampura	2018	139519.3724	150000	0.89	0	1
North West Delhi	Rohini Sector 24	2012	79136.85899	106384	2.11	0	1
North West Delhi	Rohini Sector 24	2015	74196.98601	150000	2.11	0	1
North West Delhi	Rohini Sector 24	2018	74649.08504	150000	2.11	0	1
North West Delhi	Rohini Sector 23	2012		106384	2.47	0	1
North West Delhi	Rohini Sector 23	2015	59472.55113	150000	2.47	0	1
North West Delhi	Rohini Sector 23	2018	66520.38649	150000	2.47	0	1
North East Delhi	Dilshad Garden	2012		47140	0.97	0	0
North East Delhi	Dilshad Garden	2015	72604.95156	63000	0.97	0	0
North East Delhi	Dilshad Garden	2018	69988.23574	63000	0.97	0	0
North East Delhi	Shahdara	2012	48663.07859	47140	0.39	1	0
North East Delhi	Shahdara	2015	50755.02691	63000	0.39	1	0
North East Delhi	Shahdara	2018	49860.86459	63000	0.39	1	0
North East Delhi	Jagatpuri	2012		47140	1.1	0	0
North East Delhi	Jagatpuri	2015		63000	1.1	0	0
North East Delhi	Jagatpuri	2018	48439.18102	63000	1.1	0	0
North East Delhi	Mandawali	2012		47140	2.37	0	0
North East Delhi	Mandawali	2015		63000	2.37	0	0
North East Delhi	Mandawali	2018	52991.38859	63000	2.37	0	0
North East Delhi	Sonia Vihar	2012		47140	4	0	0
North East Delhi	Sonia Vihar	2015		63000	4	0	0
North East Delhi	Sonia Vihar	2018	49629.69408	63000	4	0	0
East Delhi	Preet Vihar	2012	128406.8881	106384	0.9	1	1
East Delhi	Preet Vihar	2015	138108.3111	150000	0.9	1	1
East Delhi	Preet Vihar	2018	122834.9916	150000	0.9	1	1
East Delhi	Mayur Vihar Phase I	2012	91486.23751	106384	0.43	1	1
East Delhi	Mayur Vihar Phase I	2015	118482.239	150000	0.43	1	1
East Delhi	Mayur Vihar Phase I	2018	110077.5027	150000	0.43	1	1
East Delhi	Patparganj	2012	87836.98321	106384	1.1	0	1
East Delhi	Patparganj	2015	113459.3283	150000	1.1	0	1
East Delhi	Patparganj	2018	100012.9171	150000	1.1	0	1
East Delhi	SFS New Kondli Mayur Vihar Phase	2012	76595.97201	106384	1.93	0	1
East Delhi	SFS New Kondli Mayur Vihar Phase	2015	89288.48234	150000	1.93	0	1
East Delhi	SFS New Kondli Mayur Vihar Phase	2018	81883.74896	150000	1.22	0	1
East Delhi	Laxmi Nagar	2012	45748.11627	58361	1.5	0	0
East Delhi	Laxmi Nagar	2015	60839.61249	70070	1.5	0	0
East Delhi	Laxmi Nagar	2018	56727.86416	90000	1.5	0	0
East Delhi	Geeta Colony	2012	57050.58703	58361	1.8	0	0
East Delhi	Geeta Colony	2015	62432.72336	70070	1.8	0	0
East Delhi	Geeta Colony	2018	65462.88215	90000	1.8	0	0
Central Delhi	Chandni Chowk	2012		58361	0.28	1	0
Central Delhi	Chandni Chowk	2015		70070	0.28	1	0
Central Delhi	Chandni Chowk	2018	119601.3323	90000	0.28	1	0
Central Delhi	Darya Ganj	2012		58361	0.39	1	0
Central Delhi	Darya Ganj	2015		70070	0.39	1	0
Central Delhi	Darya Ganj	2018	124940.2966	90000	0.39	1	0
Central Delhi	Sadar Bazar	2012		58361	0.73	1	0
Central Delhi	Sadar Bazar	2015		70070	0.73	1	0
Central Delhi	Sadar Bazar	2018	153486.5847	90000	0.73	1	0
Central Delhi	Pahar Ganj	2012		58361	1.1	0	0
Central Delhi	Pahar Ganj	2015	69947.70721	70070	1.1	0	0
Central Delhi	Pahar Ganj	2018	71582.34661	90000	1.1	0	0
West Delhi	Punjabi Bagh	2012	129461.7869	106384	0.68	1	1
West Delhi	Punjabi Bagh	2015	133584.4985	150000	0.68	1	1
West Delhi	Punjabi Bagh	2018	142275.2594	150000	0.68	1	1
West Delhi	Janakpuri West	2012	107503.6911	106384	0.73	1	1
West Delhi	Janakpuri West	2015	100012.9171	150000	0.73	1	1
West Delhi	Janakpuri West	2018	98953.06781	150000	0.73	1	1
West Delhi	Paschim Vihar	2012	118482.239	106384	1.1	0	1
West Delhi	Paschim Vihar	2015	111625.4037	150000	1.1	0	1
West Delhi	Paschim Vihar	2018	116370.2906	150000	1.1	0	1
West Delhi	Vikaspuri	2012	94628.63294	106384	1.43	0	1
West Delhi	Vikaspuri	2015	91486.23251	150000	1.43	0	1
West Delhi	Vikaspuri	2018	92796.70829	150000	1.43	0	1
West Delhi	Sunder Vihar	2012		106384	1.92	0	1
West Delhi	Sunder Vihar	2015	114370.2906	150000	1.92	0	1
West Delhi	Sunder Vihar	2018	129491.7869	150000	1.92	0	1
New Delhi	Vasant Vihar	2012	612277.1798	204888	2.87	0	0
New Delhi	Vasant Vihar	2015	264811.6254	430000	2.87	0	0
New Delhi	Vasant Vihar	2018	359061.5891	430000	0.41	1	0

New Delhi	Anand Niketan	2018	250000.4446	483000	1.27	0	0
New Delhi	Vasant Enclave	2012		209000	2.14	0	0
New Delhi	Vasant Enclave	2015		420000	2.14	0	0
New Delhi	Vasant Enclave	2018	196705.0533	420000	1.88	0	0
South Delhi	Nehru Enclave (C R Park)	2012	147781.0334	133214	1.42	0	0
South Delhi	Nehru Enclave (C R Park)	2015	169977.2432	250000	1.42	0	0
South Delhi	Nehru Enclave (C R Park)	2018	132108.6738	250000	0.69	1	0
South Delhi	Kalkaji	2012	216201.0157	133214	0.66	1	0
South Delhi	Kalkaji	2015	218406.9891	250000	0.66	1	0
South Delhi	Kalkaji	2018	95393.97255	250000	0.85	1	0
South Delhi	Kalkaji Ext	2012		133214	1.33	0	0
South Delhi	Kalkaji Ext	2015	104405.7851	250000	1.33	0	0
South Delhi	Kalkaji Ext	2018	90118.40649	250000	1.33	0	0
South Delhi	Malviyanagar	2012	137249.3488	133214	2.22	0	0
South Delhi	Malviyanagar	2015	152191.985	250000	2.22	0	0
South Delhi	Malviyanagar	2018	122142.9889	250000	1.76	0	0
South West Delhi	Dwarka Sector 10	2012	85281.57158	106389	1.1	0	1
South West Delhi	Dwarka Sector 10	2015	83713.87061	150000	1.1	0	1
South West Delhi	Dwarka Sector 10	2018	84178.51883	150000	1.1	0	1
South West Delhi	Dwarka Sector 7	2012	88703.88461	106389	1.9	0	1
South West Delhi	Dwarka Sector 7	2015	88908.93559	150000	1.9	0	1
South West Delhi	Dwarka Sector 7	2018	88703.88461	150000	1.9	0	1
South West Delhi	Dwarka Sector 8	2012	82344.30528	106389	2.3	0	1
South West Delhi	Dwarka Sector 8	2015	83083.57258	150000	2.3	0	1
South West Delhi	Dwarka Sector 8	2018	82758.70859	150000	2.3	0	1
South West Delhi	Dwarka Sector 10B	2012		106389	1.6	0	1
South West Delhi	Dwarka Sector 10B	2015		150000	1.6	0	1
South West Delhi	Dwarka Sector 10B	2018	84178.51883	150000	1.6	0	1

A 3.6 Data of Variables used in Research Design 2 – Estimation of Effect of Metro Railway Expansion on Residential Land Price

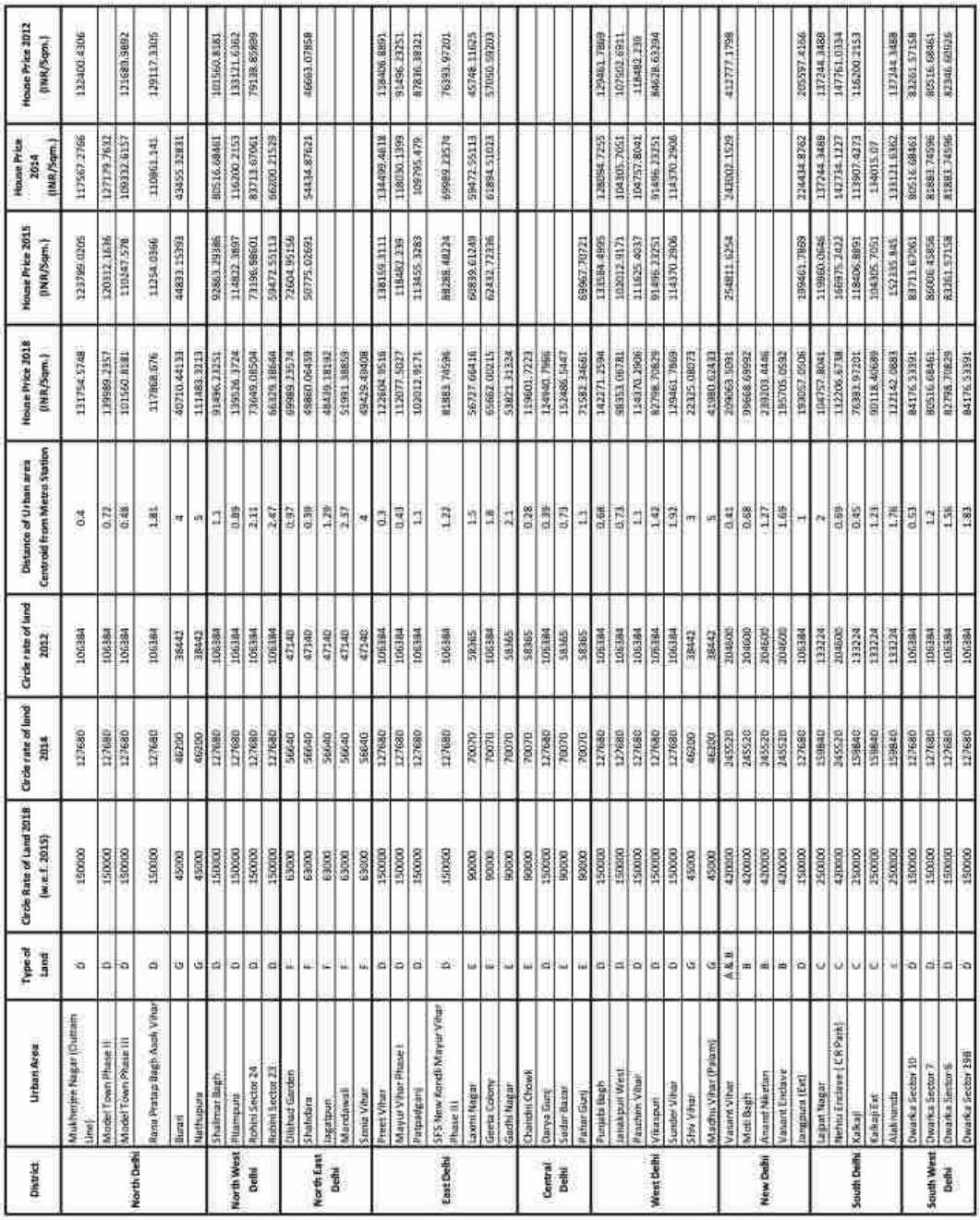
District	Year	Residential Land Price (INR/Sqmt)	Length of Metro Rail Network (KM)	Number of Metro Stations	Population Density (Peson/SqKM)	Number of Establishments	Number of Workers	Number of Hospitals (more than 50 beds or Area more than 1 acre)	Number of Colleges and institutes	Trip Produced	Trip Attracted	Total Trips	District_treated
North Delhi	1992	5300	0	0	2639.00	21263	167396	3	1	613016	365971	978987	0
North West Delhi	1992	5300	0	0	11787.00	38825	255475	3	8	670704	156846	827549	0
North East Delhi	1992	2550	0	0	20349.00	28885	218253	3	2	276509	313689	590198	1
East Delhi	1992	2550	0	0	17316.00	28281	185135	4	4	377524	418252	795776	1
Central Delhi	1992	16800	0	0	16007.00	23870	173580	3	15	217248	967209	1184457	0
West Delhi	1992	8400	0	0	12179.00	30017	255475	6	8	378035	444393	822428	1
New Delhi	1992	12600	0	0	2217.00	4044	91624	14	29	914927	914927	1829854	1
South Delhi	1992	8400	0	0	6613.00	31042	283394	8	15	374376	731942	1106318	1
South West Delhi	1992	6300	0	0	3268.00	18218	140896	2	3	383415	392112	775527	0
North Delhi	1998	5830	0	0	3411	64819	330863	4	1	750784	461374	1212158	0
North West Delhi	1998	5830	0	0	11825	98925	504952	12	12	835439	197732	1033171	0
North East Delhi	1998	2805	0	0	27134	84511	431381	4	3	377798	395463	773261	1
East Delhi	1998	2805	0	0	21307	71688	365923	8	6	510727	527284	1038011	1
Central Delhi	1998	18480	0	0	16565	67213	343085	5	15	232730	1219345	1452075	0
West Delhi	1998	9240	0	0	15368	98925	504952	8	11	474968	560240	1035208	1
New Delhi	1998	13860	0	0	3427	35478	181097	16	30	1153435	1153435	2306870	1
South Delhi	1998	9240	0	0	8428	109735	560135	14	15	506468	922748	1429216	1
South West Delhi	1998	6930	0	0	4060	54557	278484	3	7	465712	494329	960041	0
North Delhi	2005	5830	0	0	4265	71785	347531	6	3	950190	606218	1556408	0
North West Delhi	2005	5830	8.82	8	13374	131075	530390	15	16	1078386	259808	1338194	0
North East Delhi	2005	3073	6.36	4	33376	97518	453113	7	5	543229	519615	1062844	1
East Delhi	2005	3073	0	0	24673	95479	384357	11	8	725915	692820	1418735	1
Central Delhi	2005	18480	12.06	12	17024	80587	360369	6	15	251948	1602147	1854095	0
West Delhi	2005	9240	0	0	18073	101339	530390	10	14	619297	736122	1355419	1
New Delhi	2005	13860	3.65	4	3703	13654	190220	17	32	1515545	1515545	3031090	1
South Delhi	2005	9240	0	0	9981	104800	588353	19	16	719863	1212436	1932299	1
South West Delhi	2005	6930	0	0	5066	61506	292513	4	8	583741	649519	1233260	0
North Delhi	2012	106400	6.36	5	4939	73724	318960	7	3	1202521	799920	2002441	0
North West Delhi	2012	106400	12.45	11	15151	93297	286189	18	22	1391941	342823	1734764	0
North East Delhi	2012	47200	9.51	7	37960	158335	412976	10	6	781074	685646	1466720	1
East Delhi	2012	106400	11.97	10	27137	80061	215979	15	8	1031740	914195	1945935	1
Central Delhi	2012	58400	12.06	12	17575	150671	599058	6	15	272745	2114075	2386820	0
West Delhi	2012	106400	29.4	27	20032	106726	313574	13	16	807457	971332	1778789	1
New Delhi	2012	204600	33.55	20	3632	38153	269225	19	34	1999801	1999801	3999602	1
South Delhi	2012	133200	37.1	27	11103	57126	145304	24	17	1023137	1599841	2622978	1
South West Delhi	2012	106400	14.18	11	5901	117215	458516	11	16	731659	857058	1588717	0
North Delhi	2018	150000	15.09	10	5642	75715	529162	10	3	1472634	1018969	2491603	0
North West Delhi	2018	150000	17.19	12	17306	86407	807589	19	23	1733658	436701	2170359	0
North East Delhi	2018	63000	18.68	14	43360	257080	689924	12	6	1067094	873402	1940496	1
East Delhi	2018	150000	25.57	18	30997	67133	585234	15	8	1395642	1164536	2560178	1
Central Delhi	2018	90000	15.44	16	20075	281705	548709	6	16	292155	2692990	2985145	0
West Delhi	2018	150000	48.15	39	22881	112399	807589	14	17	1014405	1237320	2251725	1
New Delhi	2018	420000	64.38	38	4148	106610	289635	19	34	2547423	2547423	5094846	1
South Delhi	2018	250000	58.28	43	12682	31139	895845	26	17	1384004	2037938	3421942	1
South West Delhi	2018	150000	14.18	11	6741	223382	445390	13	18	888622	1091753	1980375	0

APPENDIX 4

A 4.1 House Price and Residential Prices with Land Category between 2012 -2018:

The house price of the urban area is taken from the real estate website www.99acre.com price trend page for the period 2012, 2014, 2015, and 2018. The mid-year average house price in the urban area (June – September) is taken for analysis. Some urban areas do not have data for June-September, hence the data corresponding to September – December has been considered as the average house price of that urban area..

