

Forced or Voluntary Local Mobility? Socioeconomic Heterogeneity and Spatial Scale in Realized Urban Proximity¹

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Abstract

Urban mobility is a major contributor to greenhouse gas emissions, and proximity-based planning—embodied in the “15-minute city”—has been proposed as a strategy to reduce travel distances. Yet physical proximity does not necessarily translate into effective local use. This paper examines whether realized local mobility reflects voluntary proximity-based behavior or structural constraint. Using anonymized mobile phone data for Chicago (2022), we construct an Effective Local Use Rate (ELUR) measuring the share of trips occurring within alternative neighborhood radii (1.25 km, 3 km, and 5 km). We find that service-rich environments are associated with greater hyperlocal mobility, but lower-income neighborhoods exhibit higher baseline levels of local travel. In contrast, higher-income neighborhoods are more responsive to improvements in nearby opportunities and expand their activity beyond the hyperlocal radius when services are abundant. Importantly, these income differences operate primarily through variation in how far everyday mobility extends, rather than through differences in how trips are allocated within comparable local ranges. Moreover, income-conditioned responsiveness is strongest at neighborhood scales and attenuates at broader urban distances. These findings suggest that localized mobility reflects both opportunity and constraint, and that its welfare interpretation depends on socioeconomic context and spatial scale.

Keywords: Local mobility; 15-minute city; Accessibility; Spatial inequality; Urban mobility; Mobile phone data.

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Introduction

Daily mobility encompasses commuting to work, school runs, shopping, housing-related trips, leisure and other activities that structure social practices through the interaction of personal preferences and spatial factors (Sheller & Urry, 2006). These practices have been increasingly recognized as a major environmental concern, since they generate a large share of transport-related emissions and energy use (Winkler et al., 2023). Promoting more sustainable travel therefore requires reducing the number of kilometers travelled by motorized modes, fostering instead more local mobility patterns enabled by better accessibility² (Banister, 2008; Wachs & Kumagai, 1973). Within this context, proximity-based planning paradigms have gained prominence, most notably the concept of the “15-minute city”, which posits that residents should be able to satisfy essential daily needs within a short walking or cycling distance from their home (Moreno et al., 2021).

However, empirical evidence suggests that physical proximity is a necessary but not sufficient condition for effective local use. Recent literature shows that only a small share of trips in U.S. cities end within a 15-minute walk from home, pointing to a persistent gap between potential proximity and realized behavior (Abbiasov et al., 2024). This mismatch is consistent with research emphasizing that accessibility is heterogeneous across individuals and infrastructure conditions, so that the same nominal distance can imply very different effective reach for different groups (Willberg et al., 2023). Finally, recent work on experienced urban inequalities shows that even when spatial access appears similar, patterns of actual use remain stratified across social groups, reinforcing the need to distinguish access from realized participation in urban opportunities (Xu et al., 2025).

Mobility inequality has been documented across disciplines and is commonly understood as the outcome of interactions between intrinsic individual attributes—including income, age, gender, household composition, or disability—and extrinsic spatial and sociocultural conditions, such as urban form, service distribution, and transport systems (Hidayati et al., 2021). In this paper, we draw on insights from the mobility justice literature (Sheller, 2018; Urry, 2004) and focus on inequalities in the conversion of potential local accessibility into realized mobility, highlighting how similar proximity conditions can

² Accessibility has been previously defined as “the potential of opportunities for interaction” (Hansen, 1959).

generate markedly different behavioral patterns and welfare implications depending on individual constraints and contextual factors.

While a growing literature has begun to document gaps between potential local accessibility and realized everyday mobility, much less is known about the mechanisms underlying these gaps. Recent contributions suggest that different mechanisms may be at play, including heterogeneity in the quality and relevance of nearby amenities (Elldér et al., 2022; Graells-Garrido et al., 2021; Guzman et al., 2024), competition and capacity constraints at local destinations (Knap et al., 2023), time and mobility constraints related to income, car ownership, and schedules (Abbiasov et al., 2024; Ermagun et al., 2025; Pyrialakou et al., 2016; Willberg et al., 2023)³.

We focus our empirical analysis on the city of Chicago. Recent evidence suggests that a substantial share of the city satisfies a 15-minute accessibility framework, albeit with marked spatial and socioeconomic disparities (Ermagun et al., 2025). Chicago combines relatively high density and an extensive public transport network—features commonly associated with proximity-based planning—with a long history of segregation and structural inequality. At the same time, existing studies rely primarily on objective measures of accessibility and acknowledge a potential mismatch between theoretical access to destinations and the places individuals actually visit. These characteristics make Chicago a particularly informative setting to examine whether observed local mobility reflects voluntary proximity-based choices or binding mobility constraints.

