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Exploring Commercial Development in Delhi's Mixed-Use Neighbourhoods: An Empirical Study

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ABSTRACT

In rapidly urbanizing regions like Delhi, India, mixed-use developments have emerged as vital urban forms, driven by the organic conversion of residential spaces into commercial hubs. This study investigates the dynamics influencing commercial performance in both planned and unplanned mixed-use neighborhoods in North-West Delhi. Employing multiple linear regression analysis on data collected from 213 commercial establishments, the research identifies key factors such as commercial area characteristics, road accessibility, and the proximity of storeowners to their businesses as significant drivers of commercial growth. However, the study reveals that local customer bases are insufficient for sustaining high commercial performance, emphasizing the need for broader catchment areas. The findings contribute to urban planning discourse by providing empirical insights into the economic sustainability of self-organized mixed-use neighbourhoods. The study highlights the complex interplay between commercial development, spatial accessibility, and urban form, offering guidance for future urban planning strategies aimed at enhancing neighbourhood-level commercial performance. These results underline the importance of considering mixed-use dynamics in urban planning to support sustainable commercial growth and community vitality in rapidly evolving urban landscapes.

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Highlights:	Contribution to the field statement:
- The Study helps in determining critical elements influencing commercial performance in mixed-use neighbourhoods. - Provides empirical evidence supporting the positive correlation between increased area, job-housing balance, accessibility and increased sales. - Demonstrates the impact of store owner residency on commercial success and highlights its importance in self-organized mixed-use development. - It recommends areas where urban planners can focus like optimizing plot size, floor area, and transportation infrastructure for sustainable mixed-use development.	This study advances understanding of factors influencing commercial performance of mixed-use neighbourhood by identifying key factors influencing sales, such as store size, employment density, and accessibility. It provides empirical evidence to link economic activity performance with mixed-use characteristics and offers insights for urban planners to understand what drives self-organized mixed-use commercialization in large Indian cities.

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1. Introduction

Mixed land-use development allows for the coexistence of several land-use uses, including residential, commercial, recreational, and educational uses, and is characterized by enhanced land-use intensity and a variety of functions (Bahadure & Kotharkar, 2015). Over time, it has evolved into a crucial component of many planning and development initiatives, including smart growth, new urbanism, livable communities, conventional neighbourhood development, and transit-oriented development (Kafrawy et al., 2021). As defined in the "The Congress of New Urbanism" charter, compact, pedestrian-friendly, mixed-use neighborhoods have become essential to contemporary urban planning (Song et al., 2013; Zheng et al., 2021). Jane Jacobs (1961) highlighted the importance of mixed neighborhoods as a well-balanced combination of living, working, and service for a vibrant, safe, and secure public space in the city and promoted fine-grain mixing of diverse activities to create livable and vibrant communities (Stiftel, 2004; Jacobs, 1961). The benefits of the urban land-use mix have been studied in several fields, particularly in transportation, public health, and urban economy (Ho et al., 2023; Iannillo & Fasolino, 2021; Mavoa et al., 2018; Song et al., 2013). From a transportation point of view, combining usage near the place of employment lowers the need for travel, and introducing mixed-use development stimulates the rise in walking and cycling and promotes the decrease in the usage of personal automobiles (Bahadure & Kotharkar, 2015; Litman, 2024). In general, mixed-use zones provide a range of services and amenities (jobs, retail, and business opportunities) to the public, resulting in a livelier urban environment with higher density, which in turn forms a larger catchment population to maintain public transportation (Guzman & Gomez Cardona, 2021). From the standpoint of public health, bringing varied locations closer to residential areas promotes active travel modes (Gehrke & Clifton, 2017; Im & Choi, 2019). Lastly, from the perspective of the urban economy, a suitable mix of complementary urban land uses can stimulate higher-density development by supplying urban services and increasing property values (Kang, 2017; Kim & Jin, 2019).

In developing countries like India, urban development has undergone significant transformations, especially in mixed-use development, and has evolved dynamically and intricately in response to local demands and socioeconomic conditions. Thus, distinct from planned, controlled, and zoning-based mixed-use mainly highlighted in international planning paradigms, Indian cities typically show the characteristics of evolved mixed-use patterns resulting from pre-independence and present urban and socio-economic factors. This phenomenon has particularly evolved in response to the inadequacies of early urban planning efforts and the organic growth driven by economic demands. At present, the masterplan approach delineates mixed-use zones under zonal plans and along transit-oriented development corridors, while a distinct variant emerges in residential areas, where businesses are gradually added to the residential property over time (Raman & Roy, 2019). This organic mixed-use development frequently occurs around streets or traffic corridors, driven by the need for local businesses and improved connectivity. This development approach presents issues like increased parking demand, traffic management, and regulation of informal activities, even though it fosters local economic growth and liveliness and requires more exploration.

Going through the previous research, most mixed-use-based studies have broadly focused on two main areas first: measuring the benefits of mixed-use based development and its contribution, especially in the field of transportation, health (increased walkability), and economic benefits like enhanced property or rent value, and secondly: in measuring the spatial mixedness to derive advanced measurement techniques to overcome the limitations presented by different mixed-use measurement indices (Song et al., 2013; Zheng et al., 2021; Zhuo et al., 2019)**.** Carefully going through the available body of research, we have found that there is a lack of empirical research in studying the evolved pattern of mixed-use development resulting from the commercialization of residential areas in developing cities and its contributing factors. Also, while focusing too much on developing spatial techniques and mathematical mixed-use measurement indices, researchers focused on mixed-use development at larger scales, ignoring its complex presence at the neighbourhood level, especially on residential streets, and the factors influencing this commercialization and formation of these self-organized mixed-use streets. "Self-organization" in the

context of urban development refers to a process in which systems independently arrange themselves into structured patterns or behaviors, with less need for outside control. This process involves communities and residents coming together to design and modify their living environments through bottom-up initiatives (Suhartini, 2023).