(Ref: https://www.99acres.com/property-rates-and-price-trends-in-delhi-ncr)



District	Urban Area	Type of Land	Circle Rate of Land 2018 (w.e.f. 2019)	Circle rate of land 2014	Circle rate of land 2012	Distance of Urban area Centroid from Metro Station	House Price 2018 (INR/Sqm.)	House Price 2015 (INR/Sqm.)	House Price 2014 (INR/Sqm.)	House Price 2012 (INR/Sqm.)
North Delhi	Mukherjee Nagar (Outrain Line)	D	150000	127680	106384	0.4	131754.5748	123786.0205	117567.2766	132400.4306
	Model Town Phase II	D	150000	127680	106384	0.72	139989.2357	120312.1636	127179.7632	
	Model Town Phase III	D	150000	127680	106384	0.48	101560.8181	110547.578	109332.6157	121683.3892
	Rana Pratap Bagh Azad Vihar	D	150000	127680	106384	1.81	117868.676	11254.0366	110861.341	129117.3305
	Burari	G	45000	46200	38442	4	40210.44133	44833.15393	43455.32831	
	Nathupura	G	43000	46200	38442	5	111483.3213			
North West Delhi	Shalimar Bagh	D	150000	127680	106384	1.1	91496.23251	92863.29386	80516.68461	101560.8361
	Pitampura	D	150000	127680	106384	0.89	139536.3724	114822.3697	116200.2153	133121.6362
	Rohini Sector 24	D	150000	127680	106384	2.11	73049.08504	73198.98601	83713.67061	79128.85899
	Rohini Sector 23	D	150000	127680	106384	2.47	66329.38648	59472.55113	66200.21528	
North East Delhi	Dilshad Garden	F	63000	56640	47140	0.97	69989.23574	72604.95156		
	Shahdara	F	83000	56640	47140	0.39	49860.06459	50775.02691	54434.87621	46663.07858
	Jagatpuri	F	83000	56640	47140	1.28	48439.18192			
	Mandawali	F	63000	56640	47140	2.37	51991.38859			
	Sonia Vihar	F	63000	56640	47140	4	49428.49408			
East Delhi	Preet Vihar	D	150000	127680	106384	0.3	122604.9518	138159.3111	134499.4618	138486.8891
	Mayur Vihar Phase I	D	150000	127680	106384	0.41	112077.5027	118487.238	118090.1399	91496.23251
	Patparganj	D	150000	127680	106384	1.1	102812.9171	113455.3283	109795.479	87836.38321
	SFS New Kondli Mayur Vihar Phase III	D	150000	127680	106384	1.22	81883.74596	88286.48224	69989.23574	76393.97201
	Laxmi Nagar	E	90000	70070	58365	1.5	56737.66416	69839.61249	59472.55113	45748.11625
	Geeta Colony	E	90000	70070	58365	1.8	65662.00215	62432.72336	61894.51023	57050.59203
	Gandhi Nagar	E	90000	70070	58365	2.1	53821.31324			
Central Delhi	Chandni Chowk	E	80000	70070	58365	0.28	119601.7223			
	Darya Ganj	D	150000	127680	106384	0.39	124940.7866			
	Sadar Bazar	E	90000	70070	58365	0.73	152486.0447			
	Pahar Ganj	E	80000	70070	58365	1.1	71581.34661	69967.70721		
West Delhi	Punjabi Bagh	D	150000	127680	106384	0.68	142271.1594	131584.4995	128084.7255	129461.7869
	Janakpuri West	D	150000	127680	106384	0.73	98353.08781	102012.9171	104305.2661	107902.6911
	Paschim Vihar	D	150000	127680	106384	1.1	114370.2906	111625.4637	104757.8041	118482.230
	Vikaspuri	D	150000	127680	106384	1.42	82798.70829	91496.23251	91496.23251	84628.63294
	Sunder Vihar	D	150000	127680	106384	1.93	129461.7869	114370.2906	114370.2906	
	Shiv Vihar	G	43000	46200	38442	3	22325.08073			
	Madhu Vihar (Palam)	G	45000	46200	38442	5	41980.62433			
New Delhi	Vasant Vihar	A & B	420000	245520	204600	0.41	209063.9091	254811.6254	242002.1529	412777.1798
	Moti Bagh	B	420000	245520	204600	0.68	99668.69992			
	Anand Niketan	B	420000	245520	204600	1.27	238103.4446			
	Vasant Enclave	B	420000	245520	204600	1.69	195705.0592			
	Jangpura (Ext)	D	150000	127680	106384	1	190062.9506	199461.7869	224434.8762	205597.4166
South Delhi	Lajpat Nagar	C	258000	159840	133224	2	104757.8041	119860.0646	137244.3488	137244.3488
	Nehru Enclave (EK Park)	C	420000	245520	204600	0.69	132206.8738	166975.2422	142734.1127	147761.0334
	Kalkaji	C	258000	159840	133224	0.45	76393.97201	118406.8891	113907.4273	116200.2153
	Kalkaji Ext	C	258000	159840	133224	1.23	99118.40689	104305.7051	134015.97	
	Alaknanda	C	258000	159840	133224	1.76	122142.0683	152185.845	131121.6362	137244.3488
South West Delhi	Dwarka Sector 10	D	150000	127680	106384	0.53	84176.33391	83713.67061	80516.68461	83261.57158
	Dwarka Sector 7	D	150000	127680	106384	1.2	80516.68461	86006.45806	81883.74596	80516.68461
	Dwarka Sector 5	D	150000	127680	106384	1.56	82798.70829	82161.57158	81883.74596	82346.68926
	Dwarka Sector 19B	D	150000	127680	106384	1.83	84176.33391			

APPENDIX 5

Source of Residential Land Price in Delhi from 1987 to 2018

The government notifies the residential land prices in Delhi from time to time, based on the increase in the property value of urban areas. The residential land price before 2007 was based on the prevailing market rate of the urban area of Delhi. In 2007, the urban area of Delhi was bifurcated into the land category zone A, B, C, D, E, F, G, and H. The Department of Revenue, Government of NCT of Delhi, published the circle rate of these land categories. The circle rate of the properties is the minimum rate for the valuation of lands and properties in Delhi. The tax collecting authorities assesses the Stamp duty and the property tax based on the land's prevailing circle rate. This appendix has provided a copy of the Government notifications of the land rate applicable in Delhi.

A5.1 Market Rate of lands in Delhi applicable from 1.4.1987 to 31.03.2000

SCHEDULE OF MARKET RATES OF LAND IN DELHI – 1.4.1987 to 31.3.2000

S.No.	Name of the Locality	Rates per Sq. m. w.e.f. 1.4.98		Rates per Sq. m. 1.4.91 to 31.3.98		Rates per Sq. m. 1.4.89 to 31.3.91		Rates per Sq. m. 1.4.87 to 31.3.89	
		Residential	Commercial	Residential	Commercial	Residential	Commercial	Residential	Commercial
	Zone –I								FAR-250
	Central Zone								
1.	Connaught Place	18,480/-	57,960/-	16,800/-	50,400/-	14,000/-	42,000/-	8000/-	23,000/-
2.	Connaught circus	18,480/-	57,960/-	16,800/-	50,400/-	14,000/-	42,000/-	8000/-	23,000/-
3.	Connaught Place Extension up to Commercial Centre	18,480/-	57,960/-	16,800/-	50,400/-	14,000/-	42,000/-	8000/-	23,000/-
4.	Barakhamba Road (beyond Connaught Place Extn. Up to Commercial Zone)	18,480/-	57,960/-	16,800/-	50,400/-	14,000/-	42,000/-	8000/-	23,000/-
5.	Curzon Road (beyond Connaught Place Extension up to Commercial Zone)	18,480/-	57,960/-	16,800/-	50,400/-	14,000/-	42,000/-	8000/-	23,000/-
6.	Hanuman Road(Commercial Zone)	18,480/-	57,960/-	16,800/-	50,400/-	14,000/-	42,000/-	8000/-	23,000/-
7.	Janpath(beyond Connaught Place Extension up to Windsor Place)	18,480/-	57,960/-	16,800/-	50,400/-	14,000/-	42,000/-	8000/-	23,000/-
8.	Bhagwandas Road	18,480/-	57,960/-	16,800/-	50,400/-	14,000/-	42,000/-	8000/-	23,000/-
9.	Hailey Road	18,480/-	57,960/-	16,800/-	50,400/-	14,000/-	42,000/-	8000/-	23,000/-
10.	Hanuman Road (Res. Zone)	18,480/-	57,960/-	16,800/-	50,400/-	14,000/-	42,000/-		
11.	Baird Road	18,480/-	57,960/-	16,800/-	50,400/-	14,000/-	42,000/-	8000/-	23,000/-
12.	Jain Mandir Road	18,480/-	57,960/-	16,800/-	50,400/-	14,000/-	42,000/-	8000/-	23,000/-
13.	Jantar Mantar Road beyond Conn. Place Extn.	18,480/-	57,960/-	16,800/-	50,400/-	14,000/-	42,000/-	8000/-	23,000/-
14.	Lady Hardinge Road	18,480/-	57,960/-	16,800/-	50,400/-	14,000/-	42,000/-	8000/-	23,000/-
15.	Mandir Marg	18,480/-	57,960/-	16,800/-	50,400/-	14,000/-	42,000/-	8000/-	23,000/-
16.	Area outside the extended commercial zone	18,480/-	57,960/-	16,800/-	50,400/-	14,000/-	42,000/-	8000/-	23,000/-

Source: Delhi Development Authority, Schedule of Market Rates of Land from 1987-2000, from https://ldo.gov.in/WriteReadData/userfiles/file/land_rates/LANDRATE-1.PDF (Reference No.10)

	Parliament Street								
17.	Minto Road	18,480/-	57,960/-	16,800/-	50,400/-	14,000/-	42,000/-	8000/-	23,000/-
18.	Panchkuian Road	18,480/-	57,960/-	16,800/-	50,400/-	14,000/-	42,000/-	8000/-	23,000/-
19.	Bhagat Singh Market	18,480/-	57,960/-	16,800/-	50,400/-	14,000/-	42,000/-	8000/-	23,000/-
20.	Babar Road	18,480/-	57,960/-	16,800/-	50,400/-	14,000/-	42,000/-	8000/-	23,000/-
21.	Krishna Market Paharganj	18,480/-	57,960/-	16,800/-	50,400/-	14,000/-	42,000/-	8000/-	23,000/-
22.	Mathura Road Press	18,480/-	57,960/-	16,800/-	50,400/-	14,000/-	42,000/-	8000/-	23,000/-
23.	Jhandewalan	18,480/-	57,960/-	16,800/-	50,400/-	14,000/-	42,000/-	8000/-	23,000/-
24.	Motia Khan (including 'C' Type tenements)	18,480/-	57,960/-	16,800/-	50,400/-	14,000/-	42,000/-	8000/-	23,000/-
	Zone – II								
	South Zone								
1.	Khan Market	13,860/-	28,980/-	12,600/-	25,200/-	10,500/-	21,000/-	6000/-	10,800/-
2.	Diplomatic Enclave	13,860/-	28,980/-	12,600/-	25,200/-	10,500/-	21,000/-	6000/-	10,800/-
3.	Diplomatic Enclave Extension	13,860/-	28,980/-	12,600/-	25,200/-	10,500/-	21,000/-	6000/-	10,800/-
4.	Golf Links	13,860/-	28,980/-	12,600/-	25,200/-	10,500/-	21,000/-	6000/-	10,800/-
5.	Aurangzeb Road	13,860/-	28,980/-	12,600/-	25,200/-	10,500/-	21,000/-	6000/-	10,800/-
6.	Prithvi Raj Road	13,860/-	28,980/-	12,600/-	25,200/-	10,500/-	21,000/-	6000/-	10,800/-
7.	Tis January Marg	13,860/-	28,980/-	12,600/-	25,200/-	10,500/-	21,000/-	6000/-	10,800/-
8.	Ratendon Road	13,860/-	28,980/-	12,600/-	25,200/-	10,500/-	21,000/-	6000/-	10,800/-
9.	Humayun Road	13,860/-	28,980/-	12,600/-	25,200/-	10,500/-	21,000/-	6000/-	10,800/-
10.	Jor Bagh	13,860/-	28,980/-	12,600/-	25,200/-	10,500/-	21,000/-	6000/-	10,800/-
11.	Sunder Nagar	13,860/-	28,980/-	12,600/-	25,200/-	10,500/-	21,000/-	6000/-	10,800/-
12.	Andrews Ganj	12,760/-	26,680/-	11,600/-	23,200/-	9,630/-	19,260/-	5500/-	9900/-
13.	Sadiq Nagar	12,760/-	26,680/-	11,600/-	23,200/-	9,630/-	19,260/-	5500/-	9900/-
14.	Defence Colony	11,550/-	24,150/-	10,500/-	21,000/-	8,750/-	17,500/-	5000/-	9000/-
15.	R.K.Puram	11,550/-	24,150/-	10,500/-	21,000/-	8,750/-	17,500/-	5000/-	9000/-
16.	Moti Bagh	11,550/-	24,150/-	10,500/-	21,000/-	8,750/-	17,500/-	5000/-	9000/-
17.	Lodi Road	11,550/-	24,150/-	10,500/-	21,000/-	8,750/-	17,500/-	5000/-	9000/-
18.	Lodi Estate	11,550/-	24,150/-	10,500/-	21,000/-	8,750/-	17,500/-	5000/-	9000/-
19.	Aliganj	11,550/-	24,150/-	10,500/-	21,000/-	8,750/-	17,500/-	5000/-	9000/-
20.	Sewa Nagar	11,550/-	24,150/-	10,500/-	21,000/-	8,750/-	17,500/-	5000/-	9000/-
21.	Lajpat Nagar facing Ring Road	11,550/-	24,150/-	10,500/-	21,000/-	8,750/-	17,500/-	4000/-	9000/-
22.	Vasant Vihar (Other than DDA land)	11,550/-	24,150/-	10,500/-	21,000/-	8,750/-	17,500/-	4000/-	9000/-
23.	Lajpat Nagar I to IV	9,240/-	19,320/-	8400/-	16,800/-	7,000/-	14,000/-	4000/-	7200/-
24.	Nizamuddin	9,240/-	19,320/-	8400/-	16,800/-	7,000/-	14,000/-	4000/-	7200/-
25.	Jangpura	9,240/-	19,320/-	8400/-	16,800/-	7,000/-	14,000/-	4000/-	7200/-
26.	Kalkaji	9,240/-	19,320/-	8400/-	16,800/-	7,000/-	14,000/-	4000/-	7200/-
27.	Maiviya Nagar (ext.) &Old.	8360/-	17,840/-	7600/-	15,200/-	6,300/-	12,600/-	3600/-	6480/-
28.	M.B. Road	8360/-	17,840/-	7600/-	15,200/-	6,300/-	12,600/-	3600/-	6480/-
	Zone – III								
	West Delhi								
1.	Ajmal Khan Road	11,550/-	24,150/-	10,500/-	21,000/-	8,750/-	17,500/-	5000/-	9000/-
2.	Ghaffar Market	11,550/-	24,150/-	10,500/-	21,000/-	8,750/-	17,500/-	5000/-	9000/-
3.	Karol Bagh	11,550/-	24,150/-	10,500/-	21,000/-	8,750/-	17,500/-	5000/-	9000/-
4.	M.M. Road	11,550/-	24,150/-	10,500/-	21,000/-	8,750/-	17,500/-	5000/-	9000/-
5.	Rani Jhansi Market	11,550/-	24,150/-	10,500/-	21,000/-	8,750/-	17,500/-	5000/-	9000/-
6.	Link Road (Karol Bagh)	11,550/-	24,150/-	10,500/-	21,000/-	8,750/-	17,500/-	5000/-	9000/-
7.	Deshbandhu Gupta Market	11,550/-	24,150/-	10,500/-	21,000/-	8,750/-	17,500/-	5000/-	9000/-
8.	Patel Nagar (East,West & South)	11,550/-	24,150/-	10,500/-	21,000/-	8,750/-	17,500/-	5000/-	9000/-
9.	Rajinder Nagar (Old & New)	11,550/-	24,150/-	10,500/-	21,000/-	8,750/-	17,500/-	5000/-	9000/-
10.	Rohtak Road (Old & New)	9240/-	19,320/-	8400/-	16,800/-	7,000/-	14,000/-	4000/-	7200/-
11.	Nazafgarh Industrial Area	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	6000/-
12.	Rameshwari Nehru Nagar	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	3400/-
13.	Moti Nagar	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	5400/-
14.	Sarai Rohilla	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	5400/-
15.	Tilak Nagar	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	5400/-
16.	Tihar- I & II	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	5400/-
17.	Ramesh Nagar	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	5400/-
18.	Industrial Area Extn.	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	5400/-
	Zone – IV								
	North Delhi								
1.	Kamla Nagar	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	6000/-
2.	Rup Nagar	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	6000/-

Source: Delhi Development Authority, Schedule of Market Rates of Land from 1987-2000, from https://ldo.gov.in/WriteReadData/userfiles/file/land_rates/LANDRATE-1.PDF (Reference No.10)

3.	Shakti Nagar	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	6000/-
4.	Qutab Road	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	6000/-
5.	Roshnara Road	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	6000/-
6.	Lajpat Rai Market	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	5400/-
7.	Ansari Market	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	5400/-
8.	Jawahar Nagar	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	5400/-
9.	Khurshid Market	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	5400/-
10.	Teliwara	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	5400/-
11.	Azad Market	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	5400/-
12.	Mall Road	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	5400/-
13.	Rajpura Road	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	5400/-
14.	Malka Ganj	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	5400/-
15.	Alipur Road	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	5400/-
16.	Gokhale Market	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	5400/-
17.	Hathi Khana	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	5400/-
18.	Khanna Market (Near Tis Hazari)	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	5400/-
19.	Lehna Singh Market	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	5400/-
20.	Nicholson Road	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	5400/-
21.	Vijay Nagar	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	5400/-
22.	Ashok Nagar	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	5400/-
23.	Subzi Mandi	6,930/-	14,490/-	6300/-	12,600/-	5,250/-	10,500/-	3000/-	5400/-
24.	Indira Nagar	5,830/-	12,190/-	5,300/-	10,600/-	4,380/-	8,760/-	2500/-	4500/-
25.	Azadpur	5,830/-	12,190/-	5,300/-	10,600/-	4,380/-	8,760/-	2500/-	4500/-
26.	Andha Mughal	5,830/-	12,190/-	5,300/-	10,600/-	4,380/-	8,760/-	2500/-	4500/-
27.	Bus Stand Area Extn. (BSA)	5,830/-	12,190/-	5,300/-	10,600/-	4,380/-	8,760/-	2500/-	4500/-
28.	Bharat Nagar	5,830/-	12,190/-	5,300/-	10,600/-	4,380/-	8,760/-	2500/-	4500/-
29.	Gur-ki-Mandi	5,830/-	12,190/-	5,300/-	10,600/-	4,380/-	8,760/-	2500/-	4500/-
30.	Gulabi Bagh	5,830/-	12,190/-	5,300/-	10,600/-	4,380/-	8,760/-	2500/-	4500/-
31.	Kingsway Camp	5,830/-	12,190/-	5,300/-	10,600/-	4,380/-	8,760/-	2500/-	4500/-
32.	Timarpur	5,830/-	12,190/-	5,300/-	10,600/-	4,380/-	8,760/-	2500/-	4500/-
33.	Angoori Bagh	5,830/-	12,190/-	5,300/-	10,600/-	4,380/-	8,760/-	2500/-	4500/-
34.	Edward Lines	5,830/-	12,190/-	5,300/-	10,600/-	4,380/-	8,760/-	2500/-	4500/-
35.	Hakikat Nagar	5,830/-	12,190/-	5,300/-	10,600/-	4,380/-	8,760/-	2500/-	4500/-
36.	Hudson Lines	5,830/-	12,190/-	5,300/-	10,600/-	4,380/-	8,760/-	2500/-	4500/-
	Zone – V								
	East Delhi								
1.	Jheel Kuranja	2805/-	5865/-	2,550/-	5100/-	2,100/-	4,200/-	1200/-	2160/-
2.	Geeta Colony	2805/-	5865/-	2,550/-	5100/-	2,100/-	4,200/-	1200/-	2160/-
3.	Narela & other Outlying Colonies	1980/-	4140/-	1,800/-	3,600/-	1,490/-	2,980/-	850/-	1530/-

Reference:

1. **For 1.4.1998 to 31.3.2000** - Letter No.J-22011/4/95-LD dated 16.4.1999 from Min. of UA&E
2. For 1.4.1996 to 31.3.1998 - Letter No.J-22011/4/95-LD dated 16.4.1999 from Min. of UA&E extending the validity of rates (for two more years) circulated vide No. J-22011/2/93-LD dated 11.11.1994
3. For 1.4.1994 to 31.3.1996 - Letter No.J-22011/2/93-LD dated 11.11.1994 from Min. of U.D. extending the validity of rates (for two more years) circulated vide No. J-22011/1/91-LD dated 3.3.1993
4. For 1.4.1992 to 31.3.1994 – Letter No. J-22011/1/91-LD dated 3.3.1993
5. **For 1.4.1991 to 31.3.1992** - Letter No. J-22011/1/91-LD dated 24.1.1992
6. **For 1.4.1989 to 31.3.1991** - Letter No.J-22011/3/89-LD(DOI) dated 5.9.1991 from Min. of U.D.
7. **For 1.4.1987 to 31.3.1989** - Letter No.J-22011/4/86-LD(DOI) dated 1.6.1987 from Min. of U.D.