This paper contributes to the literature on sustainable urban mobility and accessibility in three main ways. First, it moves beyond potential accessibility measures by constructing a behavior-based indicator of effective local mobility (ELUR) using high-resolution mobile phone data, where origins are defined by primary daytime location. This allows us to capture the concentration of visits around individuals' daytime activity anchors, reflecting patterns shaped by employment concentration and urban centrality. Second, it provides a behavioral interpretation of proximity-based mobility by documenting heterogeneous responsiveness of local use to nearby service environments across income levels, consistent with a distinction between voluntary selectivity and constrained localism. Third, it shows that these mechanisms are scale-dependent, operating most

³ Residential sorting and spatial equilibrium effects can also be understood as a mechanism underlying mobility behaviour (Abbiasov et al., 2024)

clearly at short and intermediate neighborhood radii, and further characterizes spatial selectivity through an overshooting framework. The remainder of the paper is organized as follows. Section 2 reviews the related literature. Section 3 describes the data and measurement strategy. Section 4 outlines the empirical approach. Section 5 presents the results, and Section 6 discusses policy implications and concludes.

Literature review

The concept of the 15-minute city has gained substantial attention as a normative framework for promoting sustainable and resilient urban development (Moreno et al., 2021). At its core, the 15-minute city builds upon the long-standing concept of accessibility, defined as the capacity to link individuals and activities through effective spatial reach (Chen et al., 2007; Hansen, 1959). By improving access to essential services within short distances, proximity-based planning is expected to reduce emissions, enhance social interaction, and foster environmental sustainability (Handy, 2020; Khavarian-Garmsir et al., 2023).

Despite its normative appeal, the 15-minute framework has faced increasing scrutiny (Mouratidis, 2024). Critics highlight concerns about its spatial feasibility in dispersed urban systems and warn that proximity-based development may unintentionally reinforce socioeconomic segregation (Abbiasov et al., 2024; Park & Rogers, 2015; Sharifi, 2016; Zhang et al., 2025). Methodological debates further question how proximity should be operationalized, including the arbitrariness of fixed temporal thresholds and whether accessibility should emphasize sufficiency or diversity of services (Calafiore et al., 2022; Ermagun et al., 2025; Jin et al., 2024; Logan et al., 2022). More fundamentally, however, empirical implementations often neglect interpersonal heterogeneity, overlooking differences in mobility resources, time constraints, and socioeconomic conditions that shape individuals' capacity to convert spatial proximity into realized opportunities (Willberg et al., 2023). As a result, high levels of local accessibility do not necessarily translate into equitable or voluntary patterns of local mobility, underscoring the need to examine how realized mobility responds to local opportunity structures across socioeconomic contexts.

Accessibility is inherently multidimensional and dynamic, depending on the interaction between people, transport systems, and activity locations (Hägerstrand, 1970; Järv et al.,

2018; Moya-Gómez et al., 2018). Static proximity measures may therefore overestimate effective access by neglecting temporal alignment, transport conditions, and individual constraints. Accessibility is also socially differentiated. Individual attributes such as income, age, and mobility resources shape the capacity to convert spatial proximity into realized opportunities (Geurs & Van Wee, 2004; Willberg et al., 2023). Importantly, individuals are not strictly confined to their residential locations, and activity spaces often extend beyond neighborhood boundaries (Järv et al., 2018). Beyond spatial heterogeneity, recent studies emphasize that mobility behavior follows recurrent, structured patterns shaped by distance, frequency, and anchor points in individuals' activity spaces (Alessandretti et al., 2018, 2020; Schläpfer et al., 2021). Together, these findings imply that mobility is organized across multiple scales and that individuals respond systematically to spatial opportunities rather than merely to absolute proximity.

Recent empirical research has begun to document a systematic gap between potential accessibility and realized mobility behavior. Zhang et al. (2025) identify a consistent mismatch in Finnish cities: while central areas display high potential accessibility, individuals frequently “overshoot” nearby opportunities and travel beyond their closest viable destinations, whereas peripheral areas exhibit higher levels of local mobility consistent with structural constraints. Similarly, Abbasov et al. (2024) quantify the relationship between accessibility and effective local mobility in the United States, finding that income and education are positively associated with longer travel distances, and that substantial regional heterogeneity persists. These findings suggest that proximity does not automatically translate into local use, raising the question of whether observed local mobility reflects preference-driven choices or structural constraints.