Therefore, this study tries to focus on two important areas, commercialization and self-organizing patterns in mixed-use neighbourhoods, while first emphasising the reason for their formation, and second presenting the nature of mixed-use neighbourhoods. Advancing this approach we have tried to model commercial performance as the primary driver of expanding commercialization of such streets, given that economic and business interests are the driving forces behind this organic development. While commercial performance and related variables have been studied extensively concerning socioeconomic indicators, retail locations, and transportation factors (Sung, 2022), this study contributes to the existing body of research by exploring how these variables interact in the context of self-organized mixed-use development. We have selected the northwest zone of Delhi due to its high heterogeneity in different types of residential areas with mixed characteristics. We have also used store owner survey data to develop a multiple regression-based model to predict commercial performance and its influencing factors. The novelty of this study can be presented in the following points:

- Presenting a unique approach by measuring economic output at the store level, based on a survey focusing directly on the store owners and/or residents in mixed-use neighbourhoods.
- Following an empirical model development approach to measure commercial performance on mixed-use streets.
- Assessing the effect of different commercial area-based characteristics and network accessibility on it.
- Exploring the interlinkage between perceived and actual benefits of mixedness in terms of neighbourhood-level commercial performance.

The findings from this study provide valuable insights into how commercial performance is influenced by factors such as commercial characteristics, the variety of commercial activities, customer footfall, and the origins of customers within mixed-use neighborhood settings. We discovered that elements like store size, the number of employees, retail activity type, and improved network accessibility have a positive impact on commercial performance. Additionally, our model shows that more mixed-use neighborhoods tend to yield greater economic benefits. However, the study also reveals that well-established mixed-use streets draw customers from beyond the local neighborhood. Overall, these results offer crucial insights for testing mixed-use theories and exploring their connections with concepts like urban containment, job-housing balance, and other perceived economic advantages, as well as for understanding customer footfall patterns to anticipate infrastructure needs in mixed-use neighborhoods.

2. Literature Review

This section is divided into two parts. The first section gives an overview of the relationship between commercialization and urban planning, and the second section discusses the evolution and current state of commercialization of residential areas and the formation of mixed-use neighbourhoods in Delhi.

2.1. Commercialization and Urban Planning

Urban planning and commercial performance are intricately connected, as commercial spaces play a crucial role in shaping urban economies and landscapes. Urban development and planning decisions are significantly influenced by retail businesses' location, the tenants' diversity, and the overall commercial environment. Numerous studies have demonstrated the impact of changes in commercial performance on urban mobility, spatial land-use patterns, and local economic well-being (Glaeser et al., 2001). For instance, Han et al., (2019) emphasize the importance of identifying patterns in the spatial organization of retail outlets within road networks, essential for optimizing store placements and enhancing both commercial performance and urban planning.

The relationship between retail urbanism and urban planning is further elucidated by Barata-Salgueiro & Guimarães (2020), who explain that public policies aimed at sustainability and retail resilience in urban

centres are crucial for strengthening this link. Lowe (2005) underscores the critical connection between commercial growth and urban revitalization initiatives, delving into how shopping activities can drive urban regeneration, thus supporting the argument for mixed-use development. Research by Teller & Elms (2012) highlights the role of commercial clusters in the urban fabric by differentiating between created and evolved commercial agglomerations. Recognizing this distinction is important in the context of self-organized mixed-use streets that have evolved over time. Therefore, this study focuses on exploring various factors that contribute to enhanced commercial performance in residential neighbourhoods.

As this commercialization is oriented along the streets in residential areas rather than being part of an established commercial centre, factors involved in improved commercial performance should also be selected from this perspective. Erkip & Ozuduru, (2015), in examining the evolution of commercial spaces over two decades in Turkey, identified key characteristics of evolved street retailers. These retailers tend to offer more specialized goods and services than shopping malls and provide a variety of other shopping malls and various related products. They also demonstrate adaptability to the diverse needs of consumers by offering personalized services and products, adding diversity through food and restaurants, fostering relationships with residents, and enhancing community engagement. Thus, this study focuses on finding the relationship between the measure of commercial performance and its influencing factors like commercial characteristics, mixedness-based indicators, and spatial accessibility indices.

2.2. Commercialization of Residential Areas in Delhi

The initial master plans, such as the first Delhi Master Plan of 1962, intended to create designated commercial zones like Rajendra Place and Nehru Place. However, these planned commercial centres did not develop as anticipated due to slow economic growth and the lack of localized planning efforts. Consequently, commercial activities organically expanded in areas such as Lajpat Nagar and South Extension, driven by the proximity to residential areas and the local demand for retail and services.

This organic development led to mixed-use areas, which integrated residential, commercial, and transport-based activities, deviating significantly from the master plan's directives. Subsequent master plans in 1990 and 2007 failed to adequately address the evolving urban landscape, resulting in unregulated commercialization within residential zones. The unchecked proliferation of commercial activities prompted concerns from resident welfare associations about parking issues, security threats, and the loss of residential character. With rising conflicts, authorities responded by initiating a sealing campaign in 2006, even though later under the pressure of rising litigations and traders' discontent, the number of such mixed-use streets was regularized. Delhi Master Plan 2021 highlighted the challenges in managing such mixed-use developments. These efforts often prioritized traders' concerns over comprehensive planning strategies, leading to continued conflicts among civic agencies, residents, and traders.

More recently, Raman and Roy's categorization of mixed-use areas based on origin and character provided a framework for understanding these developments. Their classification distinguishes between planned and unplanned, lawful and unlawful origins, and various scales of development, such as plot level and neighbourhood level (Raman & Roy, 2019). Expanding on their work, this study focuses on 'Tonal Mixed Land Use,' where commercialization occurs by adding commercial functions in a residential property which increases plot density and variety, often starting as unlawful but later regularized, significantly impacting the neighbourhood character.

Figure 1. Typical Mixed-use Commercial Street in Delhi's Residential Neighbourhood (Source: the authors).

3. Materials & Methods

This section explains the main research gaps, site selection and data collection techniques, description of different variables and statistical modelling approach used for this study in detail.