Notes for ref.1,2,3,4,5 & 6

1. The market rates for residential/commercial purposes are based on existing FARs prescribed for various areas and will be increased proportionate to increase in FAR
2. In so far as hotel and cinema sites are concerned, each case should be specifically considered in consultation with the Ministry of Finance.
3. For any locality not covered by these rates, the rates for comparable areas will be applied.

Notes for ref. 7

1. The rates shall be in force for all purposes except for (i) hotels,(ii) cinemas and (iii) for the purpose of recovery of unearned increase due to the lessor while granting permission for sale in respect of residential leases measuring 100 Sq.Yds.
2. The market rates for commercial purposes for Zone-I are based on FAR of 250 and for the other Zones on existing FARs.
3. Residential rates are based on the existing FARs prescribed for various areas. These rates will be reduced or increased proportionate to the reduction or increase in FAR.
4. For the purpose of calculating and recovering lessor's share of unearned increase while granting sale permissions in respect of the residential leases measuring 100 Sq. Yds. or less, the land rates laid down in the Ministry's letter No. J-22011/3/80-LD(DOI) dated 21.10.1981 will be applicable for a period of two years from 1.4.87 to 31.3.1989
5. In so far as hotel and cinema sites are concerned, each case should be specifically considered in consultation with the Ministry of Finance.

Source: Delhi Development Authority, Schedule of Market Rates of Land from 1987-2000, from https://ldo.gov.in/WriteReadData/userfiles/file/land_rates/LANDRATE-1.PDF (Reference No.10)

A5.2 Market Rate of lands in Delhi applicable from 1.04.2000 to 14.02.2006 on the land under the jurisdiction of Delhi Development Authority (DDA)

ANNEXURE-"B"

A) SHEDULE OF MARKET RATES OF LAND IN DELHI/NEW DELHI APPLICABLE FOR CONVERSION From 01-04-2000 Onwards

Sl. No.	Name of Locality	Residential (Rs. per sq. metre)
(1)	(2)	(3)
Zone-1		
Central Zone		
1.	CONNAUGHT PLACE	18,480/-
2.	CONNAUGHT CIRCUS	18,480/-
3.	CONNAUGHT PLACE EXTN. UPTO OCOMMERCIAL ZONE	
4.	BARAKHAMBA ROAD (BEYOND CONNAUGHT EXTN.) UPTO COMMERCIAL ZONE	18,480/-
5.	CURZON ROAD BEYOND CONNAUGHT PLACE EXTN. UPTO COMMERCIAL ZONE	18,480/-
6.	HANUMAN ROAD (COMMERCIAL ZONE)	18,480/-
7.	JANPATH BEYOND CONNAUGHT PLACE EXTN. UPTO WINDSOR PLACE	18,480/-
8.	BHAGWAN DASS ROAD	18,480/-
9.	HAILEY ROAD	18,480/-
10.	HANUMAN ROAD (RES. ZONE)	18,480/-
11.	BAIRD ROAD	18,480/-
12.	JAIN MANDIR ROAD	18,480/-
13.	JANTAR MANTAR ROAD BEYOND CONNAUGHT PLACE EXTN.	18,480/-
14.	LADY HARDING ROAD	18,480/-
15.	MANDIR MARG	18,480/-
16.	AREA OUTSIDE THE EXTENDED COMMERCIAL ZONE, PARLIAMENT STREET	18,480/-
17.	MINTO ROAD	18,480/-
18.	PUNCHKUIN ROAD	18,480/-
19.	BHAGAT SINGH MARKET	18,480/-
20.	BABAR ROAD	
21.	KRISHNA MARKET PAHAR GANJ	18,480/-
22.	MATHURA ROAD PRESS	18,480/-
23.	HANDEWALAN	18,480/-
24.	MOTIA KHAN (INCLUDING 'C' TYPE TENEMENTS)	18,480/-
1.	KHAN MARKET	13,860/-
2.	DIPLOMATIC ENCLAVE	13,860/-
3.	DIPLOMATIC ENCLAVE EXTN.	13,860/-
4.	GOLF LINKS	13,860/-
5.	AURNANGZEB ROAD	13,860/-
6.	PRITHVIRAJ ROAD	13,860/-
7.	TIS JANUARY MARG	13,860/-
8.	RATENDON ROAD	13,860/-
9.	HUMAYUN ROAD	13,860/-
10.	JOR BAGH	13,860/-
11.	SUNDER NAGAR	13,860/-
12.	ANDREWS GANJ	12,760/-
13.	SADIQ NAGAR	12,760/-
14.	DEFENCE COLONY	11,550/-
15.	R. K. PURAM	11,550/-
16.	MOTI BAGH	11,550/-
17.	LODHI ROAD	11,550/-
18.	LODHI ESTATE	11,550/-
19.	ALIGANJ	11,550/-
20.	SEWA NAGAR	11,550/-
21.	LAJPAT NAGAR FACING RING ROAD	11,550/-
22.	LAJPAT NAGAR (1 TO 5)	9,240/-
23.	NIZAMUDDIN	9,240/-
24.	JANGPURA	9,240/-
25.	KALKAJI	9,240/-
26.	MALVIYA NAGAR EXTN. AND OLD	8,360/-
27	M. B. ROAD	8,360/-
28.	VASANT VIHAR (DDA LAND)	13,283/-
29.	ANAND NIKETAN	13,283/-
30.	SHANTI NIKETAN	13,283/-
31.	ANAND LOK	13,283/-
32.	PANCHSHEEL PARK	13,283/-
33.	GULMOHAR PARK	13,283/-
34.	WEST END	13,283/-
35.	NITI BAGH	13,283/-
36.	MAHARANI BAGH	13,283/-
37.	NEW FRIENDS COLONY	13,283/-
38.	FRIENDS COLONY	13,283/-
39.	GREATER KAILASH	13,283/-
40.	SAFDARJUNG AREA/ENCLAVE	11,955/-

Source: Delhi Development Authority, Trnscription of Annexure-B A)Schedule of Market Rates of Land from 01-04-2000, downloaded from PDF4PRO website page link https://pdf4pro.com/view/annexure-b-a-shedule-of-market-rates-of-243250.html

41.	MASJID MOTH	10,626/-
42.	CHIRAG ENCLAVE	10,626/-
43.	E.P.R. COLONY	10,626/-
44.	EAST OF KAILASH	10,626/-
45.	SARVODAYA COLONY/ENCALVE	10,626/-
46.	SADHNA ENCLAVE	9,587/-
47.	COSMOPOLITAN HOUSE BLDG. SOCIETY	9,587/-

N.B. The DDA Flats located in the following localities would also fall under the South Zone :
Alaknanda, Badar Pur, Basant Gaon, Ber Sarai, Bhim Nagari, Chirag Enclave, Dakshin Puri, E.P.D.P. Colony, Friends Colony, Gautam Nagar, "Greater Kailash, Hauz Khas, Jasola, Kalkaji, Katwaria Sarai, Khirki, Kishan Garh, Kilokri, Lado Sarai, Madangir, Madanpur Khadar, Malviya Nagar, Mandakini Enclave, Masjid Moth, Munirka, Niti Bagh, Panchsheel Marg, Pul Pehlad Pur, Safdarjung Development Area, Safdarjung Enclave, Saket, Sarai Julaina, Sarita Vihar, Sarvapriya Vihar, Sunlight Colony, Tamoor Nagar, Tigri, Sidharth Extn. Sukhdev Vihar, Vasant Kunj, Vasant Vihar, Vijay Mandal Enclave, Yusuf Sarai, Kalu Sarai, Shahpur Jat, Sheikh Sarai, Usha Niketan.

Zone-3
West Delhi

1.	AJMAL KHAN ROAD	11,550/-
2.	GAFFAR MARKET	11,550/-
3.	KAROL BAGH	11,550/-
4.	MM ROAD	11,550/-
5.	RANI JHANSI MARKET	11,550/-
6.	LINK ROAD (KAROL BAGH)	11,550/-
7.	DESH BANDHU GUPTA MARKET	11,550/-
8.	PATEL NAGAR (EAST WEST AND SOUTH)	11,550/-
9.	RAJINDER NAGAR (OLD & NEW)	11,550/-
10.	jksgrd jksM+ ¼iqjkuk vkSj u;k½@ROHTAK ROAD (OLD & NEW)	9,240/-
11.	NAJAFGARH INDL. AREA	6,930/-
12.	RAMESHWARI NEHRU NAGAR	6,930/-
13.	MOTI NAGAR	6,930/-
14.	SARAI ROHILLA	6,930/-
15.	TILAK NAGAR	6,930/-
16.	TIHAR 1 & 2	6,930/-
17.	RAMESH NAGAR	6,930/-
18.	INDUSTRIAL AREA EXTN	6,930/-
19.	TAGORE GARDEN	5,706/-
20.	NARAINA	6,076/-
21.	VIKAS PURI	2,287/-
22.	JANAKPURI	3,419/-
23.	PASCHIM PURI (PASCHIM VIHAR)	3,050/-
24.	CHAUKHANDI	3,050/-
25.	NANGLOI	3,050/-

N.B. The D.D.A. flats located in the following localities would also fall in the West Zone :-
Bodella, Hari nagar, Hastal, Jaidev Park, Jwala Puri, Khyala, Madipur, Pankha Road, Peera garhi, Possangi Pur, Prasad Nagar, Punjabi Bagh, Raghubir Nagar, Rajouri Garden, Rehgar Pura, Sultan Puri, Tagore Garden, Toda Pur, Madipur, Rohtak Road, Mansarover Garden.

Zone-4 North Delhi

1.	KAMLA NAGAR	6,930/-
2.	ROOP NAGAR	6,930/-
3.	SHAKTI NAGAR	6,930/-
4.	QUTAB ROAD	6,930/-
5.	ROSHNARA ROAD	6,930/-
6.	LAJPAT RAI MARKET	6,930/-
7.	ANSARI MARKET	6,930/-
8.	JAWAHAR NAGAR	6,930/-
9.	KHURSHID MARKET	6,930/-
10.	TELIWARA	6,930/-
11.	AZAD MARKET	6,930/-
12.	MALL ROAD	6,930/-
13.	RAJPUR ROAD	6,930/-
14.	MALKA GANJ	6,930/-
15.	ALIPUR ROAD	6,930/-
16.	GOKHALE MARKET	6,930/-
17.	HATHI KHANA	6,930/-
18.	KHANNA MARKET (NEAR TIS HAZARI)	6,930/-
19.	LAHNA SINGH MARKET	6,930/-
20	NICHOLSON ROAD	6,930/-
21.	VIJAY NAGAR	6,930/-
22.	ASHOK MARKET	6,930/-

Source: Delhi Development Authority, Trnscription of Annexure-B A)Schedule of Market Rates of Land from 01-04-2000, downloaded from PDF4PRO website page link https://pdf4pro.com/view/annexure-b-a-shedule-of-market-rates-of-243250.html

23.	SUBZI MANDI	6,930/-
24.	INDIRA NAGAR	5,830/-
25.	AZAD PUR	5,830/-
26.	ANDHA MUGHAL	5,830/-
27.	BAND STAND AREA EXT. (BSA)	5,830/-
28.	BHARAT NAGAR	5,830/-
29.	GUR KI MANDI	5,830/-
30.	GULABI BAGH	5,830/-
31.	KINGSWAY CAMP	5,830/-
32.	TIMAR PUR	5,830/-
33.	ANGOORI BAGH	5,830/-
34.	EDWARD LINES	5,830/-
35.	HAKIKAT NAGAR	5,830/-
36.	HUDSON LINES	5,830/-
37.	WAZIR PUR/ASHOK VIHAR	7,450/-
38.	SRI NAGAR	7,450/-
39.	SHALIMAR BAGH	5,475/-
40.	PITAMPURA	3,488/-
41.	HAIDERPURI (PRASHANT VIHAR)	3,488/-
42.	BHAROLA	3,488/-
43.	ROHINI	3,488/-
44.	G T KARNAL ROAD	6,930/-
45.	MALIK PUR CHHAWNI, RAJPUR CHHAWNI	6,930/-
46.	TAGORE PARK	5,706/-

N.B. The D.D.A. flats located in the following localities would also fall in the North Zone :-
Ashok Vihar, Avantika, Jahangir Puri, Lawrence Road, Mangol Puri, Ram Pura, Sarai Rohilla, Shakur Pur,

Zone-5 East Delhi

1.	JHEEL KURANJA	2,805/-
2.	GEETA COLONY	2,805/-
3.	JHILMIL	3,073/-
4.	YAMUNA VIHAR	3,073/-
5.	ZAFRABAD	3,073/-
6.	OTHER COLONIES OF TRANS YAMUNA AREA	3,073/-

N.B. The DDA flats located in the following localities would also under the East zone.
Anand Vihar, Bhat Nagar, Chilla Village, Dilshad Garden, East of Loni Road, Gazipur, Himmat Puri, Kondli Gharoli, kalyan Puri, Mayur Vihar, Mansarovar Park, Nirman Vihar, Nand Nagri, New Seelampur, Priyadarshni Vihar, Shastri Park, Trilokpuri, Vivek Vihar.

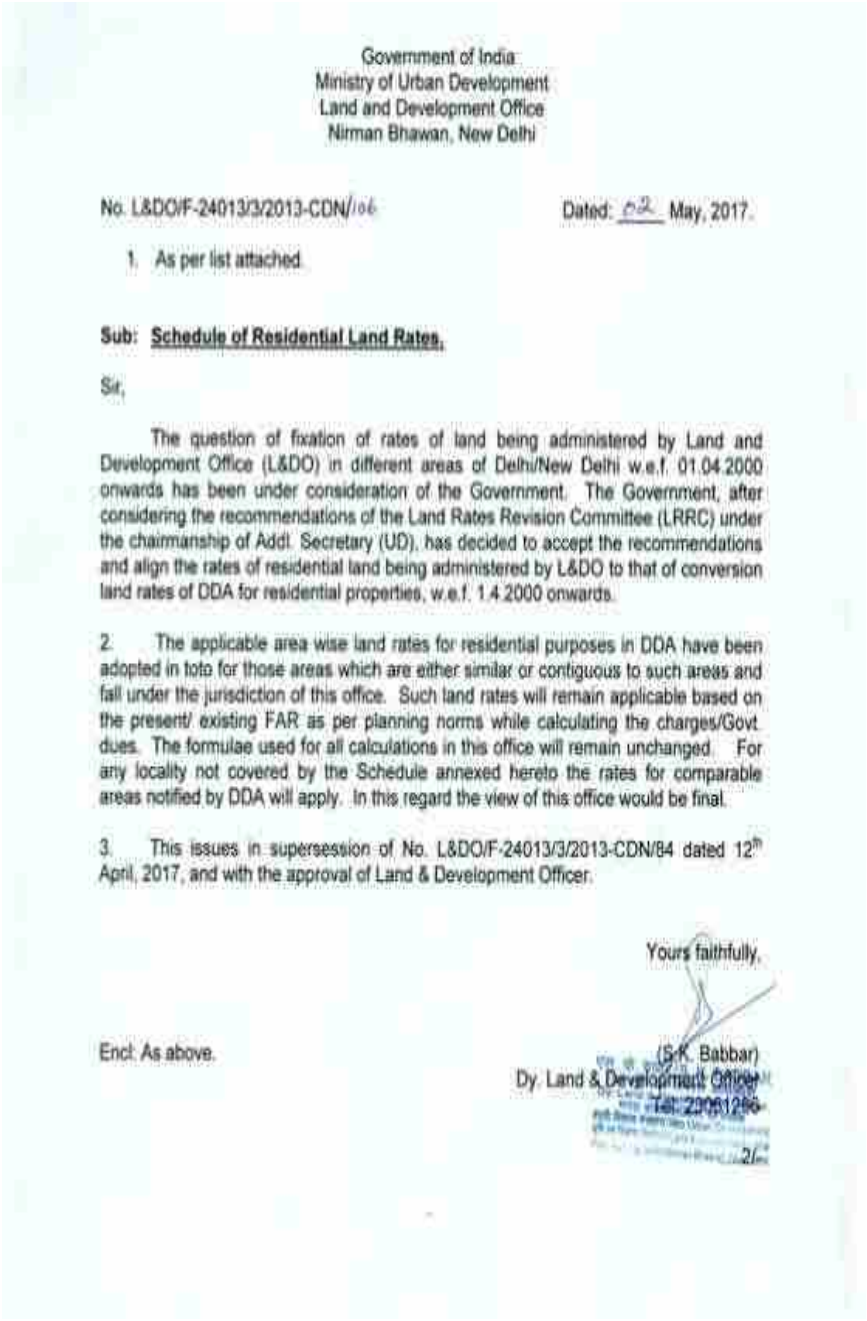
	Persq.Mater
NARELA& OTHER OUTLYING COLONIES	1980/-

Note :The localities for which no market rates of land have been indicated above the market rates of land shown as above for the adjoining/comparable locality may be made applicatable.