Despite this complexity, urban policy has largely focused on supply-side accessibility - the spatial availability of services - while paying limited attention to effective accessibility, that is, individuals' ability to convert potential proximity into realized participation (Willberg et al., 2023; Xu et al., 2025). Supply may be a necessary condition for sustainable mobility, but it is not sufficient to guarantee realized local usage. This distinction is crucial when interpreting high levels of localized mobility, which may reflect either successful proximity-based planning or constrained mobility conditions.

Yet, the existing literature remains largely silent on how localized mobility should be interpreted from a welfare perspective. From a behavioral perspective, localized mobility

may emerge from at least two distinct mechanisms. First, opportunity-driven selectivity arises when individuals voluntarily concentrate activity within nearby areas despite having the capacity to travel farther. Second, constraint-driven confinement occurs when limited mobility resources restrict spatial reach, leading to high local-use shares independent of nearby opportunity quality. Distinguishing between these mechanisms is essential because their welfare implications diverge fundamentally. Empirically distinguishing between these mechanisms requires examining heterogeneous responsiveness to local opportunity structures and the spatial scale at which mobility is realized.

Data and measurement strategy

We draw on the Advan Monthly Patterns dataset, which provides anonymized and aggregated visitation data to points of interest (POIs) across the United States. Constructed from a large opt-in mobile device panel, the dataset reports monthly visits and the Census Block Group (CBG) associated with visitors' primary daytime location (9am–5pm). It also includes establishment-level attributes such as opening hours, business category, parking availability, and median dwell time. Our study focuses on 2022. Visits are attributed to POIs using detailed building geometries, ensuring accurate detection of entries and exits. These data allow us to observe behavior-based mobility patterns at fine spatial resolution while preserving individual privacy.

For the purposes of this research, we aggregate visits to the CBG–month level, which serves as our unit of analysis. From these data, we construct the Effective Local Use Rate (ELUR), defined as the share of visits originating from each CBG—based on primary daytime location—that occur within a given spatial radius. The main advantage of this dataset is that it provides a dynamic and behavior-based view of urban mobility at fine spatial resolution, overcoming the limitations of traditional surveys. However, it also has limitations: the data derive from a sample of mobile devices and represent normalized estimates rather than full population counts.

Effective local use

To measure the spatial scale of effective local mobility within Chicago metropolitan area, we constructed a high-resolution indicator of *daytime mobility proximity* using

anonymized visitation data from points of interest (POIs). Using this origin–destination structure, we construct flows between origin CBGs and destination POIs.

Using the origin–destination structure of the visitation data, we construct flows between origin CBGs—defined by primary daytime location (9am–5pm)—and destination POIs. Each POI is geolocated by latitude and longitude, and CBG geometries are obtained from the 2020 U.S. Census Bureau shapefile. For each flow (i,j) , we compute the Euclidean distance between the centroid of origin CBG i and the location of POI j . While this measure does not capture travel time, it provides a consistent approximation of spatial proximity across the urban system. We restrict the sample to flows whose origins fall within the administrative boundary of Chicago.

For each origin CBG i , we compute the share of total daytime visits that occur within a given radius r . We define three spatial thresholds - 1.25 km, 3 km, and 5 km - corresponding to hyperlocal, neighborhood, and broader local scales. The Effective Local Use Rate (ELUR) is defined as:

$$Effective\ Local\ Use_i(r) = \frac{\sum_{j:d_{ij} \leq r} Visitors_{ij}}{\sum_j Visitors_{ij}}$$

where i indexes origin CBGs (primary daytime location) and d_{ij} denotes the centroid-to-POI distance in meters. Defining origins by primary daytime location allows us to examine how mobility is structured around individuals’ daytime activity anchors, capturing patterns shaped by employment concentration and urban centrality.

Sociodemographic variables

We complement the mobility and amenity measures with neighborhood socio-demographic characteristics from the U.S. Census Bureau’s American Community Survey (ACS) 5-year estimates (2022). We retrieve data at the Census Block Group level for the set of counties that define the Chicago metropolitan area (Cook, DuPage, Lake, Will, Kane, McHenry, Kendall, DeKalb, and Grundy; Illinois). We extract variables capturing local socioeconomic conditions and population composition, including median household income, total population, median age, race counts, labor market status and unemployment, educational attainment (used to construct the share with bachelor’s degree or higher among residents aged 25+), housing tenure (used to compute owner and

renter shares), average household size, and commuting mode shares (including driving alone, carpooling, public transit, walking, bicycling, and working from home, as well as an “active modes” share). We additionally compute population density as total population divided by block-group land area (km²), and proxy centrality by measuring the distance from each block-group centroid to the Chicago CBD (the Loop) using projected coordinates.