3.1. Research Gaps and Research Strategy

By reviewing the available literature and studying the evolution of mixed-use commercial streets in Delhi, we find that this self-organized commercial development and the reasons behind it from an urban planning perspective have largely remained unexplored. Therefore, we hypothesize that the tendency to receive economic gains leads to such commercialization of residential neighbourhoods, converting them into mixed-use neighbourhoods. It is essential to measure the commercial performance of stores located in such areas and to explain different factors and their effect size on these stores' commercial performance. For this study, based on available literature (Kang, 2022; C. D. Kang, 2016; Reigadinha et al., 2017; Sung, 2022), we have decided to study commercial performance based on three main factors: indicators defining commercial characteristics, mixedness based indicators, and transport network accessibility-based measures. The background and relevance of these factors are discussed further in the variable description section. Finally, to study this relationship, we have tried to test three main hypotheses in this study.

- HP-1: Commercial characteristics of these stores have a significant relationship with commercial performance.
- HP-2: Mixedness-based indicators have a significant relationship with commercial performance.
- HP-3: Network accessibility-based indicators have a significant relationship with commercial performance.

This research aims to test these hypotheses and understand the dynamics between commercial performance and the type of commercial development taking place at the neighbourhood level based on specific attributes like the area of the shop, number of people employed, number of customers buying, and types of businesses. Secondly, to understand the formation of self-organized mixed-use street patterns and the knowledge gap between actual performance and perceived benefits derived via theories regarding urban containment and addressing the local commercial demand in the context of mixed-use

neighbourhoods. Third, establishing the impact of road accessibility in the context of vehicular and pedestrian friendliness on commercial performance. In general, the answers to these queries will aid in comprehending how organically evolved mixed-use development interacts with the commercial environment in terms of its performance. Planners can reduce future stakeholder conflicts and successfully manage these areas by using insights about different variables and their level of influence on commercial performance. Key steps and approaches adopted for this study are presented in *Figure 2*.

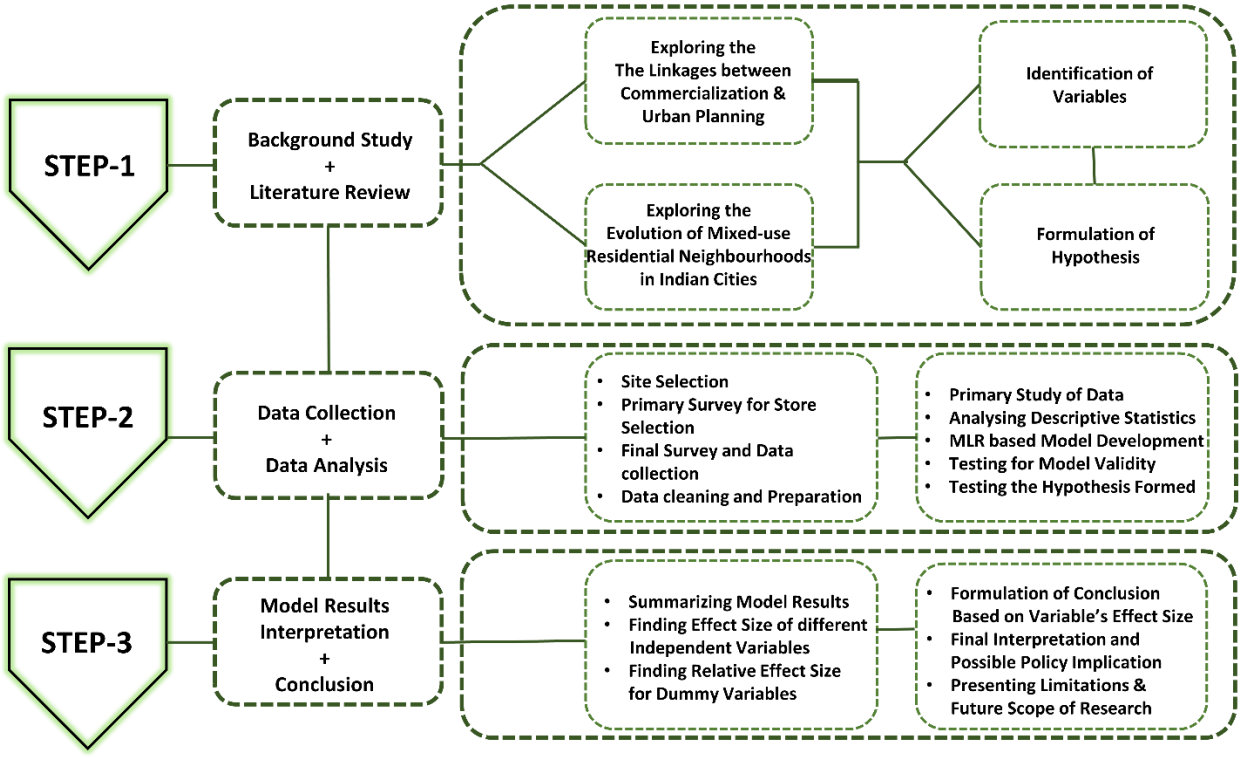

Figure 2. Key Steps for Data Collection, Analysis, and Model Development (Source: The authors).

3.2. Site Selection and Data Collection

Within the national capital region of Delhi, there are fifteen planning zones as per the master plan for Delhi-2021. Zone 'H, also referred to as Northwest Delhi-I, spans 5677 hectares of land and is primarily characterized by a combination of commercial, institutional, planned industrial, and recreational land uses organized into various hierarchies (Delhi Development Authority, 2007). The neighborhoods are effectively connected to all other major city attractions through an effective road network and Delhi metro service (red line). It comprised urbanized villages, pre-1962 residential and rehabilitation colonies, cooperative housing, resettlement colonies, unlawful regularized colonies, and planned residential (plotted and group housing). This zone was chosen for the study's mixed-use street survey because of its diversity of settlements. Conducting a mixed-use street survey involved first choosing the streets from the list of declared mixed-use streets in zone H's zonal development plan.