B)FOR FIXED TERM RESIDENTIAL BUILT UP PROPERTIES WHERE PREMUM HAS NOT BEEN CHARGED.	
Name of the Locality Mater	Rs. Per sq.
Karol Bagh	26681/-

Source: Delhi Development Authority, Trnscription of Annexure-B A)Schedule of Market Rates of Land from 01-04-2000, downloaded from PDF4PRO website page link https://pdf4pro.com/view/annexure-b-a-shedule-of-market-rates-of-243250.html

A 5.3 Market Rate of lands in Delhi applicable from 1.04.2000 to 14.11.2012



Government of India
Ministry of Urban Development
Land and Development Office
Nirman Bhawan, New Delhi

No. L&DO/F-24013/3/2013-CDN/106 Dated: 02 May, 2017.

1. As per list attached

Sub: Schedule of Residential Land Rates.

Sir,

The question of fixation of rates of land being administered by Land and Development Office (L&DO) in different areas of Delhi/New Delhi w.e.f. 01.04.2000 onwards has been under consideration of the Government. The Government, after considering the recommendations of the Land Rates Revision Committee (LRRC) under the chairmanship of Addl. Secretary (UD), has decided to accept the recommendations and align the rates of residential land being administered by L&DO to that of conversion land rates of DDA for residential properties, w.e.f. 1.4.2000 onwards.

2. The applicable area wise land rates for residential purposes in DDA have been adopted in toto for those areas which are either similar or contiguous to such areas and fall under the jurisdiction of this office. Such land rates will remain applicable based on the present/ existing FAR as per planning norms while calculating the charges/Govt. dues. The formulae used for all calculations in this office will remain unchanged. For any locality not covered by the Schedule annexed hereto the rates for comparable areas notified by DDA will apply. In this regard the view of this office would be final.

3. This issues in supersession of No. L&DO/F-24013/3/2013-CDN/84 dated 12th April, 2017, and with the approval of Land & Development Officer.

Yours faithfully,

Encl: As above.

(S.K. Babbar)
Dy. Land & Development Officer
Tel: 23061286

2/-

Source: Government of India, Ministry of Urban Development, Land and Development Office, retrieved from https///ldo.gov.in/WriteReadData/userfiles/file/land_rates/Residential-LandRates-02052017 (Reference No.31)

SCHEDULE OF LAND RATES OF LAND OF RESIDENTIAL IN DELHI/ NEW DELHI

Sr. No.	Name of the Locality	Rates w.e.f. 1.4.2000 to 14.2.2006 (Rs. per Sq. Mtr)	Rates w.e.f. 15.2.2006 to 11.8.2011 (Rs. per Sq. Mtr)	Rates w.e.f. 12.8.2011 to onwards till further orders (Rs. per Sq. Mtr)
1	2	3		4
ZONE – I CENTRAL ZONE				
1	Connaught Place	18,480/-	27,720/-	41,580/-
2	Connaught Circus	18,480/-	27,720/-	41,580/-
3	Connaught Place Extension up to Commercial Center.	18,480/-	27,720/-	41,580/-
4	Barakhamba Road (beyond Conn. Place extn. up to commercial zone).	18,480/-	27,720/-	41,580/-
5	Curzon Road Beyond Connaught Place extn. up to commercial zone.	18,480/-	27,720/-	41,580/-
6	Hanuman Road Commercial Zone	18,480/-	27,720/-	41,580/-
7	Jan Path beyond (Conn. Place extn. up to Windsor Place)	18,480/-	27,720/-	41,580/-
8	Bhagwandas Road	18,480/-	27,720/-	41,580/-
9	Hailey Road	18,480/-	27,720/-	41,580/-
10	Hanuman Road(Res. Zone)	18,480/-	27,720/-	41,580/-
11	Baird Road	18,480/-	27,720/-	41,580/-
12	Jain Mandir Road	18,480/-	27,720/-	41,580/-
13	Jantar Mantar Road beyond Conn. Place Extn.	18,480/-	27,720/-	41,580/-
14	Lady Harding Road	18,480/-	27,720/-	41,580/-
15	Mandir Marg	18,480/-	27,720/-	41,580/-
16	Area outside the extended commercial Zone Parliament Street.	18,480/-	27,720/-	41,580/-
17	Minto Road	18,480/-	27,720/-	41,580/-
18	Panchkuian Road	18,480/-	27,720/-	41,580/-
19	Bhagat Singh Market	18,480/-	27,720/-	41,580/-
20	Babar Road	18,480/-	27,720/-	41,580/-

1	2	3	4	5
21	Krishna Market Paharganj	18,480/-	27,720/-	41,580/-
22	Mathura Road Press	18,480/-	27,720/-	41,580/-
23	Jhandewalan	18,480/-	27,720/-	41,580/-
24	Motia Khan (including 'c' type tenements).	18,480/-	27,720/-	41,580/-

ZONE - II SOUTH ZONE

1	2	3	4	5
1	Khan Market	13,860/-	20,790/-	31,185/-
2	Diplomatic Enclave	13,860/-	20,790/-	31,185/-
3	Diplomatic Enclave Extn.	13,860/-	20,790/-	31,185/-
4	Golf Links	13,860/-	20,790/-	31,185/-
5	Aurangzeb Road	13,860/-	20,790/-	31,185/-
6	Prithvi Raj Road	13,860/-	20,790/-	31,185/-
7	Tis January Marg	13,860/-	20,790/-	31,185/-
8	Ratendori Road	13,860/-	20,790/-	31,185/-
9	Humayun Road	13,860/-	20,790/-	31,185/-
10	Jor Bagh	13,860/-	20,790/-	31,185/-
11	Sunder Nagar	13,860/-	20,790/-	31,185/-
12	Andrews Ganj	12,780/-	19,140/-	28,710/-
13	Sadiq Nagar	12,760/-	19,140/-	28,710/-
14	Defence Colony	11,550/-	17,325/-	25,988/-
15	R.K.Puram	11,550/-	17,325/-	25,988/-
16	Moti Bagh	11,550/-	17,325/-	25,988/-
17	Lodi Road	11,550/-	17,325/-	25,988/-
18	Lodi Estate	11,550/-	17,325/-	25,988/-
19	Aliganj	11,550/-	17,325/-	25,988/-
20	Sewa Nagar	11,550/-	17,325/-	25,988/-
21	Lajpat Nagar facing Ring Road	11,550/-	17,325/-	25,988/-
22	Vasant Vihar (other than DDA land).	11,550/-	17,325/-	25,988/-
23	Lajpat Nagar I to IV.	9,240/-	13,860/-	20,790/-
24	Nizamuddin	9,240/-	13,860/-	20,790/-
25	Jangpura	9,240/-	13,860/-	20,790/-
26	Kalkaji	9,240/-	13,860/-	20,790/-
27	Malviya Nagar(ext.) & Old.	8,360/-	12,540/-	18,810/-
28	M.B.Road	8,360/-	12,540/-	18,810/-

Source: Government of India, Ministry of Urban Development, Land and Development Office, retrieved from https///ldo.gov.in/WriteReadData/userfiles/file/land_rates/Residential-LandRates-02052017 (Reference No.31)

ZONE - III
WEST DELHI

1	2	3	4	5
1	Ajmal Khan Road	11,550/-	17,325/-	25,988/-
2	Ghaffar Market	11,550/-	17,325/-	25,988/-
3	Karol Bagh	11,550/-	17,325/-	25,988/-
4	M.M. Road	11,550/-	17,325/-	25,988/-
5	Rani Jhansi Market	11,550/-	17,325/-	25,988/-
6	Link Road (Karol Bagh)	11,550/-	17,325/-	25,988/-
7	Deshbandhu Gupta Market	11,550/-	17,325/-	25,988/-
8	Patel Nagar (East,West & South)	11,550/-	17,325/-	25,988/-
9	Rajinder Nagar (Old & New)	11,550/-	17,325/-	25,988/-
10	Rohtak Road (Old & New)	9,240/-	13,860/-	20,790/-
11	Nazafgarh Industrial Area	6,930/-	10,395/-	15,593/-
12	Rameshwari Nehru Nagar	6,930/-	10,395/-	15,593/-
13	Moti Nagar	6,930/-	10,395/-	15,593/-
14	Sarai Rohilla	6,930/-	10,395/-	15,593/-
15	Tilak Nagar	6,930/-	10,395/-	15,593/-
16	Tihar I & II	6,930/-	10,395/-	15,593/-
17	Ramesh Nagar	6,930/-	10,395/-	15,593/-
18	Industrial Area Extn.	6,930/-	10,395/-	15,593/-

ZONE - IV
NORTH DELHI

1	2	3	4	5
1	Kamla Nagar	6,930/-	10,395/-	15,593/-
2	Roop Nagar	6,930/-	10,395/-	15,593/-
3	Shakti Nagar	6,930/-	10,395/-	15,593/-
4	Qutab Road	6,930/-	10,395/-	15,593/-
5	Roshnara Road	6,930/-	10,395/-	15,593/-
6	Lajpat Rai Market	6,930/-	10,395/-	15,593/-
7	Ansari Market	6,930/-	10,395/-	15,593/-
8	Jawahar Nagar	6,930/-	10,395/-	15,593/-
9	Khurshid Market	6,930/-	10,395/-	15,593/-
10	Tellwara	6,930/-	10,395/-	15,593/-

1	2	3	4	5
11	Azad Market	6,930/-	10,395/-	15,593/-
12	Mall road	6,930/-	10,395/-	15,593/-
13	Rajpura Road	6,930/-	10,395/-	15,593/-
14	Malka Ganj	6,930/-	10,395/-	15,593/-
15	Alipur Road	6,930/-	10,395/-	15,593/-
16	Gokhala Market	6,930/-	10,395/-	15,593/-
17	Hathi Khana	6,930/-	10,395/-	15,593/-
18	Khanna Market (Near Tis Hazari)	6,930/-	10,395/-	15,593/-
19	Lehna Singh Market	6,930/-	10,395/-	15,593/-
20	Nicholson Road	6,930/-	10,395/-	15,593/-
21	Vijay Nagar	6,930/-	10,395/-	15,593/-
22	Ashok Nagar	6,930/-	10,395/-	15,593/-
23	Subzi Mandi	6,930/-	10,395/-	15,593/-
24	Indira Nagar	5,830/-	8,745/-	13,118/-
25	Azadpur	5,830/-	8,745/-	13,118/-
26	Andhe Mughal	5,830/-	8,745/-	13,118/-
27	Band Stand Area Extn (BSA)	5,830/-	8,745/-	13,118/-
28	Bharat Nagar	5,830/-	8,745/-	13,118/-
29	Gurki Mandi	5,830/-	8,745/-	13,118/-
30	Gulabi Bagh	5,830/-	8,745/-	13,118/-
31	Kingsway Camp	5,830/-	8,745/-	13,118/-
32	Timarpur	5,830/-	8,745/-	13,118/-
33	Angoori Bagh	5,830/-	8,745/-	13,118/-
34	Edward Lines	5,830/-	8,745/-	13,118/-
35	Hakikat Nagar	5,830/-	8,745/-	13,118/-
36	Hudson Lines	5,830/-	8,745/-	13,118/-

Source: Government of India, Ministry of Urban Development, Land and Development Office, retrieved from https///ldo.gov.in/WriteReadData/userfiles/file/land_rates/Residential-LandRates-02052017 (Reference No.31)

ZONE - V
East Delhi

1	2	3	4	5
1	Jheel Kurenja	2,805/-	4,208/-	6,312/-
2	Geeta Colony	2,805/-	4,208/-	6,312/-
3	Narela & other outlying colonies	1,980/-	2,970/-	4,455/-

Source: Government of India, Ministry of Urban Development, Land and Development Office, retrieved from https///ldo.gov.in/WriteReadData/userfiles/file/land_rates/Residential-LandRates-02052017 (Reference No.31)

(TO BE PUBLISHED IN PART-IV OF THE DELHI GAZETTE EXTRAORDINARY)
GOVERNMENT OF NATIONAL CAPITAL TERRITORY OF DELHI REVENUE DEPARTMENT, 5 SHAM NATH MARG, DELHI

No. F.1(152)/Regn.Br./Div.Com./HQ/2011/ 780 Dated 04/12/2012

NOTIFICATION

No. F.1(152)/Regn.Br./Div.Com./2011: In exercise of the powers conferred by section 27 and section 47A of the Indian Stamp Act, 1899 (2 of 1899) as in force in Delhi and in pursuance of the provisions of rule 4 of the Delhi Stamp (Prevention of Under-valuation of Instruments) Rules, 2007, read with the Ministry of Home Affairs, Government of India SO 1726(No.F.2(5/61-Judl-II) dated 22nd July, 1961 and Notification S.O. 2709(41/2/66-Delhi), dated 7th September,1966, and in supersession of this Government's Notification No.F1(152)/Regn.Br./Div.Com./HQ/2011/919 Dated 15-11-2011 the Lt. Governor of the National Capital Territory of Delhi, vide, and notifies, the minimum rates (circle rates) for valuation of lands and immovable properties in Delhi for the purposes and intent of the said Act and the rules made thereunder, as specified in Annexure I to this notification.

The above rates shall be taken into consideration for registration of instruments relating to lands and immovable properties in Delhi by all the Registering Authorities under the provisions of the Indian Stamp Act, 1899(2 of 1899) at the time of registration of instruments under the provisions of the Registration Act, 1908(XVI of 1908), having jurisdiction on the transaction placed before them for registration, under the provisions of the Indian Stamp Act, 1899 (2 of 1899), as in force in Delhi.

These revised rates shall come into force with effect from **05.12.2012.**

By order and in the name of the
Lt. Governor of the National
Capital Territory of Delhi.

(NILA MOHANAN)
Spl. Inspector General (Registration)-I

Source: Government of NCT of Delhi, Department of Revenue, Extracted From Delhi Development Authority Document Upload from the link http://delhi-masterplan.com/wp-content/uploads/2009/07/circle+rate+041220121

ANNEXURE-I

Minimum Rates(Circle Rates) for valuation of Land and Properties for purposes of Registration under the Registration Act, 1908 in Delhi:-

1 Minimum Land Rates for Residential Use:-

Table- 1

Category of Locality	Minimum rate for valuation of land for residential use (in Rupees per square meter)
A	645000
B	204600
C	133200
D	105400
E	58400
F	47200
G	38500
H	19400

2 Minimum Land Rates for Commercial, Industrial and other uses:

2.1 The following multiplicative use factors shall be employed to the above minimum land rates for residential use while calculating the cost of land under different uses:-

Table- 1.1

Use*	Residential	Public purpose e.g. government schools hospitals etc.	Public utility e.g. private school colleges, hospitals	Industrial	Commercial
Factor	1	1	2	2	3

* Definitions are as in the Unit Area Property Tax System

Source: Government of NCT of Delhi, Department of Revenue, Extracted From Delhi Development Authority Document Upload from the link http://delhi-masterplan.com/wp-content/uploads/2009/07/circle+rate+041220121

A5.4 Circle Rate of lands in Delhi applicable from 15.11.2012 and revisions

(Ref: https://www.mapsofindia.com/delhi/information/mcd-circle-rates.html)

All areas of Delhi have been categorized into eight land type – A, B, C, D, E, F, G, and H.

December 2015 MCD Circle rate:

Category	**Minimum Land Rate INR / Sq. Meter**
A-1	Rs.1,000,000
A	Rs.700,000
B	Rs.420,000
C	Rs.250,000
D	Rs.150,000
E	Rs.90,000
F	Rs.63,000
G	Rs.45,000
H	Rs.30,000

September 2014 MCD Circle Rate:

Category	Minimum Land Rate INR / Sq. Meter
A	Rs.775,000
B	Rs.245,520
C	Rs.159,840
D	Rs.127,680
E	Rs.70,070
F	Rs.56,640
G	Rs.46,200
H	Rs.23,280

November 2012 MCD Circle Rate:

Category	Minimum Land Rate INR / Sq. Meter
A	Rs.645,000
B	Rs.204,600
C	Rs.133,224
D	Rs.106,384
E	Rs.58,365
F	Rs.47,140
G	Rs.38,442
H	Rs.19,361

Source: mapsofindia website on circle rate of Delhi and Government of NCT of Delhi Notifications on Circle Rate of Delhi (Summarized by Author).