Methods

Our empirical goal is to quantify how characteristics of the proximate service environment translate into realized local mobility, and to provide a behavioral interpretation of local mobility as either primarily voluntary (choice-driven) or constrained (restriction-driven). Given data availability and the focus on spatial heterogeneity in realized mobility patterns, we adopt a cross-sectional design. While this approach does not allow causal identification, it enables us to characterize systematic spatial gradients in opportunity and constraint mechanisms.

Baseline relationship

We estimate the cross-sectional relationship between realized local use and observable characteristics of the local service environment. Because origins are defined by primary daytime location, ELUR captures the concentration of visits around daytime activity anchors rather than strictly residential neighborhoods:

$$ELUR_i(R) = \alpha + \beta X_i(R) + \gamma Z_i(R) + \varepsilon_i,$$

Where $ELUR_i(R)$ denotes the share of trips from Census Block Group (CBG) i that occur within radius R . The vector X_i captures characteristics of the proximate service environment within radius R , including the number of establishments (extensive margin) and aggregated establishment characteristics such as average dwell time, average opening time, and the share of establishments with parking facilities (intensive margin).

The vector Z_i includes socio-demographic and structural controls measured at the CBG level (e.g., income, population density, commuting structure, education, and distance to the CBD). A positive coefficient on elements of $X_i(R)$ is consistent with an opportunity-responsive mechanism, whereby more attractive or accessible local service environments are associated with greater realized local use.

Disentangling Voluntary vs Constrained Local Mobility: Heterogeneous responsiveness

A core implication of the constraint mechanism is that resource-constrained neighborhoods should exhibit weaker responsiveness of local use to improvements in the proximate service environment. If mobility is primarily shaped by binding economic or structural constraints, realized local use may not systematically increase with more attractive or better-equipped nearby establishments.

To assess this, we allow the relationship between realized local use and service-environment characteristics to vary with neighborhood-level proxies for mobility constraints. Let C_i denote a constraint proxy measured at the CBG level (e.g., lower income, higher car dependence, lower educational attainment, or greater commuting burdens). We estimate:

$$ELUR_i(R) = \alpha + \beta_1 X_i(R) + \beta_2 X_i(R) * C_i + \gamma Z_i(R) + \varepsilon_i,$$

If $\beta_1 > 0$: on average, realized local use increases with improvements in the local service environment, consistent with opportunity responsiveness. If $\beta_2 > 0$: responsiveness is weaker in more constrained neighborhoods, consistent with constrained local mobility (i.e., local use is less driven by improvements in proximate service characteristics). Conversely, if constrained neighborhoods exhibit high baseline levels of ELUR regardless of service-environment characteristics, this pattern is consistent with forced localism rather than voluntary proximity-driven behavior.

All models are estimated using cross-sectional OLS with heteroskedasticity-robust standard errors. The unit of observation is the Census Block Group (CBG). The analysis focuses on 2022. We estimate all specifications across alternative radii (1.25 km, 3 km, 5 km) to assess whether responsiveness mechanisms operate differently across spatial scales. To further distinguish voluntary spatial selectivity from structural confinement, we construct an overshooting index measuring the extent to which trips extend beyond the hyperlocal radius.

Overshooting is defined as the difference between the share of visits occurring within a broader radius (3 km or 5 km) and the share occurring within the hyperlocal radius (1.25 km). Formally:

$$OS_i(R) = ELUR_i(R) - ELUR_i(1.25km) \text{ with } R \in \{3km, 5km\}$$

This measure captures the absolute spatial expansion of mobility beyond the immediate catchment area of the daytime anchor. Higher values indicate that a larger share of trips extends beyond the hyperlocal environment. To distinguish overall spatial expansion from the internal allocation of trips within the broader local radius, we also construct a relative overshooting ratio:

$$ROS_i(R) = \frac{ELUR_i(R) - ELUR_i(1.25km)}{ELUR_i(R)} \text{ with } R \in \{3km, 5km\}$$

This ratio measures the proportion of trips within the broader local catchment that occur outside the hyperlocal radius. While $OS_i(R)$ captures the extensiveness of spatial reach, $ROS_i(R)$ captures how mobility is distributed within the local activity space.