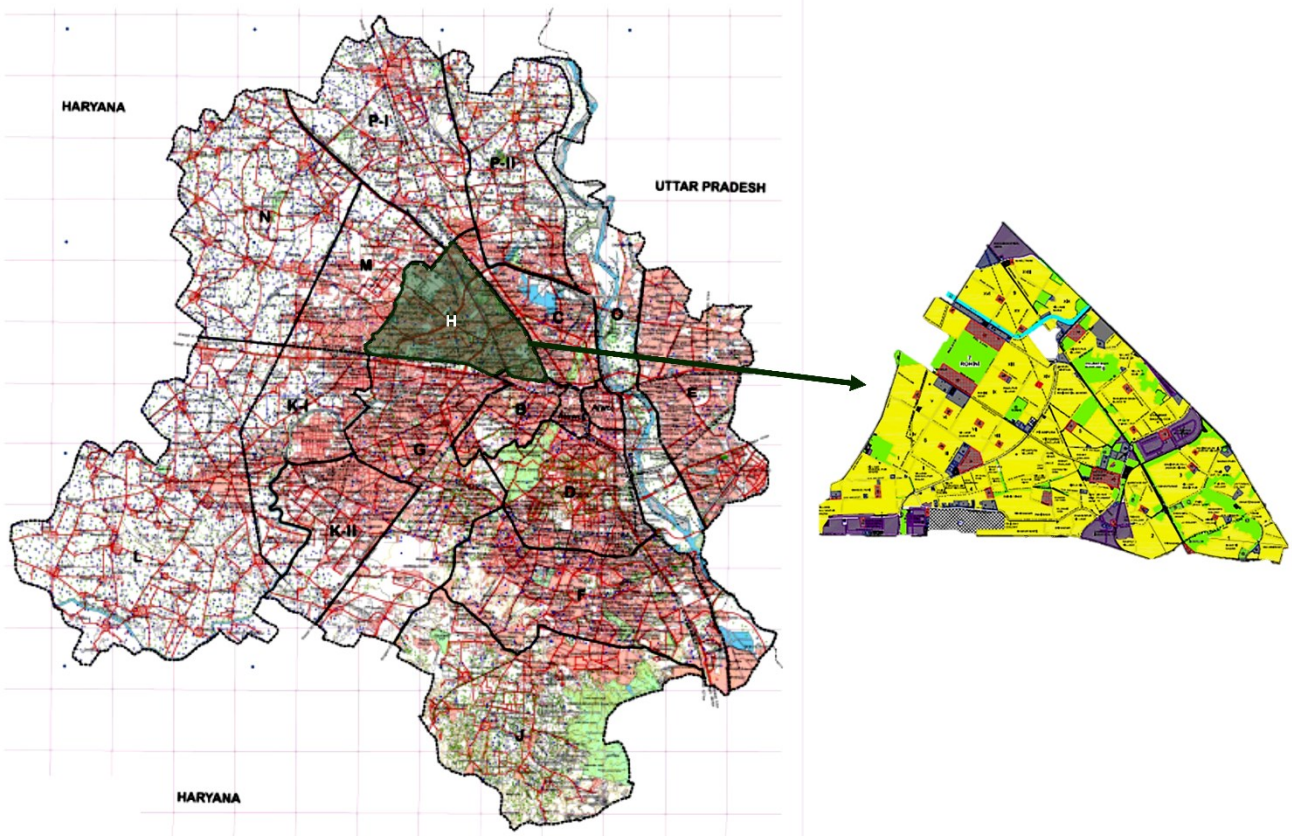

Figure 3. Survey Location Zone-H, Delhi and its Land use with Residential Areas (in Yellow) (Source: Delhi Development Authority).

These streets were carefully chosen to include both planned and unplanned areas to better represent the residential areas' heterogeneity. The zonal development plan categorizes these streets based on the right of way (ROW). Thus, streets representing different road widths were selected, ranging in 9-meter, 13.5-meter, and 18-meter widths. After completing a site assessment, it was discovered that many of the streets regularized by the local authorities are just short stretches or small clusters of commercial stores. As a result, only those streets with a total length of at least 500 meters were chosen for this study. The commercial activities occurring on these streets were analysed using a video recording before the questionnaire survey. This allowed for a better representation of a wider variety of activities, including informal ones, on the finally selected eight streets. Subsequently, a systematic sampling technique was used where the survey started from the street's midpoint. Every 5th store was selected for survey extending in both opposite directions and repeated on both sides of the street. Data was collected in between 25-28 stores from each surveyed street, and 213 samples were gathered using questionnaire surveys, which were further used for statistical analysis.

3.3. Description of Variables

a) Average Sale of a store on a weekday: Several studies have used the sale values of stores to study the relationship between different urban planning and socioeconomic factors with commercialization, customer attraction, and commercial performance (Kang, 2022; C. D. Kang, 2016; Lewison & Hawes, 2015; Perdikaki et al., 2012; Yoshimura et al., 2020). To model commercial performance, average sales on an average weekday are taken as a dependent variable for this study, and several independent predictor variables are employed and explained here. The unit for this variable was set as a sale figure in multiple of 1000 rupees.

3.3.1. Commercial Characteristics-Based Indicators

Several studies have demonstrated how commercial activity characteristics and composition affect local economies, urban mobility, and land-use patterns (C. D. Kang, 2016). Multiple variables are selected to investigate their possible influence on commercial performance and are presented here.

a) Store Size: The number of floors designated for commercial activities and the total area determines the size of the store. The extent to which it affects commercial performance might guide the planning decisions such as floor area ratio and built-up area concerns. The unit for this variable was set as the area in square feet.

b) Number of People Employed: Studies suggest customer satisfaction and loyalty are directly correlated with the quality of the salesperson-customer contact. Customers' preference for small stores on shopping streets is attributed to the individualized attention they receive from personnel (Medrano et al., 2016). Therefore, the relationship between average sales and the number of store employees is selected for this study. It is also an important variable in assessing the effect of the size of the job-housing balance on the productivity of mixed-use neighbourhoods.

c) Number of Customers Visiting: Past research has established that the number of customers visiting shops is a crucial indicator of commercial performance affecting increased sales value. It represents areas like economic vitality, customer engagement, attractiveness & appeal of the product, and social interaction (Philp et al., 2021; Torrens, 2022). Therefore, the number of individuals that visit a store on an average weekday (Categories; 0–25, 26–50, 51–75, 76–100, Above 100) is used as an independent measurable variable for this study.

d) Product/Service Type: An important factor in determining the average sales of a specific establishment is the kind of products or services it offers. A site survey was conducted to identify a broad typology of commercial activity along with previous research (Saraiva & Pinho, 2015; Sarma, 2006) and contextualized according to the local conditions. As a result, five main typologies of commercial activities were included.