APPENDIX 6

STATA Programming Codes and Results

The STATA programming code of research design 1, 2, and 3 along with the results, data editor file, graphs, and regression result tables are enclosed in this appendix.

```
******Research Design 1 - Effect of Distance from Metro Network on Average House prices in Delhi**********

use "/Users/kaushal/Desktop/Final Thesis Work/data_file/house_price_thesis.dta"


* egen urban_area_id = group(urban_area)
*(Already existed in Data Editor)



global id urban_area_id
global t year


global ylist house_price
global xlist station_dist d_near_station
sort $id $t
xtset $id $t, delta(3)


asdoc summarize house_price station_dist year, stat(N mean sd min max), dec(4)font(Times New Roman) ///
fs(11) save(summary_hp_dist.doc) title(Summary of House Price of Urban Area and Distance from Metro Network),replace


asdoc xtsum $id $t $ylist $xlist, stat(N mean sd min max), dec(4) font(Times New Roman) ///
fs(11) save(summary_hp_dist.doc) title(Summary of House Price of Urban Area and Distance from Metro Network)

xtsum $id $t $ylist $xlist


* 1 DID-Estimation
*drop did_near_station

*Regression Result of Research Design 1  (Logrithm form of variable already existed in Data Editor)

*gen l_house_price = ln(house_price)

*gen diff_near_metro = d_near_station*station_dist


set level 90
```

```
46 asdoc xtreg l_house_price station_dist if d_near_station == 1,  dec(4)font(Times
   New Roman) ///
47 fs(11) save(hp_inf_dist.doc) nest title(Research Design 1 : Effect of Distance From
    Metro on House Price) ///
48 cnames(Within_Metro_influence), replace
49
50 asdoc xtreg l_house_price station_dist if d_near_station == 0, dec(4)font(Times New
    Roman) ///
51 fs(11) save(hp_inf_dist.doc) nest title(Research Design 1 : Effect of Distance From
    Metro on House Price) ///
52 cnames(Away Influ_zone)
53
54 asdoc xtreg l_house_price station_dist d_near_station diff_near_metro, dec(4)font(
   Times New Roman) ///
55 fs(11) save(hp_inf_dist.doc) nest title(Research Design 1 : Effect of Distance From
    Metro on House Price) ///
56 cnames(Difference_metro_influence)
57
58 asdoc xtreg l_house_price station_dist d_near_station diff_near_metro, robust, dec(
   4)font(Times New Roman) ///
59  fs(11) save(hp_inf_dist.doc) nest title(Research Design 1 : Effect of Distance
   From Metro on House Price) ///
60  cnames(Difference_robust)
61
62
63 *2 Graphs for Regression Results:
64
65
66 *2A - Average House Price Trend with Distance from Metro Network in Residential
   Land Category D
67
68
69 twoway (lpoly house_price station_dist if d_near_station == 1 & D_res_zone_D == 1)
   ///
70 (lpoly house_price station_dist if d_near_station == 0 & D_res_zone_D == 1), ///
71 xline(0.73, lcolor(green)) xlabel(0.73 "Metro Influence Zone")
72
73
74 *2B- Average House Price Treand within and outside influence zone in all urban area
75
76 twoway (qfit house_price year if d_near_station == 1, lcolor(blue)) ///
77 (qfit house_price year if d_near_station == 0, lcolor(yellow)), xline(2015, lcolor(
   green)) ///
78 xlabel(2015 "Mid Year 2015")
79
80 *2C - Average House Price Trend within and outside influence Zone in Residential
   Land Category D
81
82 twoway (qfit house_price year if d_near_station == 1 & D_res_zone_D == 1, lcolor(
   blue)) ///
83 (qfit house_price year if d_near_station == 0 & D_res_zone_D == 1, lcolor(yellow)),
    ///
84 xline(2015, lcolor(green)) xlabel(2015 "Mid Year 2015")
85
86
87 ******************************** End of Research Design 1 Command
   ************************************************
```

```
**********************Reserach Design 2**********************

use "/Users/kaushal/Desktop/Final Thesis Work/data_file/res_land_price_thesis.dta"


**"District ID already existed in the Data Editor"
*egen district_id = group(district_name)

global id district_id
global t year

sort $id $t
xtset $id $t, delta(6)


** "Variables already existed in Data Editor"
*gen l_res_land_price = ln(res_land_price)
*gen l_population_density = ln(population_density)
*gen l_business_est = ln(business_est)
*gen l_workers = ln(workers)
*gen l_hospitals = ln(hospitals)
*gen l_colleges = ln(college)
*gen l_trips = ln(trips)


*xtdescribe

asdoc summarize res_land_price stations metro_length trips population_density ///
business_est workers hospitals college year, ///
stat(N mean sd min max), dec(4)font(Times New Roman) fs(11) save(summary_RD_2.doc)
///
 title(Summary of Variables of Research Design 2),replace



global ylist l_res_land_price
global xlist metro_length stations l_population_density l_business_est l_workers ///
l_hospitals l_college l_trips

asdoc xtsum $id $t $ylist $xlist, stat(N mean sd min max), dec(4)font(Times New
Roman) ///
 fs(11) save(summary_RD_2.doc) title(Summary of Variables of Research Design 2)


**1 Creation of Year Dummy (Already Generated in Data Editor)


*gen y1992=0
*replace y1992=1 if year==1992

*gen y1998=0
*replace y1998=1 if year==1998

*gen y2005=0
*replace y2005=1 if year==2005

*gen y2012=0
*replace y2012=1 if year==2012

*gen y2018=0
*replace y2018=1 if year==2018
```

```
/*2-Defining Treatment and Control Groups (Treatment Group = District are North East Delhi,
*East Delhi, West Delhi,New Delhi and South Delhi) and
(Control groups are North Delhi, North West Delhi,  Central Delhi, South West Delhi) */


/* 3 - Define treatment year as year after 1998 that is year 2005, 2012 and 2018
(Already Generated in Data Editor)*/

*gen treated_year = (year>1998)

*4 - generate interaction term for treatment of metro (Already Existed in Data Editor)
*gen  interection = treated_year*treated_district


*5 - Test For Endogeneity *****************

asdoc xtreg stations l_population_density l_business_est l_workers l_hospitals l_colleges, ///
dec(4) font(Times New Roman) fs(11) save(endogeneity_test.doc) nest title(Result of Endogeneity Test) ///
cnames(Reg_Stations ), replace

predict e1

asdoc xtreg l_res_land_price stations e1 l_population_density l_business_est l_workers l_hospitals l_colleges, ///
dec(4) font(Times New Roman) fs(11) save(endogeneity_test.doc) nest title(Result of Endogeneity Test) ///
cnames(Endogen_est)

/*asdoc xtreg l_res_land_price stations e1 l_population_density l_business_est l_workers l_hospitals l_colleges,
 dec(4) font(Times New Roman) fs(11) save(endogeneity_test.doc) title(Statistics of Endogeneity Test*/


*6 -  Hausman Test for testing Efficiency of RE and FE Model **************

/*H0 is that re is preferred model. Since p value is 0.014 < 0.05 hence we reject null and
hence fixed effect model is prefereed model.*/


asdoc xtreg l_res_land_price stations l_population_density l_business_est l_workers l_college l_hospitals,re, ///
dec(4) font(Times New Roman) fs(11) save(hausman_test.doc) ///
nest title(Result of Hausman Test to check  Random Effect and Fixed Effect Model Efficiency) cnames(Random effect ), replace

estimate store re

asdoc xtreg l_res_land_price stations l_population_density l_business_est l_workers l_college l_hospitals,fe, ///
dec(4) font(Times New Roman) fs(11) save(hausman_test.doc) ///
nest title(Result of Hausman Test to check  Random Effect and Fixed Effect Model Efficiency) cnames(Fixed effect )

estimate store fe

asdoc hausman fe re, dec(4) font(Times New Roman) fs(11) save(hausman_test.doc) ///
title(Result of Hausman Test to check  Random Effect and Fixed Effect Model Efficiency)


drop e1
drop _est_fe
drop _est_re
drop station_hat
```

```
/*7 - Regression Models with 1. GLS, 2. DID, 3. DiD Robust  4. IV Regression FE Model ,
5. 2SLS IV with Fixed Effect **********************/

asdoc xtreg stations metro_length l_trips l_population_density l_business_est l_workers l_college l_hospitals, ///
dec(4) font(Times New Roman) fs(11) save(research_design2.doc) ///
title( First Stage of Two Stage Instrument Variable Regression ) cnames(First Stage IV), fe, replace

predict station_hat

asdoc xtreg l_res_land_price treated_year treated_district interection, dec(4) font(Times New Roman) ///
fs(11) save(research_design2.doc) nest title(Results of Second Research Design, DiD method have treatment Year after 1998 ) ///
cnames(Dummy Only )

asdoc xtreg l_res_land_price treated_year treated_district  interection stations, dec(4) ///
font(Times New Roman) fs(11) save(research_design2.doc) ///
nest title(Results of Second Research Design, DiD method have treatment Year after 1998) cnames(DiD_Var_of_Interest)


asdoc xtreg l_res_land_price treated_year treated_district  interection stations l_population_density ///
l_business_est l_workers l_college l_hospitals,  dec(4) font(Times New Roman) fs(11) save(research_design2.doc) ///
nest title(Results of Second Research Design, DiD method have treatment Year after 1998) cnames(DiD_All_Var)

asdoc xtreg l_res_land_price treated_year treated_district  interection stations l_population_density l_business_est ///
l_workers l_college l_hospitals, robust,  dec(4) font(Times New Roman) fs(11) save(research_design2.doc) ///
nest title(Results of Second Research Design, DiD method have treatment Year after 1998) cnames(DiD_robust)

asdoc xtivreg l_res_land_price l_population_density l_business_est l_workers l_college l_hospitals ///
(stations = metro_length l_trips), fe, dec(4) font(Times New Roman) fs(11) ///
save(research_design2.doc) nest title( Results of Second Research Design, DiD method have treatment Year after 1998) ///
cnames(IV+Fixed Effect)


asdoc xtreg l_res_land_price station_hat l_population_density l_business_est l_workers l_college l_hospitals, fe, ///
dec(4) font(Times New Roman) fs(11) save(research_design2.doc) nest title( Results of Second Research Design, ///
DiD method have treatment Year after 1998) cnames(2SLS IV+Fixed Effect)

asdoc corr stations metro_length l_trips l_population_density l_business_est l_workers l_college l_hospitals,  ///
dec(4) font(Times New Roman) fs(11) save(corr_design2.doc) ///
title(Table 6.4 Correlation among Explanatary and Instrument Variables )

**********************
```

```
*8 Graphical Representation of the results:

* 8A - Diffference of residential land price trend in treatment and control group districts

twoway (lpoly res_land_price year if treated_district == 1, lcolor(blue)) ///
(lpoly res_land_price year if treated_district == 0, lcolor(yellow)), xline(2005, lcolor(green)) ///
 xlabel(2005 "Treatment Year 2005")


*8B - Trend of selected variables with year and best fit for  predicted station_hat

twoway  (lpoly l_res_land_price year, lcolor(red))  (lpoly stations year, lcolor(blue)) ///
(lpoly station_hat year, lcolor(green)) (lpoly metro_length year, lcolor(yellow)) ///
(lpoly l_trips year, lcolor(orange)), xline(2005, lcolor(black)) xlabel(2005 "Treatment Year")

twoway  (lfit res_land_price stations, lcolor(red))  (lfit res_land_price station_hat, lcolor(blue))

*****************************End of RD 2 Command **********************************
```

```
/* Research Design 3 - Correlation Between Average House Price and Residential
Land Price in Urban Area of Delhi */

 use "/Users/kaushal/Desktop/Final Thesis Work/data_file/rd3.dta"

 ** "ID already generated and existed in the Data Editor"
*egen urban_area_id = group(urban_area)

global id urban_area_id
global t year

global ylist house_price
global xlist station_dist d_near_station
sort $id $t
xtset $id $t, delta(3)


* 1 - Correaltion Between Average House Price and Residential Land Price Within
Influence Zone


asdoc corr res_land_price house_price if d_near_metro ==1, stat(N mean sd min max),
 ///
dec(4)font(Times New Roman) fs(11) save(summary_RD_3.doc) ///
title(Correlation of Residentail Land Price and House Price Witin Inflence Zone ),
replace


* 2 - Correlation between Average House Price and Residential Land Price Outside
Influence Zone
asdoc corr res_land_price house_price if d_near_metro ==0, stat(N mean sd min max),
 ///
dec(4)font(Times New Roman) fs(11) save(summary_RD_3.doc) ///
title(Correlation of Residentail Land Price and House Price Outside Inflence Zone )


/*3 Graphical Representation of the  Correlation between Average House Price and
Residential
Land Price Within and Outside Influence Zone */

twoway (qfit house_price  res_land_price  if d_near_metro ==1, lcolor(blue)) ///
 (qfit house_price  res_land_price  if d_near_metro ==0, lcolor(red))

****************************** End of RD 3 Commands
************************************
```

Summary of House Price of Urban Area and Distance from Metro Network

	N	Mean	St.Dev	min	max
house price	94	106000	50800	11300	413000
station dist	120	1.3573	.8185	.28	4
year	120	2015	2.4598	2012	2018

Summary of Variables of Research Design 2

	N	Mean	St.Dev	min	max
res land price	45	61500	84900	2550	420000
stations	45	8	11.4515	0	43
metro length	45	10.5429	15.9847	0	64.38
trips	45	1760000	913000	590198	5094846
population density	45	14200	10100	2217	43360
business est	45	83700	59200	4044	281705
workers	45	390000	190000	91624	895845
hospitals	45	10.4889	6.1297	2	26
college	45	12.9111	8.9235	1	34
year	45	2005	9.4436	1992	2018

Result of Endogeneity Test

	(1)	(2)
	Reg_Stations	Endogen_est
l_population_~y	0.5024	-0.3996*
	(2.2061)	(0.2250)
l_business_est	0.4130	0.4348*
	(2.7811)	(0.2629)
l_workers	3.1603	-0.7477
	(4.4375)	(0.7094)
l_hospitals	7.7903**	-0.6969
	(3.1601)	(1.7502)
l_colleges	1.0353	
	(2.2679)	
stations		0.0909***
		(0.0145)
e1		0.1371
		(0.1990)
_cons	-60.6684	18.0970
	(39.2198)	(11.9498)
Obs.	45	45
Pseudo R^2	.z	.z

Standard errors are in parenthesis
*** *p<0.01,* ** *p<0.05,* * *p<0.1*

Result of Hausman Test to check Random Effect And Fixed Effect Model Efficiency

	(1)	(2)
	Random_effect	Fixed_effect
stations	0.0909***	0.0722***
	(0.0145)	(0.0163)
l_population_~y	-0.3307*	2.0107
	(0.2000)	(1.4253)
l_business_est	0.4914*	-0.0875
	(0.2520)	(0.2592)
l_workers	-0.3146	-0.5381
	(0.4046)	(0.3835)
l_colleges	0.1419	0.3610
	(0.2060)	(0.7493)
l_hospitals	0.3708	0.7178
	(0.3078)	(0.5814)
_cons	9.7819***	-3.7859
	(3.6602)	(11.0116)
Obs.	45	45
R-squared	.z	0.8139

Standard errors are in parenthesis
*** *p<0.01,* ** *p<0.05,* * *p<0.1*

Result of Hausman Test to check Random Effect and Fixed Effect Model Efficiency

	Coef.
Chi-square test value	19.7337
P-value	.0031

Research Design 1 : Effect of Distance From Metro on House Price

	(1)	(2)	(3)	(4)
	Within_Metro_inf~e	Away_Influ_zone	Difference_metro~e	Difference_robust
station_dist	0.2457***	-0.1730	-0.1752*	-0.1752**
	(0.0644)	(0.1176)	(0.1063)	(0.0768)
d_near_station			-0.2190	-0.2190
			(0.2225)	(0.1878)
diff_near_metro			0.4896***	0.4896***
			(0.1597)	(0.0832)
_cons	11.5317***	11.6664***	11.6778***	11.6778***
	(0.0832)	(0.2107)	(0.1905)	(0.1600)
Obs.	34	60	94	94
Pseudo R^2	.z	.z	.z	.z

Standard errors are in parenthesis
**** p<0.01, ** p<0.05, * p<0.1*

First Stage of Two Stage Instrument Variable Regression

stations	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
metro_length	0.6525	0.0355	18.39	0.000	0.592	0.713	***
l_trips	3.8936	3.2369	1.20	0.239	-1.606	9.393	
l_population_density	-0.8217	4.4327	-0.19	0.854	-8.354	6.710	
l_business_est	-0.7763	0.6161	-1.26	0.218	-1.823	0.270	
l_workers	-0.6573	0.9164	-0.72	0.479	-2.214	0.900	
l_colleges	-1.1103	1.8071	-0.61	0.544	-4.181	1.960	
l_hospitals	1.4022	1.5998	0.88	0.388	-1.316	4.120	
Constant	-30.3397	30.9717	-0.98	0.335	-82.965	22.285	

Mean dependent var	8.0000	SD dependent var	11.4515
R-squared	0.9808	Number of obs	45.0000
F-test	211.8062	Prob > F	0.0000
Akaike crit. (AIC)	178.5029	Bayesian crit. (BIC)	192.9562

*** *p<0.01, ** p<0.05, * p<0.1*

Results of Second Research Design, DiD method have treatment Year after 1998

	(1)	(2)	(3)	(4)	(5)	(6)
	Dummy_Only	DiD_Var_of_Inter~t	DiD_All_Var	DiD_robust	IV+Fixed_Effect	2SLS_IV+Fixed_Ef~t
treated_year	1.7846***	0.9112**	0.4251	0.4251		
	(0.5643)	(0.4186)	(0.4859)	(0.5015)		
treated_distr~t	-0.2669	-0.2669	-0.7084	-0.7084		
	(0.5864)	(0.4124)	(0.4699)	(0.5746)		
interection	0.3319	-0.4251	-0.2453	-0.2453		
	(0.7571)	(0.5447)	(0.5367)	(0.4788)		
stations		0.0970***	0.0884***	0.0884***	0.0787***	
		(0.0148)	(0.0152)	(0.0115)	(0.0167)	
l_population_~y			-0.0257	-0.0257	1.6918	1.6918
			(0.2227)	(0.1337)	(1.4393)	(1.3703)
l_business_est			0.2059	0.2059	-0.0713	-0.0713
			(0.2605)	(0.1844)	(0.2600)	(0.2475)
l_workers			-0.4897	-0.4897***	-0.5319	-0.5319
			(0.3895)	(0.1793)	(0.3845)	(0.3661)
l_colleges			0.0481	0.0481	0.4861	0.4861
			(0.2002)	(0.1620)	(0.7542)	(0.7181)
l_hospitals			0.7062*	0.7062*	0.6580	0.6580
			(0.3717)	(0.4180)	(0.5838)	(0.5558)
station_hat						0.0787***
						(0.0159)
_cons	8.9547***	8.9547***	12.0744***	12.0744***	-1.2875	-1.2875
	(0.4371)	(0.3074)	(3.5468)	(1.3273)	(11.1222)	(10.5886)
Obs.	45	45	45	45	45	45
R-squared	.z	.z	.z	.z	.z	0.8304