Conceptually, greater overshooting is consistent with voluntary spatial selectivity, whereby mobility expands beyond the immediate anchor when individuals have the capacity to choose across a broader neighborhood radius. Conversely, lower overshooting may reflect spatial confinement, where mobility remains concentrated near the daytime anchor due to structural constraints.

Descriptive evidence

Figure 1 displays the spatial distribution of the Effective Local Use Rate (ELUR) across Chicago neighborhoods for three distance thresholds (1.25 km, 3 km, and 5 km). As expected, the overall share of mobility resolved locally increases mechanically with the radius considered. However, the spatial distribution of local mobility remains markedly heterogeneous across neighborhoods. At the shortest radius (1.25 km), local mobility appears highly dispersed, with substantial variation even among adjacent census block groups. As the radius expands to 3 km, more structured spatial patterns begin to emerge. At 5 km, a clearer spatial gradient becomes visible, suggesting that local mobility is not randomly distributed but follows broader urban structures.

In particular, central-eastern neighborhoods display consistently higher shares of locally resolved mobility, while several southern peripheral areas exhibit comparatively lower local mobility even at larger radii. This pattern may reflect differences in urban density, land-use composition, or the spatial distribution of services. However, since the measure captures daytime-origin mobility from origin CBGs defined by primary daytime location, part of the observed variation may also reflect the functional differentiation between predominantly residential areas and mixed-use or employment-intensive zones. These descriptive patterns suggest that effective local mobility is spatially structured, but they do not yet allow us to distinguish whether higher local mobility reflects proximity-based opportunities, voluntary behavioral preferences, or structural constraints.

[Figure 1 here]

Figure 2 plots the Effective Local Use Rate (ELUR) within a 1.25 km radius against distance to Chicago's central business district (CBD). The relationship suggests a negative spatial gradient: hyperlocal mobility tends to decline as distance from the urban core increases. Peripheral neighborhoods rarely exhibit high levels of short-distance mobility, with most census block groups beyond 15 km displaying ELUR values below 0.10.

However, the gradient is far from deterministic. Substantial dispersion characterizes central areas, where census block groups located at similar distances from the CBD exhibit markedly different mobility patterns ($R^2 \approx 0.14$). In particular, neighborhoods within the first few kilometers of the CBD range from very low to exceptionally high ELUR values. This heterogeneity may reflect functional differences between employment-dominated zones and dense mixed-use or predominantly residential neighborhoods.

Overall, distance to the CBD captures an important structural dimension of urban centrality but provides only limited explanatory power for effective local mobility. The persistence of dispersion at short distances suggests that proximity to the urban core alone does not determine local travel behavior. Instead, neighborhood-level characteristics—such as land-use composition, service density, and socioeconomic structure—are likely to account for a substantial share of the observed variation. As in the previous analysis, origins are defined based on daytime device location (9am–5pm), which may partly

reflect employment concentration in central areas. Consequently, some central census block groups may capture work-based rather than purely residential mobility patterns.

[Figure 2 here]

Table 1 reports summary statistics for Census Block Groups (CBGs) in the Chicago metropolitan area in 2022. On average, CBGs generate approximately 58,000 annual outgoing visits, although mobility volumes are highly dispersed across neighborhoods. The Effective Local Use Rate (ELUR) indicates that only 9.2% of trips occur within 1.25 km of the CBG centroid, increasing to 19.7% within 3 km and 30.1% within 5 km. These figures suggest that most daily mobility extends beyond very short distances, even within a dense metropolitan context.

The local service environment within a 1.25 km radius also exhibits substantial heterogeneity. The average CBG hosts a sizable number of establishments (log mean \approx 4.58), though dispersion is considerable. Establishments operate for roughly 4,200 minutes per week on average (log-transformed), and the average logged dwell time is 3.62, indicating meaningful variation in service intensity across neighborhoods. Only about 3.3% of establishments are flagged as including an on-site parking lot, suggesting that explicitly car-oriented facilities constitute a small share of proximate services. In terms of functional composition, essential services (education and healthcare) account for approximately 15% of nearby establishments, while recreational amenities represent about 31%, pointing to differences in the structure of local opportunity sets.