- Retail (various products and brands offered by the stores)
- Services (medical, personal care, professional services, repair, maintenance etc.)
- Multipurpose (general store/groceries and all-purpose stores etc.)
- Food (restaurants/ eateries and takeaways)
- Others (additional undefined categories)

e) Informal Activity Linked: These mixed-use streets are integral to the informal activities that take place there. Demand-driven informal commercial activity aggregation has been seen to occur as sidewalk vendors, transient kiosks, and frequently as an outgrowth of long-term businesses (Roni et al., 2022). The government has recommended a separate vending regulation to properly administer this unstructured but essential industry. Due to their importance, a binary variable is created to study the informal activity taking place. A specific store's average sale relates to the informal activity in front of that store. Data was collected by asking simple Yes/No questions about the existence of informal activity.

3.3.2. Mixedness Based Indicators

Two key metrics are devised and tested to validate the widely accepted advantages of mixed-use areas in theoretical discussions to determine whether a higher degree of shopkeeper association with the business location correlates with increased commercial performance. Additionally, the location-based composition of the visiting customers and its relationship with commercial performance within a specific radius of the neighbourhood are considered. Determining the correlation between the variables can help in offering further insights into the impact of store owners' and customers' location on neighbourhood economics and urban confinement.

a) Distance to Shop Owner's Residence: A polychotomous variable is created regarding the distance between the store and the business owner's home. The question of whether they lived within 500 meters, 1000 meters, or further away from the store was posed to the store owners.

b) Number of Local Customers Based on Distance: Data is gathered to determine the proportion of customers originating from different areas. The criterion for establishing whether a consumer is local was set at 2000 meters (2 km) based on primary interviews with experts and shop owners. Responses on the

proportion of visitors who are local customers were categorized into five groups: 0–20%, 21–40%, 41-60%, 61–80%, and over 80%. This variable was created to test the assumption that mixed-use zones satisfy local demand and to determine whether stores with higher average sales also attract more local customers.

3.3.3. Network Accessibility Based Indicator

a) Right-of-way (ROW): As a critical measure of accessibility, the right-of-way can impact accessibility by determining the amount of space available for pedestrians, cyclists, and vehicles to move through the area (Dawson, 2004). Measuring its relationship with commercial performance is also important because the basic categorization of regularized mixed-used streets is based on ROW. Therefore, the measurement of surveyed roads right of way in meters is taken as a variable for network accessibility measure.

3.4. Sample Size Calculation and Statistical Model Development

a) Sample Size: This study calculated sample size using G*Power software (version 3.1.9.7). An apriori power analysis was performed to ascertain the necessary sample size for the multiple linear regression analysis. The power analysis aimed to establish adequate power for determining a significant effect, with specified significance level, effect size, and number of predictors A power ($1-\beta$) of.80, a medium effect size ($f2 = 0.15$), and an alpha level (α) of.05 were the parameters used for the power analysis (Faul et al., 2009). Furthermore, the number of independent variables used as predictors was taken to be 22, including all continuous and categorical variables. These criteria led the G*Power analysis to conclude that 163 would be the minimum sample size needed to detect a medium effect size with adequate power. Thus, to ensure the validity of the statistical analysis, sufficiently more than the minimum requirement, 213 samples were utilized for this study.

b) Statistical Model Development: Multiple Linear Regression with a dummy coding-based model is developed. It's a powerful statistical tool to analyse the relationship between a continuous dependent variable and multiple independent variables, including categorical variables (Schinka et al., 2003). Dummy variables are employed to convert categorical data into numerical values that may be utilized in the regression analysis. In this study, 'average sale' is chosen as a dependent variable and a continuous variable, along with many other independent variables that are categorical. The generalized equation for multiple linear regression with dummy variables is presented as:

$$y = b0 + b1x1 + b2x2 + \ldots + bnxn + \varepsilon$$

Where y is the dependent variable (continuous), b0 is the intercept or constant term, b1, b2, …, bn are the regression coefficients for each independent variable, and x1, x2, …, xn are the independent variables (including dummy variables), with ε representing error term. Here, each dummy variable is a binary variable with a value of 0 otherwise and 1 if the observation falls into a particular category. The category that a dummy variable does not specifically represent is the reference category. Regression coefficients are used to interpret the results, which show the variation in the dependent variable, after adjusting for all other independent factors, between the reference category and the category represented by the dummy variable. The results-based discussion and implications of the model results are presented in the next sections.

4. Results & Discussion

Data obtained from a survey of 213 businesses was tested by running multiple linear regression analyses in the SPSS statistical package. Descriptive statistics of important categorical variables are presented in *Figure 4 and Figure 5*.