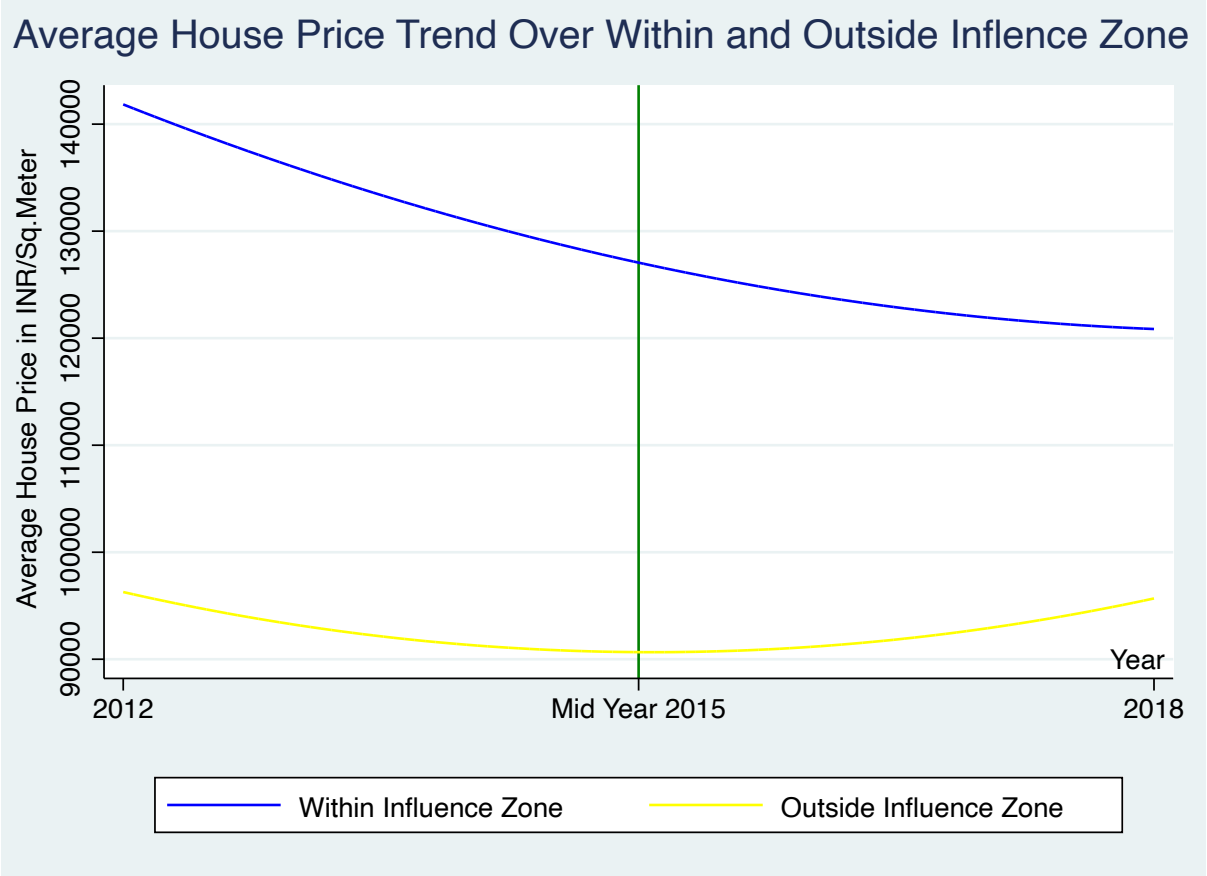
Standard errors are in parenthesis
*** *p<0.01, ** p<0.05, * p<0.1*

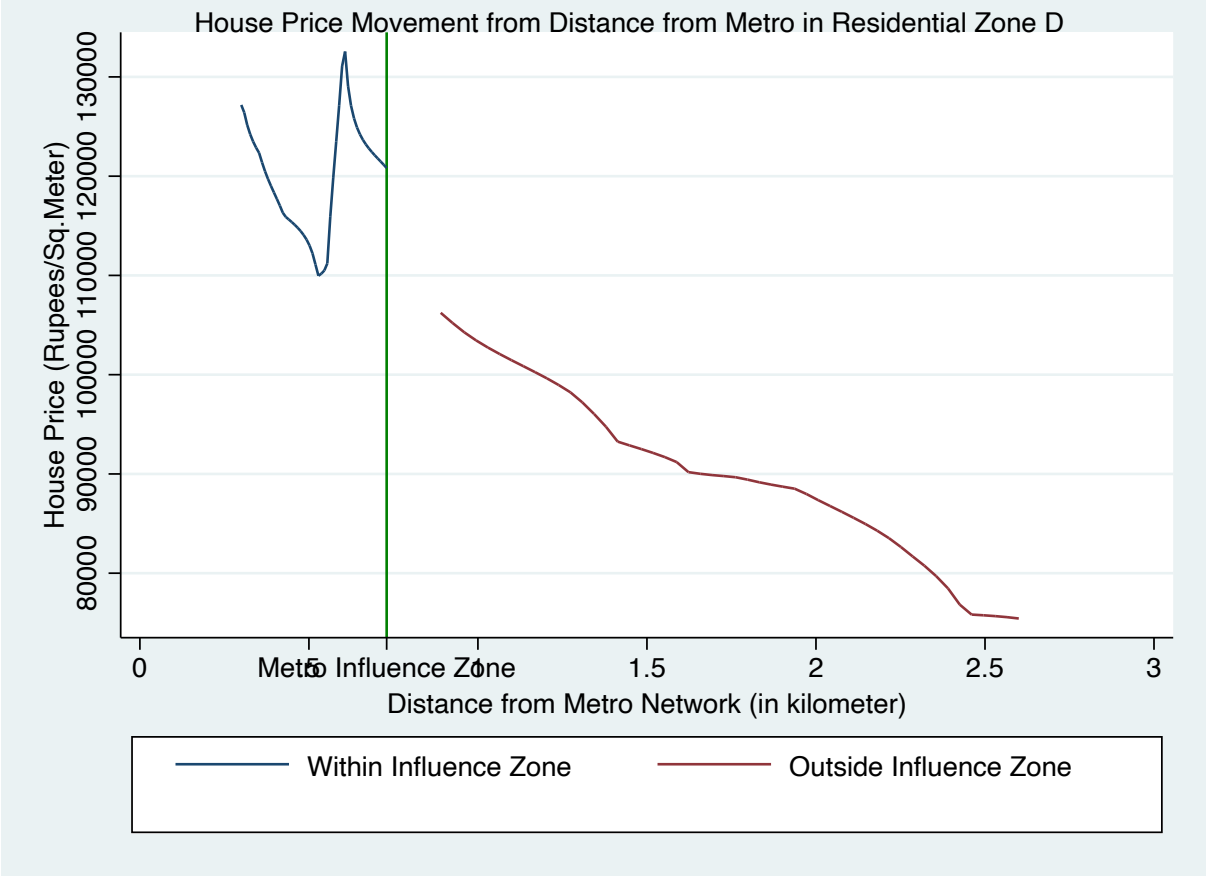
Correlation of Residential Land Price and House Price Within Influence Zone 0.73 Kilometer from metro

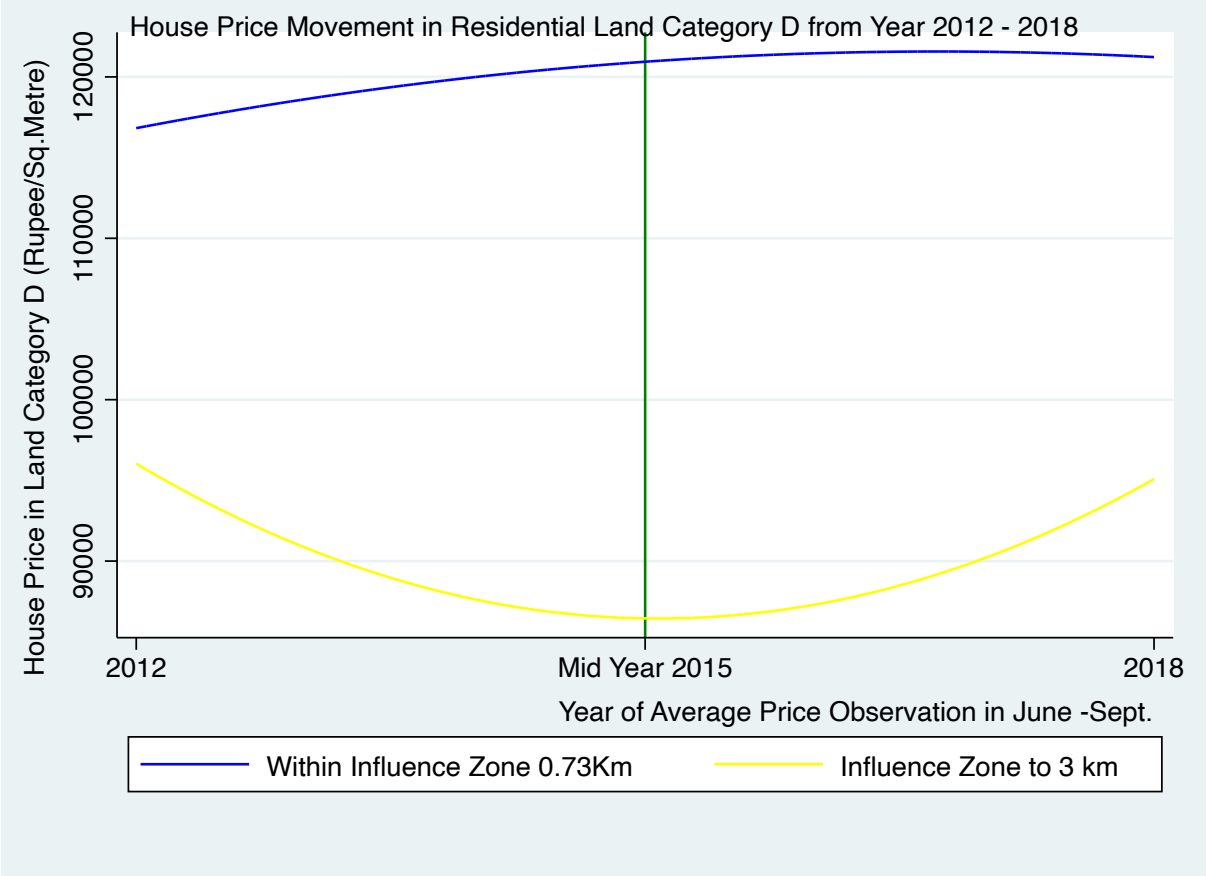
Variables	(1)	(2)
(1) res_land_price	1.0000	
(2) house_price	0.4162	1.0000

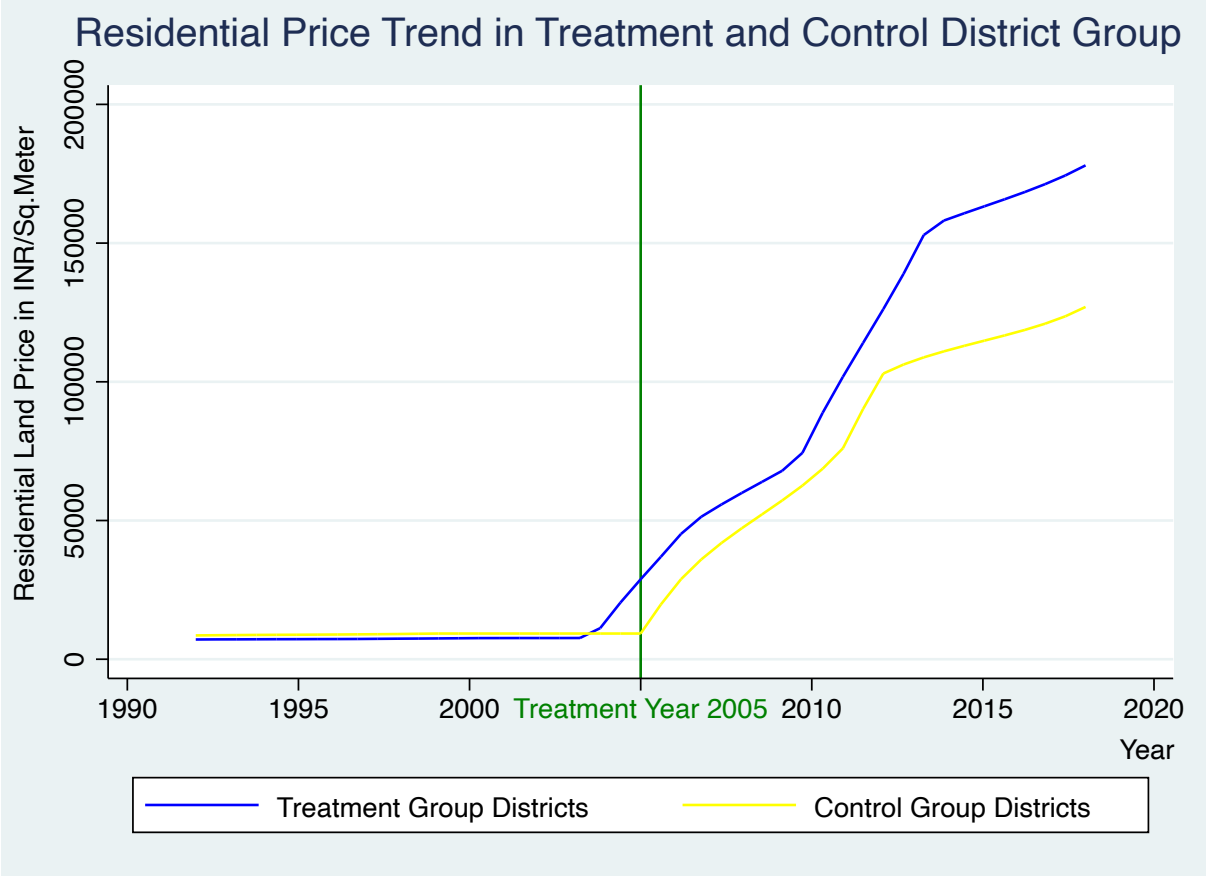
Correlation of Residential Land Price and House Price Outside Influence Zone 0.73 – 4.0 Kilometer from metro

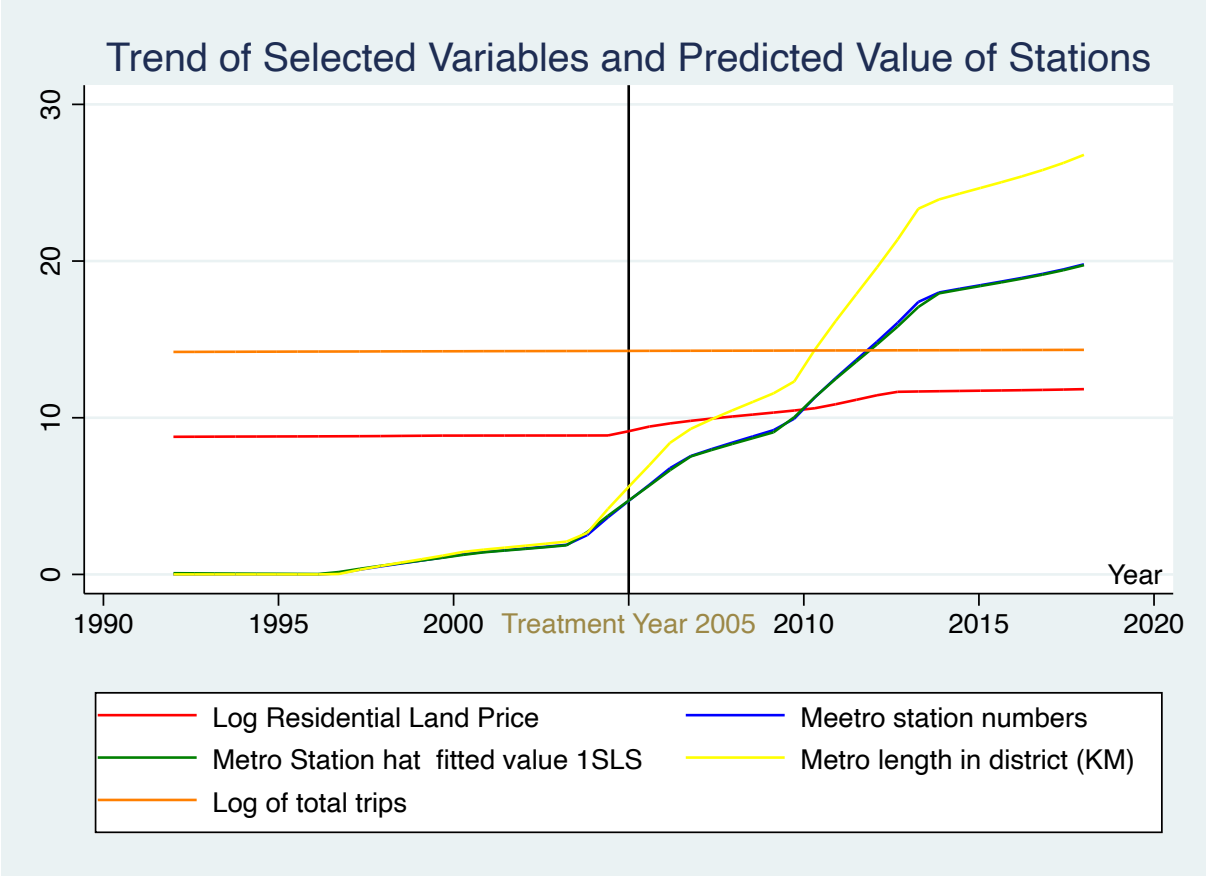
Variables	(1)	(2)
(1) res_land_price	1.0000	
(2) house_price	0.6398	1.0000