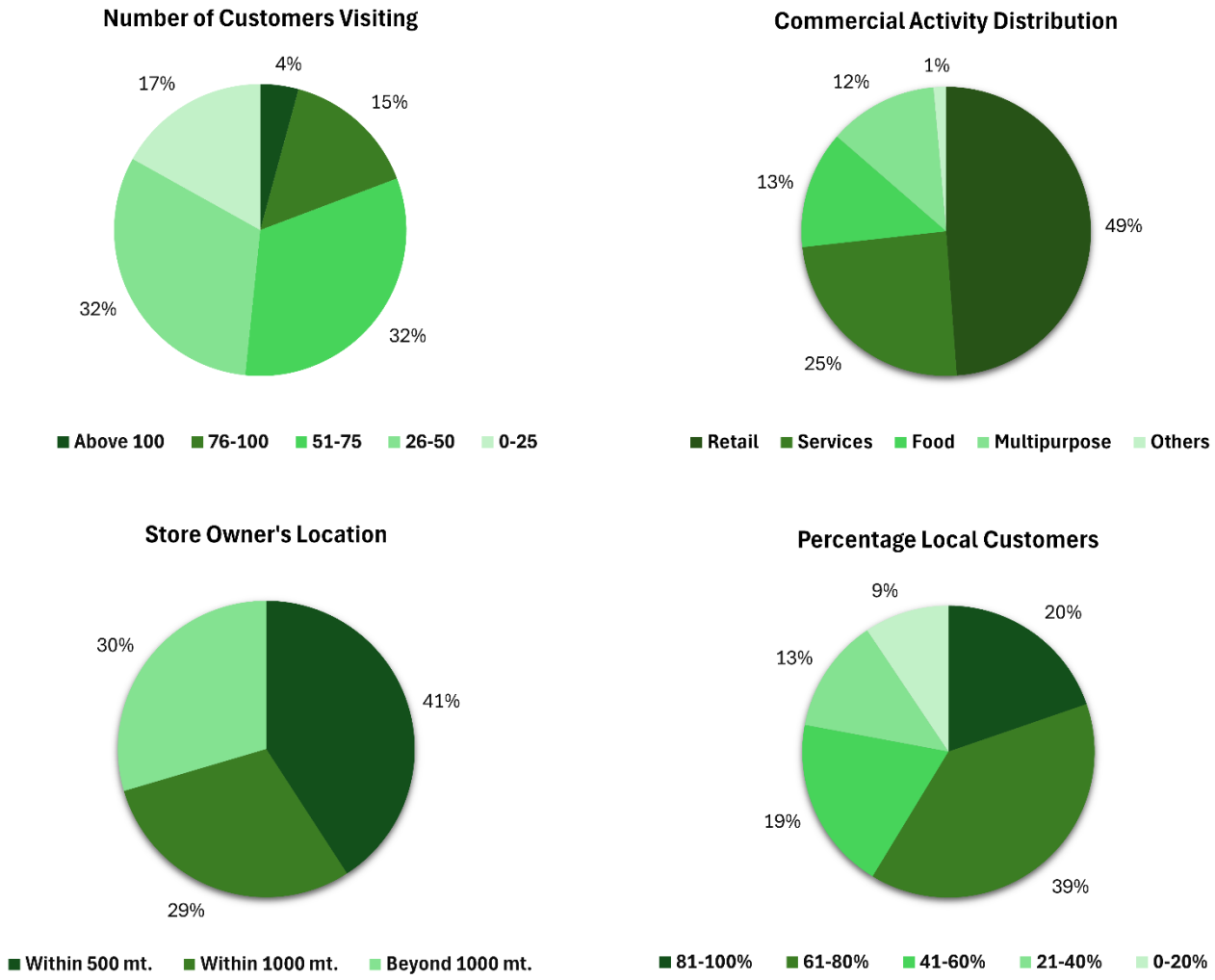

Figure 4. Survey Results for Different Stores (Developed by the authors).

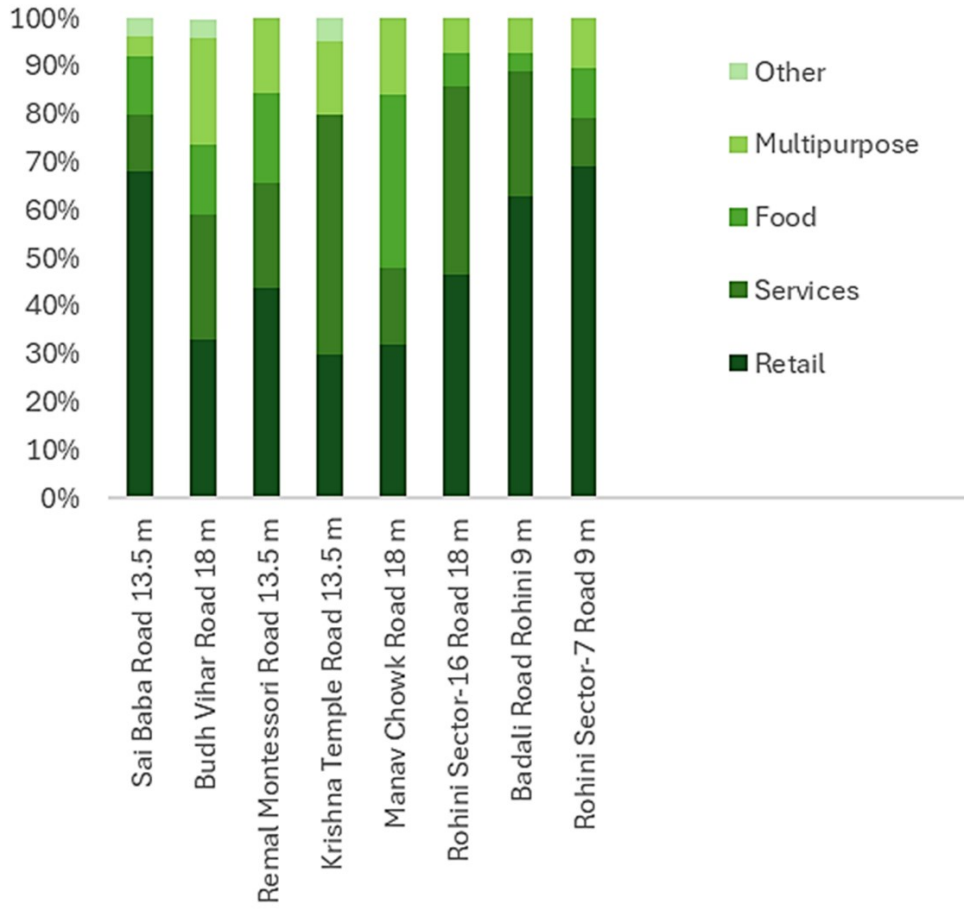

Figure 5. Distribution of Commercial Activity Type on Eight Surveyed Streets (Developed by the authors).

Analysis results are based on the relationship of the dependent variable (average sale of a store on a typical weekday) with several predictor variables, and results based on parameter estimates are explained further.

The analysis incorporates log-transformed values for different continuous variables. Assessing the validity of the model, we found the overall model was statistically significant, $F(19, 190) = 18.046$, $p < .001$, indicating that the set of independent variables explained a significant portion of the variance in average sales. The model accounted for 64.3% ($R^2 = .643$) of the variance in average sales. After adjusting for the number of predictors in the model, the adjusted R^2 remained substantial at 60.8%, suggesting good explanatory power. In general, VIF values below 5 are considered acceptable; in this analysis, all VIF values are below 3.74, suggesting that the issue of multicollinearity is not present. The model's intercept is significant ($\beta = 1.417$, $t = 2.298$, $p = .023$), representing the average sale when all other independent variables are set to zero. Based on these parameters, the internal validity of the model is confirmed before studying the effect size and significance of various predictor variables, which are discussed in detail here.

Table 1: Model Summary.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.802[a]	0.643	0.608	0.18214

Table 2: Model Coefficients

	Unstandardized Beta	Standard Error	Coefficient Beta	t	Sig.	VIF
(Constant)	1.417	0.617		2.298	0.023*	
Commercial Characteristics Variables						
Log Store Size	0.294	0.063	0.274	4.648	<.001**	1.854
Log Employee	0.589	0.098	0.390	6.004	<.001**	2.246
Customer Visiting= 0-25(Ref.)						
Customer Visiting=26-50	0.056	0.041	0.090	1.391	0.166	2.250
Customer Visiting=51-75	0.144	0.043	0.232	3.318	0.001*	2.613
Customer Visiting=76-100	0.293	0.057	0.363	5.184	<.001**	2.614
Customer Visiting=Above 100	0.340	0.083	0.238	4.124	<.001**	1.768
Activity Type-Others	0.145	0.115	0.059	1.269	0.206	1.171
Activity Type-Multipurpose	-0.138	0.048	-0.156	-2.847	0.005*	1.610
Activity Type- Food	-0.153	0.052	-0.180	-2.948	0.004*	1.982
Activity Type- Services	-0.076	0.037	-0.114	-2.092	0.038*	1.577
Activity Type- Retail (Ref.)						
Informal Activity Linked (Yes)	0.025	0.032	0.041	0.805	0.422	1.403
Mixedness Based Variables						
Shop Owner Living= Beyond 1000mtr. (Ref.)						
Shop Owner Living=500-1000mtr.	0.069	0.036	0.102	1.949	0.053	1.469
Shop Owner Living=Within 500mtr.	0.090	0.034	0.151	2.666	0.008*	1.708
Local Customer=0-20% (Ref.)						
Local Customer=21-40%	-0.081	0.058	-0.091	-1.407	0.161	2.223
Local Customer=41-60%	-0.091	0.053	-0.125	-1.71	0.089	2.827
Local Customer=61-80%	-0.133	0.050	-0.225	-2.68	0.008*	3.739
Local Customer=81-100%	-0.078	0.054	-0.107	-1.431	0.154	2.979
Network Accessibility						
Log ROW	0.511	0.165	0.204	3.102	0.002*	2.31

*Dependent Variable= Log Average Sale, (Ref. = Reference category); *Significant at 95% confidence interval, ** Significant at 99% confidence interval*

4.1. Effect of Commercial Characteristics-Based Variables

- Store size is an important indicator tested to predict average sales, and the parameter estimate value of ($\beta = .294$, $t = 4.648$, $p < .001$) suggests a positive relationship between the two. This suggests that stores with larger floor areas tend to generate higher average sales as one unit increase in the value of store area is associated with a 0.294 unit increase in the average sale value of the store. These results provide clear evidence that dedicating a larger area to commercial purposes brings more revenue in the form of increased average sales. Thus, these results can be further interpreted in defining the inclination of neighbourhood residents to a covert sizable part of their residential property into a commercial one.
- Several employees also demonstrate a significant positive relationship with the average sale ($\beta = .589$, $t = 6.004$, $p < .001$), indicating that stores with more employees tend to achieve higher average sales and the addition of one worker increases the average sale by 0.589 times. These results are significant in the context of previous studies where better job housing balance in an

area indicates more mix (Litman, 2024). Thereby approving the perceived benefit of mixed-use neighbourhoods that increased job-housing balance relates positively with economic performance and supports the ability of mixed-use in creating self-contained neighbourhoods.

- The Total number of customers visiting a store has shown a generally positive relationship with increased average sales. The reference category with (0-25 visitors) accounts for 17% of total stores. Compared to reference category stores receiving (25-50 visitors) are 32% in number but show a non-significant relationship. However, categories with higher customer footfall, like (51-75 visitors) with 32% share and ($\beta = 0.144$, $t = 3.318$, $p < .05$), (76-100 visitors) with 15% share and ($\beta = 0.293$, $t = 5.184$, $p < .001$) and (above 100 visitors) with 4% share and ($\beta = 0.340$, $t = -2.847$, $p < .05$) show significant and positive association with higher average sales. These results suggest a gradual increase in average sales value with a gradual increase in average sales value with increased customer footfall to these stores. These results confirm the association between sales value and customer footfall, as highlighted by Sung (2022). They can be further utilized to predict the floating population by using customer footfall in these stores. The results hold significance in guiding future policies regarding parking and pedestrian infrastructure demands in these neighbourhoods.
- The effects of various commercial activities on average sales vary category-wise. The reference category used is 'retail'49.0% of the total surveyed stores, and it has a higher association with average sales among all other categories. Services (25.0%) is the second most common commercial activity taking place on these streets with results ($\beta = -0.076$, $t = -2.092$, $p < .05$), similarly food joints representing 13.0% of total stores, with ($\beta = -0.153$, $t = -2.948$, $p < .05$) and multipurpose stores with total 12% representation of all stores and ($\beta = -0.138$, $t = -2.847$, $p < .05$) show significantly lower association with a high average sale than the reference category 'retail'. These results indicate retail activities are dominant in the composition of commercial activities and are associated with higher commercial performance. Also, studies like C. D. Kang (2016) highlight the tendency of retail, food, and services to align along the streets, attracting higher pedestrian volume to receive higher sales. Thus, our results confirm that major business categories incentivize greater heterogeneity and higher accessibility along the mixed-use streets.
- The model suggests a nominal increase in commercial performance if a particular store indicates that informal activity is taking place in front of that store; however, the results are not statistically significant and need further investigation. However, two-thirds of the stores have registered some kind of informal activities attached in front of their location, contributing to the overall mixedness of the area and increasing pedestrian volume. This spillover effect of informal activities in the context of pedestrian volume, floating population, and overall environment of commercial agglomeration needs to be studied in the future, especially in the context of studies like Kang, (2022), which suggest their positive influence on retail sales.