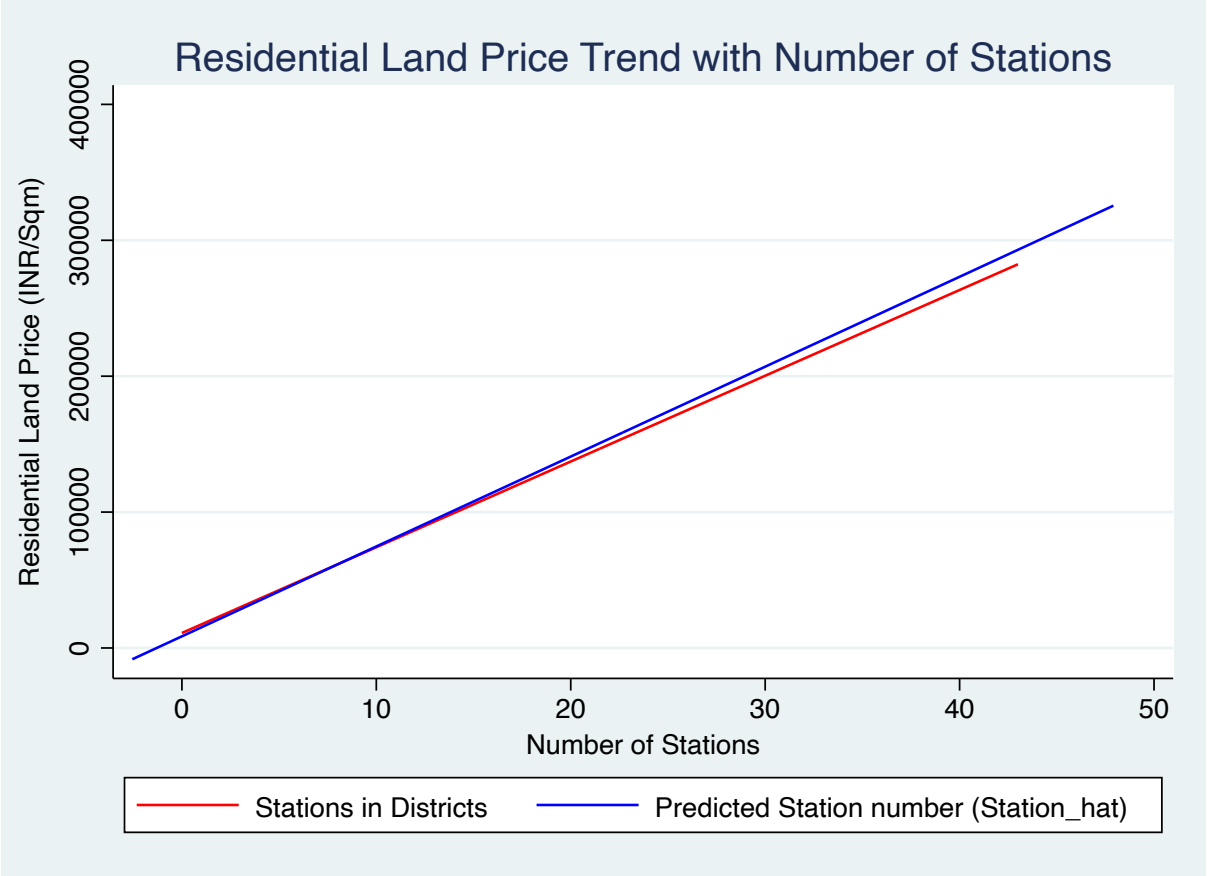

Average House Price Trend Over Within and Outside Inflence Zone
Average House Price in INR/Sq.Meter
90000
100000
110000
120000
130000
140000
Year
2012
Mid Year 2015
2018
Within Influence Zone
Outside Influence Zone

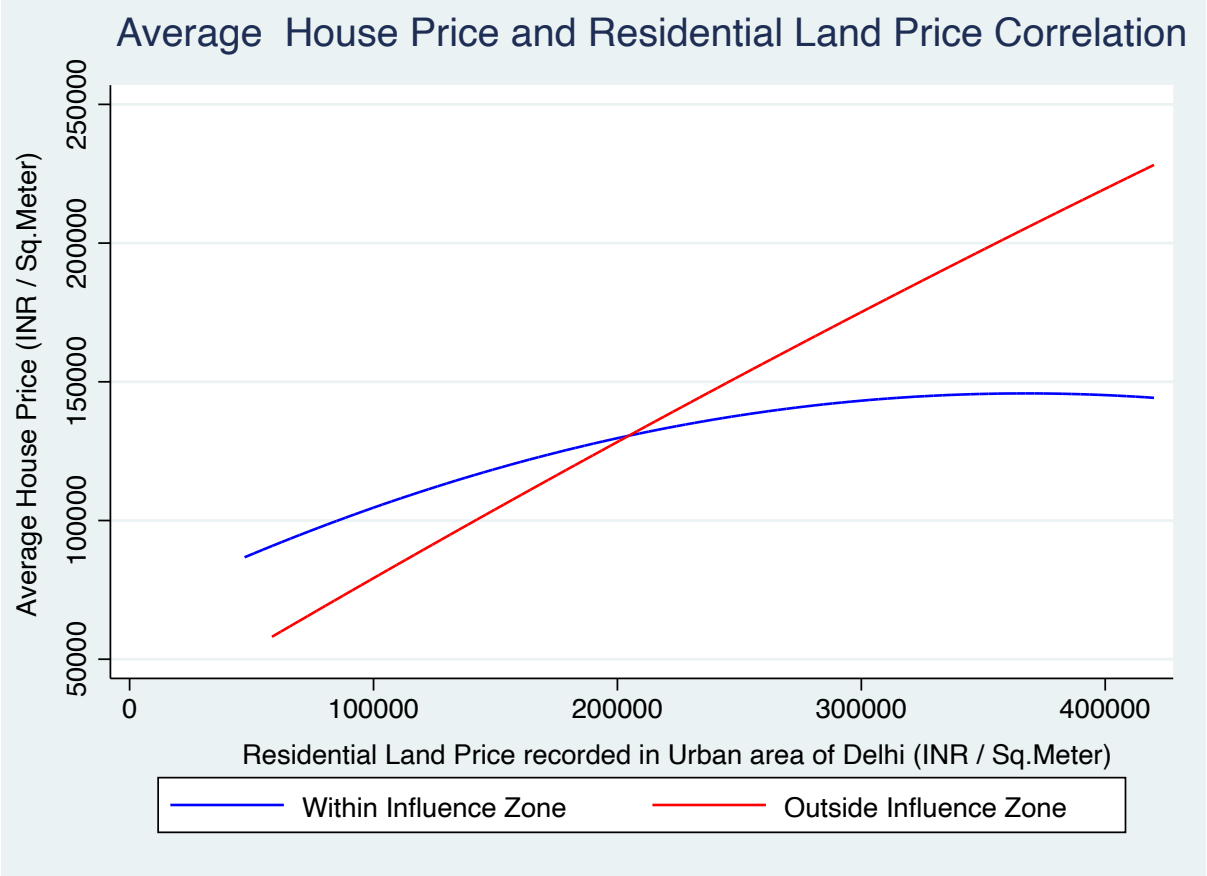

House Price Movement from Distance from Metro in Residential Zone D
House Price (Rupees/Sq.Meter)
80000
90000
100000
110000
120000
130000
0
.5
1
1.5
2
2.5
3
Metro Influence Zone
Distance from Metro Network (in kilometer)
Within Influence Zone
Outside Influence Zone


House Price Movement in Residential Land Category D from Year 2012 - 2018
House Price in Land Category D (Rupee/Sq.Metre)
90000
100000
110000
120000
2012
Mid Year 2015
2018
Year of Average Price Observation in June -Sept.
Within Influence Zone 0.73Km
Influence Zone to 3 km


Residential Price Trend in Treatment and Control District Group
Residential Land Price in INR/Sq.Meter
0
50000
100000
150000
200000
1990
1995
2000
Treatment Year 2005
2010
2015
2020
Year
Treatment Group Districts
Control Group Districts


Trend of Selected Variables and Predicted Value of Stations
0
10
20
30
1990
1995
2000
Treatment Year 2005
2010
2015
2020
Year
Log Residential Land Price
Meetro station numbers
Metro Station hat fitted value 1SLS
Metro length in district (KM)
Log of total trips


Residential Land Price Trend with Number of Stations
Residential Land Price (INR/Sqm)
0
100000
200000
300000
400000
0
10
20
30
40
50
Number of Stations
Stations in Districts
Predicted Station number (Station_hat)


Average House Price and Residential Land Price Correlation
Average House Price (INR / Sq.Meter)
50000
100000
150000
200000
250000
0
100000
200000
300000
400000
Residential Land Price recorded in Urban area of Delhi (INR / Sq.Meter)
Within Influence Zone
Outside Influence Zone

	urban_area	year	house_price	station_dist	d_near_sta~n	D_res_zone_D	urban_area~d	l_house_pr~e	diff_near_~o
1	Alaknanda	2012	137244	2.22	0	0	1	11.82952	0
2	Alaknanda	2015	152336	2.22	0	0	1	11.93384	0
3	Alaknanda	2018	122142	1.76	0	0	1	11.71294	0
4	Anand Niketan	2012	.	1.87	0	0	2	.	0
5	Anand Niketan	2015	.	1.87	0	0	2	.	0
6	Anand Niketan	2018	239203	1.27	0	0	2	12.38507	0
7	Chandni Chowk	2012	.	.28	1	0	3	.	.28
8	Chandni Chowk	2015	.	.28	1	0	3	.	.28
9	Chandni Chowk	2018	119602	.28	1	0	3	11.69192	.28
10	Darya Gunj	2012	.	.39	1	0	4	.	.39
11	Darya Gunj	2015	.	.39	1	0	4	.	.39
12	Darya Gunj	2018	124941	.39	1	0	4	11.7356	.39
13	Dilshad Garden	2012	.	.97	1	0	5	.	.97
14	Dilshad Garden	2015	72605	.97	0	0	5	11.19279	0
15	Dilshad Garden	2018	69989.2	.97	0	0	5	11.1561	0
16	Dwarka Sector 10	2012	83261.6	1.1	0	1	6	11.32974	0
17	Dwarka Sector 10	2015	83713.7	1.1	0	1	6	11.33516	0
18	Dwarka Sector 10	2018	84176.5	1.1	0	1	6	11.34067	0
19	Dwarka Sector 19B	2012	.	2.6	0	1	7	.	0
20	Dwarka Sector 19B	2015	.	2.6	0	1	7	.	0
21	Dwarka Sector 19B	2018	84176.5	2.6	0	1	7	11.34067	0
22	Dwarka Sector 6	2012	82346.6	2.3	0	1	8	11.31869	0
23	Dwarka Sector 6	2015	83261.6	2.3	0	1	8	11.32974	0
24	Dwarka Sector 6	2018	82798.7	2.3	0	1	8	11.32417	0
25	Dwarka Sector 7	2012	80516.7	1.9	0	1	9	11.29622	0
26	Dwarka Sector 7	2015	86006.5	1.9	0	1	9	11.36218	0
27	Dwarka Sector 7	2018	80516.7	1.9	0	1	9	11.29622	0
28	Geeta Colony	2012	57050.6	1.8	0	0	10	10.95169	0
29	Geeta Colony	2015	62432.7	1.8	0	0	10	11.04184	0
30	Geeta Colony	2018	65662	1.8	0	0	10	11.09228	0
31	Jagatpuri	2012	.	1.1	0	0	11	.	0
32	Jagatpuri	2015	.	1.1	0	0	11	.	0
33	Jagatpuri	2018	48439.2	1.1	0	0	11	10.78806	0
34	Janakpuri West	2012	107503	.73	1	1	12	11.58527	.73
35	Janakpuri West	2015	102013	.73	1	1	12	11.53286	.73
36	Janakpuri West	2018	98353.1	.73	1	1	12	11.49632	.73
37	Kalkaji	2012	116200	.66	1	0	13	11.66307	.66
38	Kalkaji	2015	118407	.66	1	0	13	11.68188	.66
39	Kalkaji	2018	76394	.45	1	0	13	11.24366	.45
40	Kalkaji Ext	2012	.	1.23	0	0	14	.	0
41	Kalkaji Ext	2015	104306	1.23	0	0	14	11.55508	0
42	Kalkaji Ext	2018	90118.4	1.23	0	0	14	11.40888	0
43	Laxmi Nagar	2012	45748.1	1.5	0	0	15	10.73091	0
44	Laxmi Nagar	2015	60839.6	1.5	0	0	15	11.016	0
45	Laxmi Nagar	2018	56727.7	1.5	0	0	15	10.94602	0
46	Mandawali	2012	.	2.37	0	0	16	.	0
47	Mandawali	2015	.	2.37	0	0	16	.	0
48	Mandawali	2018	51991.4	2.37	0	0	16	10.85883	0
49	Mayur Vihar Phase I	2012	91496.2	.43	1	1	17	11.42405	.43
50	Mayur Vihar Phase I	2015	118482	.43	1	1	17	11.68252	.43
51	Mayur Vihar Phase I	2018	112078	.43	1	1	17	11.62695	.43
52	Model Town Phase II	2012	.	.72	1	1	18	.	.72
53	Model Town Phase II	2015	120312	.72	1	1	18	11.69785	.72
54	Model Town Phase II	2018	139989	.72	1	1	18	11.84932	.72
55	Model Town Phase III	2012	121690	.48	1	1	19	11.70923	.48
56	Model Town Phase III	2015	110248	.48	1	1	19	11.61048	.48
57	Model Town Phase III	2018	101561	.48	1	1	19	11.52841	.48
58	Moti Bagh	2012	.	1.37	1	0	20	.	1.37
59	Moti Bagh	2015	.	1.37	1	0	20	.	1.37
60	Moti Bagh	2018	99668.7	.68	1	0	20	11.50961	.68
61	Mukherjee Nagar (Outram Line)	2012	132400	.4	1	1	21	11.79359	.4
62	Mukherjee Nagar (Outram Line)	2015	123789	.4	1	1	21	11.72633	.4
63	Mukherjee Nagar (Outram Line)	2018	131755	.4	1	1	21	11.7887	.4
64	Nehru Enclave (C R Park)	2012	147761	1.42	0	0	22	11.90335	0
65	Nehru Enclave (C R Park)	2015	166975	1.42	0	0	22	12.0256	0
66	Nehru Enclave (C R Park)	2018	132207	.69	1	0	22	11.79212	.69
67	Pahar Gunj	2012	.	1.1	0	0	23	.	0
68	Pahar Gunj	2015	69967.7	1.1	0	0	23	11.15579	0
69	Pahar Gunj	2018	71582.3	1.1	0	0	23	11.1786	0
70	Paschim Vihar	2012	118482	1.1	0	1	24	11.68252	0
71	Paschim Vihar	2015	111625	1.1	0	1	24	11.6229	0
72	Paschim Vihar	2018	114370	1.1	0	1	24	11.6472	0
73	Patpadganj	2012	87836.4	1.1	0	1	25	11.38323	0
74	Patpadganj	2015	113455	1.1	0	1	25	11.63916	0
75	Patpadganj	2018	102013	1.1	0	1	25	11.53286	0

	urban_area	year	house_price	station_dist	d_near_sta~n	D_res_zone_D	urban_area~d	l_house_pr~e	diff_near_~o
76	Pitampura	2012	133122	.89	0	1	26	11.79902	0
77	Pitampura	2015	114822	.89	0	1	26	11.65114	0
78	Pitampura	2018	139526	.89	0	1	26	11.84601	0
79	Preet Vihar	2012	118407	.3	1	1	27	11.68188	.3
80	Preet Vihar	2015	138159	.3	1	1	27	11.83616	.3
81	Preet Vihar	2018	122605	.3	1	1	27	11.71672	.3
82	Punjabi Bagh	2012	129462	.68	1	1	28	11.77114	.68
83	Punjabi Bagh	2015	133585	.68	1	1	28	11.80249	.68
84	Punjabi Bagh	2018	142271	.68	1	1	28	11.86549	.68
85	Rana Pratap Bagh Asok Vihar	2012	129117	1.81	0	1	29	11.76848	0
86	Rana Pratap Bagh Asok Vihar	2015	11254	1.81	0	1	29	9.328482	0
87	Rana Pratap Bagh Asok Vihar	2018	117869	1.81	0	1	29	11.67733	0
88	Rohini Sector 23	2012	.	2.47	0	1	30	.	0
89	Rohini Sector 23	2015	59472.6	2.47	0	1	30	10.99327	0
90	Rohini Sector 23	2018	66329.4	2.47	0	1	30	11.10239	0
91	Rohini Sector 24	2012	79138.9	2.11	0	1	31	11.27896	0
92	Rohini Sector 24	2015	73197	2.11	0	1	31	11.20091	0
93	Rohini Sector 24	2018	73649.1	2.11	0	1	31	11.20707	0
94	SFS New Kondli Mayur Vihar Phase III	2012	76394	1.93	0	1	32	11.24366	0
95	SFS New Kondli Mayur Vihar Phase III	2015	88288.5	1.93	0	1	32	11.38836	0
96	SFS New Kondli Mayur Vihar Phase III	2018	81883.7	1.22	0	1	32	11.31306	0
97	Sadar Bazar	2012	.	.73	1	0	33	.	.73
98	Sadar Bazar	2015	.	.73	1	0	33	.	.73
99	Sadar Bazar	2018	152487	.73	1	0	33	11.93483	.73
100	Shahdara	2012	46663.1	.39	1	0	34	10.75071	.39
101	Shahdara	2015	50775	.39	1	0	34	10.83516	.39
102	Shahdara	2018	49860.1	.39	1	0	34	10.81698	.39
103	Shalimar Bagh	2012	101561	1.75	0	1	35	11.52841	0
104	Shalimar Bagh	2015	92863.3	1.75	0	1	35	11.43888	0
105	Shalimar Bagh	2018	91496.2	1.29	0	1	35	11.42405	0
106	Sonia Vihar	2012	.	4	0	0	36	.	0
107	Sonia Vihar	2015	.	4	0	0	36	.	0
108	Sonia Vihar	2018	49429.5	4	0	0	36	10.8083	0
109	Sunder Vihar	2012	.	1.92	0	1	37	.	0
110	Sunder Vihar	2015	114370	1.92	0	1	37	11.6472	0
111	Sunder Vihar	2018	129462	1.92	0	1	37	11.77114	0
112	Vasant Enclave	2012	.	2.14	0	0	38	.	0
113	Vasant Enclave	2015	.	2.14	0	0	38	.	0
114	Vasant Enclave	2018	195705	1.69	0	0	38	12.18436	0
115	Vasant Vihar	2012	412777	2.87	1	0	39	12.93066	2.87
116	Vasant Vihar	2015	254812	2.87	1	0	39	12.44828	2.87
117	Vasant Vihar	2018	209064	.41	1	0	39	12.25039	.41
118	Vikaspuri	2012	84628.6	1.42	0	1	40	11.34603	0
119	Vikaspuri	2015	91496.2	1.42	0	1	40	11.42405	0
120	Vikaspuri	2018	82798.7	1.42	0	1	40	11.32417	0