Overall, these results pertaining to retail characteristics variables confirm the significant relationship between store size, number of employees, and number of visiting customers, store type- retail is an important predictor of average sales of a store. This supports our hypothesis HP-1 and provides a better understanding of the dynamics between commercial performance and type of commercial development at the mixed-use neighbourhood level. However, specific attributes, such as informal activities, must be tested further with larger data sets.

4.2. Effect of Mixedness-Based Variables

- Shop owner residence in locations with categories (Within 1000 meters) and (Within 500 meters) has significant positive associations with average sales ($\beta = .069$, $t = 1.949$, $p = .053$; $\beta = .090$, $t = 2.666$, $p = .008$, respectively) compared to reference category representing stores beyond 1000 meters from storekeepers residence, indicating that stores with shop owners living nearby tend to generate higher average sales compared to the reference category. These results show a strong association between shop-owner's residences and high commercial performance. These results are significant in testing the perceived benefits of mixed-use neighbourhoods (Kang, 2022; Litman,

2024) regarding self-containment and in controlling urban sprawl. It also shows that better job housing balance in a limited area (within 500 meters buffer area) results in higher commercial performance. These results provide strong evidence to support our hypothesis HP-2 and suggest that with the reduction of distance between residential and business places, commercial performance experiences a significant increase.

- The local customers category (0-20%) is the reference category, and 9% of the stores fall in this category. Compared to this, stores receiving 21-40%, 41-60%, 61-80%, and 81-100% local customers show a negative association with average sales. With a statistically significant relationship for category (61-80%) with ($\beta = -.133$, $t = -2.680$, $p < .05$). These results indicate that higher average sale is not positively associated with an increased percentage of local customers. Thus, better sales are associated with receiving a larger customer base from regions well beyond 2000 meters from the store location. These results don't support our hypothesis HP-2 and provide contrary evidence regarding the positive relationship between a higher number of local customers and higher average sales. In light of studies like Kang (2017) and Sung (2022), which highlight the role of the floating population in receiving higher sales, these results need to be explored further to differentiate the impact of local versus distant visitors to these stores' sales.

4.3. Effect of Network Accessibility-Based Variables

- Road width (ROW) based indicator presents a significant positive relationship with the average sale ($\beta = .511$, $t = 3.102$, $p < .05$). These results suggest that a unit increase in the width of the road increases the value of the average sale of a store by 0.51 units. In conformation with past studies like Yoshimura et al.,(2020), and Kang (2022), which highlighted the role of transport accessibility and commercial performance, this study presents strong empirical evidence to confirm our hypothesis HP-3. Residential areas with greater street accessibility are better equipped to receive higher sales in store locations.

These results provide a better understanding of the commercialization of mixed-use neighbourhoods and their influencing factors. Overall, we have found evidence-based findings via empirical modelling to highlight specific attributes which support the hypothesis initially formed for this study. With these results, one can assess the effect size and relative importance of different indicators and carry out further research into specific areas to gain further insights.

5. Conclusion

This study proposes a framework to assess commercial performance in mixed-use neighbourhoods, considering three main factors: retail characteristics, mixedness, and network accessibility. This study focuses on the evolved pattern of mixed-use development and tries to find the contributing factors that result in commercializing residential areas in developing cities. The model provides clear evidence in terms of the positive relation between store size and increased sales, which justifies people's motivation to make incremental changes towards more commercialization of residential units. Similarly, the model shows that the effect of additional employment marks a positive relationship with commercial performance, thus, as highlighted in other studies, the perceived benefit of mixedness in terms of better job-housing balance can be confirmed. The association between customer footfall and its positive relation with sales value can be utilized further to predict the floating population in these neighbourhoods to meet parking pedestrian infrastructure demands and resolve stakeholder conflicts among residents, customers, and traders. Survey results confirm there is strong diversity in terms of the type of commercial activity taking place, retail businesses being the dominant one. It will be interesting to study the role of these specific business activities in attracting pedestrian and customer traffic to these areas in the future to develop planning policies. To understand the tendency of self-organization and incremental increase in commercialization, this study provides clear evidence that storeowners' residential proximity increases the commercial performance of the store, which justifies more residents choosing to commercialize their own property for economic benefits. However, the model result shows significant dependence on customers from distant locations to receive increased sales. Therefore, further studies are required to study

the effect of store types and other factors on customer distribution in these stores to define optimum catchment areas for future mix-use neighbourhood planning. Finally, road network accessibility has proved to be one of the crucial factors in our model. Higher average sale is expected with stores on streets with increased right of way. These results indicate that increased plot size, which is also associated with higher road accessibility, is positively related to commercial performance, and therefore, from a spatial planning point of view, plot size and prescribed floor area guidelines must consider their role in neighbourhood economic sustainability in advance. Future studies about the interrelationship of such developments with associated transit stations must be conducted to further help in planning for TOD-based developments, with mixed-use as one of their policy objectives.

While this study employs a data-driven, statistical modelling-based approach to explore the commercial performance of existing self-organized mixed-use streets, there are certain limitations of our study, like direct survey-based responses might be underreported or overreported by the store owners thus, to ensure the reliability of average sale data other methods like trade-based tax and revenue records and other secondary sources can be adopted. Also, this study was conducted in October, which is considered less harsh and more pleasant from consumers' point of view. However, studies like Badorf & Hoberg, (2020) suggest weather conditions affect daily sales. As accounting for weather conditions was out of scope for this study, we suggest further research in this area to address this limitation. Furthermore, as this model is exploratory, it would be advised to use a larger dataset before making more generalized predictions about commercial performance. Finally, areas like the effect of agglomeration and competitive clustering on commercial performance and other spatio-temporal variables related to mixed-use urban areas must be considered for future studies apart from addressing the limitations mentioned in this study.

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The author(s) declare(s) no conflicts of interest.

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