	district_name	year	res_land_p~e	metro_length	stations	population~y	business_est	workers	hospitals	college	trips	treated_di~t	district_id	l_res_land~e	l_populati~y	l_business~t	l_workers	l_hospitals	l_colleges	l_trips	y1992	y1998	y2005	y2012	y2018	treated_year	interection	station_hat
1	Central Delhi	1992	16800	0	0	16007	23870	173580	3	15	1.2e+06	0	1	9.729135	9.680781	10.08038	12.06439	1.098612	2.70805	13.98479	1	0	0	0	0	0	0	-1.066309
2	Central Delhi	1998	18480	0	0	16565	67213	343085	5	15	1.5e+06	0	1	9.824445	9.715047	11.11562	12.74573	1.609438	2.70805	14.1885	0	1	0	0	0	0	0	-.8365688
3	Central Delhi	2005	18480	12.06	12	17024	80587	360369	6	15	1.9e+06	0	1	9.824445	9.742379	11.29709	12.79488	1.791759	2.70805	14.43291	0	0	1	0	0	1	0	8.04393
4	Central Delhi	2012	58400	12.06	12	17575	150671	599058	6	15	2.4e+06	0	1	10.97507	9.774233	11.92285	13.30311	1.791759	2.70805	14.68547	0	0	0	1	0	1	0	8.18127
5	Central Delhi	2018	90000	15.44	16	20075	281705	548709	6	16	3.0e+06	0	1	11.40757	9.90723	12.54862	13.21532	1.791759	2.772589	14.90916	0	0	0	0	1	1	0	10.64853
6	East Delhi	1992	2550	0	0	17316	28281	185135	4	4	795776	1	2	7.843849	9.759386	10.24995	12.12884	1.386294	1.386294	13.58707	1	0	0	0	0	0	0	-.982475
7	East Delhi	1998	2805	0	0	21307	71688	365923	8	6	1.0e+06	1	2	7.939159	9.966791	11.18008	12.81018	2.079442	1.791759	13.85282	0	1	0	0	0	0	0	-.7664239
8	East Delhi	2005	3073	0	0	24673	95479	384357	11	8	1.4e+06	1	2	8.03041	10.11346	11.46666	12.85933	2.397895	2.079442	14.16528	0	0	1	0	0	1	1	.2019541
9	East Delhi	2012	106400	11.97	10	27137	80061	215979	15	8	1.9e+06	1	2	11.57496	10.20865	11.29054	12.28294	2.70805	2.079442	14.48125	0	0	0	1	0	1	1	10.11467
10	East Delhi	2018	150000	25.57	19	30997	67133	585234	15	8	2.6e+06	1	2	11.91839	10.34165	11.11443	13.27977	2.70805	2.079442	14.75559	0	0	0	0	1	1	1	19.42875
11	New Delhi	1992	12600	0	0	2217	4044	91624	14	29	1.8e+06	1	3	9.441452	7.70391	8.30499	11.42545	2.639057	3.367296	14.41975	1	0	0	0	0	0	0	5.478034
12	New Delhi	1998	13860	0	0	3427	35478	181097	16	30	2.3e+06	1	3	9.536762	8.139441	10.47667	12.10679	2.772589	3.401197	14.6514	0	1	0	0	0	0	0	4.037892
13	New Delhi	2005	13860	3.65	4	3703	13654	190220	17	32	3.0e+06	1	3	9.536762	8.216899	9.521788	12.15594	2.833213	3.465736	14.92443	0	0	1	0	0	1	1	8.141208
14	New Delhi	2012	204600	33.55	20	3632	38153	269225	19	34	4.0e+06	1	3	12.22881	8.197538	10.54936	12.5033	2.944439	3.526361	15.2017	0	0	0	1	0	1	1	27.8084
15	New Delhi	2018	420000	64.38	38	4148	106610	289635	19	34	5.1e+06	1	3	12.94801	8.330381	11.57693	12.57638	2.944439	3.526361	15.44374	0	0	0	0	1	1	1	47.91176
16	North Delhi	1992	5300	0	0	2639	21263	167396	3	1	978987	0	4	8.575462	7.878155	9.964724	12.02812	1.098612	0	13.79427	1	0	0	0	0	0	0	2.793657
17	North Delhi	1998	5830	0	0	3411	64819	330863	4	1	1.2e+06	0	4	8.670773	8.134761	11.07935	12.70946	1.386294	0	14.00791	0	1	0	0	0	0	0	2.504822
18	North Delhi	2005	5830	0	0	4265	71785	347531	6	3	1.6e+06	0	4	8.670773	8.358197	11.18143	12.75861	1.791759	1.098612	14.25789	0	0	1	0	0	1	0	2.531691
19	North Delhi	2012	106400	6.36	5	4939	73724	318960	7	3	2.0e+06	0	4	11.57496	8.504918	11.20808	12.67282	1.94591	1.098612	14.50988	0	0	0	1	0	1	0	7.793863
20	North Delhi	2018	150000	15.09	10	5642	75715	529162	10	3	2.5e+06	0	4	11.91839	8.637994	11.23473	13.17905	2.302585	1.098612	14.72844	0	0	0	0	1	1	0	14.37833
21	North East Delhi	1992	2550	0	0	20349	28885	218253	3	2	590198	1	5	7.843849	9.920787	10.27108	12.29341	1.098612	.6931472	13.28821	1	0	0	0	0	0	0	-2.037079
22	North East Delhi	1998	2805	0	0	27134	84511	431381	4	3	773261	1	5	7.939159	10.20854	11.34464	12.97475	1.386294	1.098612	13.55837	0	1	0	0	0	0	0	-2.549765
23	North East Delhi	2005	3073	6.36	4	33378	97518	453113	7	5	1.1e+06	1	5	8.03041	10.41565	11.48779	13.0239	1.94591	1.609438	13.87646	0	0	1	0	0	1	1	2.742376
24	North East Delhi	2012	47200	9.51	7	37960	158335	412976	10	6	1.5e+06	1	5	10.76215	10.54429	11.97247	12.93114	2.302585	1.791759	14.19854	0	0	0	1	0	1	1	5.928402
25	North East Delhi	2018	63000	18.68	14	43360	257080	689924	12	6	1.9e+06	1	5	11.05089	10.67729	12.45714	13.44434	2.484907	1.791759	14.47845	0	0	0	0	1	1	1	12.43427
26	North West Delhi	1992	5300	0	0	11787	38825	255475	3	8	827549	0	6	8.575462	9.374752	10.56682	12.45088	1.098612	2.079442	13.62622	1	0	0	0	0	0	0	-2.144663
27	North West Delhi	1998	5830	0	0	11825	98925	504952	12	12	1.0e+06	0	6	8.670773	9.377972	11.50212	13.13222	2.484907	2.484907	13.84814	0	1	0	0	0	0	0	-.9635186
28	North West Delhi	2005	5830	8.82	8	13374	131075	530390	15	16	1.3e+06	0	6	8.670773	9.501068	11.78352	13.18137	2.70805	2.772589	14.10683	0	0	1	0	0	1	0	5.440108
29	North West Delhi	2012	106400	12.45	11	15151	93297	286189	18	22	1.7e+06	0	6	11.57496	9.625822	11.44354	12.56441	2.890372	3.091043	14.36638	0	0	0	1	0	1	0	9.288196
30	North West Delhi	2018	150000	17.19	12	17306	66407	807589	19	23	2.2e+06	0	6	11.91839	9.758808	11.10356	13.60181	2.944439	3.135494	14.5904	0	0	0	0	1	1	0	12.75243
31	South Delhi	1992	8400	0	0	6613	31042	283394	8	15	1.1e+06	1	7	9.035987	8.796793	10.3431	12.55459	2.079442	2.70805	13.91655	1	0	0	0	0	0	0	.243554
32	South Delhi	1998	9240	0	0	8428	109735	560135	14	15	1.4e+06	1	7	9.131297	9.039315	11.60582	13.23593	2.639057	2.70805	14.17264	0	1	0	0	0	0	0	.3979112
33	South Delhi	2005	9240	0	0	9981	104800	588353	19	16	1.9e+06	1	7	9.131297	9.208439	11.55981	13.28508	2.944439	2.772589	14.47422	0	0	1	0	0	1	1	1.793139
34	South Delhi	2012	133200	37.1	27	11103	57126	145304	24	17	2.6e+06	1	7	11.79961	9.314971	10.95301	11.88658	3.178054	2.833213	14.77982	0	0	0	1	0	1	1	28.75301
35	South Delhi	2018	250000	58.28	43	12682	31139	895845	26	17	3.4e+06	1	7	12.42922	9.447939	10.34622	13.70552	3.258096	2.833213	15.04572	0	0	0	0	1	1	1	42.88629
36	South West Delhi	1992	6300	0	0	3268	18218	140896	2	3	775527	0	8	8.748305	8.091933	9.810165	11.85578	.6931472	1.098612	13.5613	1	0	0	0	0	0	0	.1557785
37	South West Delhi	1998	6930	0	0	4060	54557	278484	3	7	960041	0	8	8.843616	8.308938	10.907	12.53712	1.098612	1.94591	13.77473	0	1	0	0	0	0	0	-.8631236
38	South West Delhi	2005	6930	0	0	5066	61506	292513	4	8	1.2e+06	0	8	8.843616	8.530307	11.02689	12.58626	1.386294	2.079442	14.02517	0	0	1	0	0	1	0	.0598164
39	South West Delhi	2012	106400	14.18	11	5901	117215	458516	11	16	1.6e+06	0	8	11.57496	8.682878	11.67177	13.03575	2.397895	2.772589	14.27844	0	0	0	1	0	1	0	10.02547
40	South West Delhi	2018	150000	14.18	11	6741	223382	445390	13	18	2.0e+06	0	8	11.91839	8.815964	12.31664	13.00671	2.564949	2.890372	14.4988	0	0	0	0	1	1	0	10.39601
41	West Delhi	1992	8400	0	0	12179	30017	255475	6	8	822428	1	9	9.035987	9.407469	10.30952	12.45088	1.791759	2.079442	13.62002	1	0	0	0	0	0	0	-1.024021
42	West Delhi	1998	9240	0	0	15368	98925	504952	8	11	1.0e+06	1	9	9.131297	9.640042	11.50212	13.13222	2.079442	2.397895	13.85011	0	1	0	0	0	0	0	-1.643146
43	West Delhi	2005	9240	0	0	18073	101339	530390	10	14	1.4e+06	1	9	9.131297	9.802175	11.52623	13.18137	2.302585	2.639057	14.11962	0	0	1	0	0	1	1	-.7329292
44	West Delhi	2012	106400	29.4	27	20032	106726	313574	13	16	1.8e+06	1	9	11.57496	9.905087	11.57802	12.65579	2.564949	2.772589	14.39144	0	0	0	1	0	1	1	19.94862
45	West Delhi	2018	150000	48.15	39	22881	112399	807589	14	17	2.3e+06	1	9	11.91839	10.03806	11.62981	13.60181	2.639057	2.833213	14.62721	0	0	0	0	1	1	1	32.36588

	urban_area	year	house_price	res_land_p~e	dist_metro	d_near_metro	urban_area~d
1	Alaknanda	2012	137244	133224	2.22	0	1
2	Alaknanda	2015	152336	250000	2.22	0	1
3	Alaknanda	2018	122142	250000	1.76	0	1
4	Anand Niketan	2012	.	204600	1.87	0	2
5	Anand Niketan	2015	.	420000	1.87	0	2
6	Anand Niketan	2018	239203	420000	1.27	0	2
7	Chandni Chowk	2012	.	58365	.28	1	3
8	Chandni Chowk	2015	.	70070	.28	1	3
9	Chandni Chowk	2018	119602	90000	.28	1	3
10	Darya Gunj	2012	.	58365	.39	1	4
11	Darya Gunj	2015	.	70070	.39	1	4
12	Darya Gunj	2018	124941	90000	.39	1	4
13	Dilshad Garden	2012	.	47140	.97	0	5
14	Dilshad Garden	2015	72605	63000	.97	0	5
15	Dilshad Garden	2018	69989.2	63000	.97	0	5
16	Dwarka Sector 10	2012	83261.6	106384	1.1	0	6
17	Dwarka Sector 10	2015	83713.7	150000	1.1	0	6
18	Dwarka Sector 10	2018	84176.5	150000	1.1	0	6
19	Dwarka Sector 19B	2012	.	106384	2.6	0	7
20	Dwarka Sector 19B	2015	.	150000	2.6	0	7
21	Dwarka Sector 19B	2018	84176.5	150000	2.6	0	7
22	Dwarka Sector 6	2012	82346.6	106384	2.3	0	8
23	Dwarka Sector 6	2015	83261.6	150000	2.3	0	8
24	Dwarka Sector 6	2018	82798.7	150000	2.3	0	8
25	Dwarka Sector 7	2012	80516.7	106384	1.9	0	9
26	Dwarka Sector 7	2015	86006.5	150000	1.9	0	9
27	Dwarka Sector 7	2018	80516.7	150000	1.9	0	9
28	Geeta Colony	2012	57050.6	58365	1.8	0	10
29	Geeta Colony	2015	62432.7	70070	1.8	0	10
30	Geeta Colony	2018	65662	90000	1.8	0	10
31	Jagatpuri	2012	.	47140	1.1	0	11
32	Jagatpuri	2015	.	63000	1.1	0	11
33	Jagatpuri	2018	48439.2	63000	1.1	0	11
34	Janakpuri West	2012	107503	106384	.73	1	12
35	Janakpuri West	2015	102013	150000	.73	1	12
36	Janakpuri West	2018	98353.1	150000	.73	1	12
37	Kalkaji	2012	116200	133224	.66	1	13
38	Kalkaji	2015	118407	250000	.66	1	13
39	Kalkaji	2018	76394	250000	.45	1	13
40	Kalkaji Ext	2012	.	133224	1.23	0	14
41	Kalkaji Ext	2015	104306	250000	1.23	0	14
42	Kalkaji Ext	2018	90118.4	250000	1.23	0	14
43	Laxmi Nagar	2012	45748.1	58365	1.5	0	15
44	Laxmi Nagar	2015	60839.6	70070	1.5	0	15
45	Laxmi Nagar	2018	56727.7	90000	1.5	0	15
46	Mandawali	2012	.	47140	2.37	0	16
47	Mandawali	2015	.	63000	2.37	0	16
48	Mandawali	2018	51991.4	63000	2.37	0	16
49	Mayur Vihar Phase I	2012	91496.2	106384	.43	1	17
50	Mayur Vihar Phase I	2015	118482	150000	.43	1	17
51	Mayur Vihar Phase I	2018	112078	150000	.43	1	17
52	Model Town Phase II	2012	.	106384	.72	1	18
53	Model Town Phase II	2015	120312	150000	.72	1	18
54	Model Town Phase II	2018	139989	150000	.72	1	18
55	Model Town Phase III	2012	121690	106384	.48	1	19
56	Model Town Phase III	2015	110248	150000	.48	1	19
57	Model Town Phase III	2018	101561	150000	.48	1	19
58	Moti Bagh	2012	.	204600	1.37	0	20
59	Moti Bagh	2015	.	420000	1.37	0	20
60	Moti Bagh	2018	99668.7	420000	.68	1	20
61	Mukherjee Nagar (Outram Line)	2012	132400	106384	.4	1	21
62	Mukherjee Nagar (Outram Line)	2015	123789	150000	.4	1	21
63	Mukherjee Nagar (Outram Line)	2018	131755	150000	.4	1	21
64	Nehru Enclave (C R Park)	2012	147761	133224	1.42	0	22
65	Nehru Enclave (C R Park)	2015	166975	250000	1.42	0	22
66	Nehru Enclave (C R Park)	2018	132207	250000	.69	1	22
67	Pahar Gunj	2012	.	58365	1.1	0	23
68	Pahar Gunj	2015	69967.7	70070	1.1	0	23
69	Pahar Gunj	2018	71582.3	90000	1.1	0	23
70	Paschim Vihar	2012	118482	106384	1.1	0	24
71	Paschim Vihar	2015	111625	150000	1.1	0	24
72	Paschim Vihar	2018	114370	150000	1.1	0	24
73	Patpadganj	2012	87836.4	106384	1.1	0	25
74	Patpadganj	2015	113455	150000	1.1	0	25
75	Patpadganj	2018	102013	150000	1.1	0	25

	urban_area	year	house_price	res_land_p~e	dist_metro	d_near_metro	urban_area~d
76	Pitampura	2012	133122	106384	.89	0	26
77	Pitampura	2015	114822	150000	.89	0	26
78	Pitampura	2018	139526	150000	.89	0	26
79	Preet Vihar	2012	118407	106384	.3	1	27
80	Preet Vihar	2015	138159	150000	.3	1	27
81	Preet Vihar	2018	122605	150000	.3	1	27
82	Punjabi Bagh	2012	129462	106384	.68	1	28
83	Punjabi Bagh	2015	133585	150000	.68	1	28
84	Punjabi Bagh	2018	142271	150000	.68	1	28
85	Rana Pratap Bagh Asok Vihar	2012	129117	106384	1.81	0	29
86	Rana Pratap Bagh Asok Vihar	2015	11254	150000	1.81	0	29
87	Rana Pratap Bagh Asok Vihar	2018	117869	150000	1.81	0	29
88	Rohini Sector 23	2012	.	106384	2.47	0	30
89	Rohini Sector 23	2015	59472.6	150000	2.47	0	30
90	Rohini Sector 23	2018	66329.4	150000	2.47	0	30
91	Rohini Sector 24	2012	79138.9	106384	2.11	0	31
92	Rohini Sector 24	2015	73197	150000	2.11	0	31
93	Rohini Sector 24	2018	73649.1	150000	2.11	0	31
94	SFS New Kondli Mayur Vihar Phase III	2012	76394	106384	1.93	0	32
95	SFS New Kondli Mayur Vihar Phase III	2015	88288.5	150000	1.93	0	32
96	SFS New Kondli Mayur Vihar Phase III	2018	81883.7	150000	1.22	0	32
97	Sadar Bazar	2012	.	58365	.73	1	33
98	Sadar Bazar	2015	.	70070	.73	1	33
99	Sadar Bazar	2018	152487	90000	.73	1	33
100	Shahdara	2012	46663.1	47140	.39	1	34
101	Shahdara	2015	50775	63000	.39	1	34
102	Shahdara	2018	49860.1	63000	.39	1	34
103	Shalimar Bagh	2012	101561	106384	1.75	0	35
104	Shalimar Bagh	2015	92863.3	150000	1.75	0	35
105	Shalimar Bagh	2018	91496.2	150000	1.29	0	35
106	Sonia Vihar	2012	.	47140	4	0	36
107	Sonia Vihar	2015	.	63000	4	0	36
108	Sonia Vihar	2018	49429.5	63000	4	0	36
109	Sunder Vihar	2012	.	106384	1.92	0	37
110	Sunder Vihar	2015	114370	150000	1.92	0	37
111	Sunder Vihar	2018	129462	150000	1.92	0	37
112	Vasant Enclave	2012	.	204600	2.14	0	38
113	Vasant Enclave	2015	.	420000	2.14	0	38
114	Vasant Enclave	2018	195705	420000	1.69	0	38
115	Vasant Vihar	2012	412777	204600	2.87	0	39
116	Vasant Vihar	2015	254812	420000	2.87	0	39
117	Vasant Vihar	2018	209064	420000	.41	1	39
118	Vikaspuri	2012	84628.6	106384	1.42	0	40
119	Vikaspuri	2015	91496.2	150000	1.42	0	40
120	Vikaspuri	2018	82798.7	150000	1.42	0	40