Socioeconomic characteristics likewise display marked spatial variation. Average population density (in logs) corresponds to dense urban conditions, and the mean distance to the central business district (CBD) is 12.2 km. Median household income (in logs) and educational attainment vary substantially across CBGs, with 38% of residents aged 25 and over holding at least a bachelor's degree. Labor market indicators and demographic composition further reveal heterogeneity, while nearly 60% of workers commute by car, indicating significant car dependence in many areas. Taken together, these patterns highlight pronounced differences in both local opportunity structures and neighborhood socioeconomic conditions, providing a suitable empirical setting to examine whether observed local mobility reflects voluntary proximity-based choices or binding spatial and socioeconomic constraints.

[Table 1 here]

Results

Table 2 reports cross-sectional associations between local service environment characteristics and the share of trips occurring within 1.25 km of the Census Block Group centroid (ELUR). Estimates should be interpreted as conditional correlations.

Column (1) shows that service density, temporal availability, and the share of essential establishments within 1.25 km are positively associated with local mobility. Areas with more establishments and longer opening hours exhibit higher shares of short-distance trips, consistent with the idea that accessible and functionally dense environments facilitate hyperlocal activity. Column (2) adds urban form and socioeconomic controls. The positive associations for service density, opening hours, and essential services remain robust, indicating that these relationships are not fully explained by demographic composition. At the same time, systematic socioeconomic gradients emerge. Median household income and car commuting share are negatively associated with local mobility, whereas population density and educational attainment are positively associated. Parking availability is also negatively related to local travel, highlighting the role of car-oriented urban design.

Taken together, the results indicate that local mobility is structured by both opportunity and constraint. Dense and service-rich environments are associated with higher local use, yet lower-income and less car-dependent areas also exhibit higher hyperlocal shares. These patterns suggest that local mobility may reflect a combination of facilitation mechanisms—where proximity enables voluntary local activity—and structural constraints that limit the spatial expansion of activity around daytime anchors.

[Table 2 about here]

Table 3 examines whether the relationship between service accessibility and local mobility differs across income levels. Building on the baseline results, we find clear evidence of heterogeneous responsiveness. The interaction between local service density and income is positive and statistically significant, indicating that the elasticity of local mobility with respect to nearby opportunities increases with income. In higher-income neighborhoods, additional establishments are associated with larger increases in short-distance trips. A similar pattern emerges for temporal availability. Greater opening hours

translate into stronger local mobility responses in higher-income areas. At the same time, the main effect of income remains negative, implying that, conditional on similar levels of service provision, higher-income neighborhoods tend to exhibit lower baseline local mobility.

Taken together, these results refine the interpretation from Table 2. While lower-income areas display higher average levels of local mobility, higher-income neighborhoods appear more responsive to improvements in local opportunity structures. This combination of a negative income main effect and a positive interaction term is consistent with a dual mechanism: baseline hyperlocal concentration in lower-income contexts coexists with greater opportunity responsiveness in higher-income neighborhoods. Finally, areas with higher prevalence of remote work exhibit lower shares of short-distance trips, consistent with reduced daily travel demand in more telework-intensive environments.

[Table 3 about here]

Table 4 extends the analysis by examining whether income heterogeneity in local mobility varies across spatial scales. Using alternative radii (1.25 km, 3 km, and 5 km), we assess how the responsiveness to local service availability evolves with distance.

[Table 4 about here]

At the local scale (1.25 km), service density is positively associated with local mobility, and its interaction with income remains significant, confirming that higher-income neighborhoods are more responsive to nearby opportunities. At the intermediate 3 km scale, this heterogeneous responsiveness becomes even stronger, indicating that income conditions not only condition hyperlocal mobility but also activity within the broader neighborhood environment. By contrast, at the 5 km scale, the interaction between income and service density attenuates and loses statistical significance. This suggests that income-based selectivity operates primarily at short and medium distances, while mobility patterns at larger urban scales are shaped by additional citywide factors.

Urban form effects also vary with scale. Density is positively associated with mobility at shorter distances but not at 5 km, and car-oriented features become increasingly relevant as the radius expands. Taken together, these findings indicate that the dual mechanism

identified in Tables 2 and 3—facilitation versus constraint—is fundamentally scale-dependent. Income-conditioned responsiveness emerges within neighborhood-sized catchments, whereas broader spatial mobility reflects more complex structural forces.

[Table 5 about here]

Table 5 moves beyond local intensity to examine spatial expansion beyond the hyperlocal radius. The dependent variables measure overshooting as the difference between the share of trips occurring within 3 km (or 5 km) and those occurring within 1.25 km. Higher values therefore indicate greater spatial expansion beyond the immediate neighborhood.

Consistent with the heterogeneity identified in Tables 2–4, we find evidence of income-conditioned spatial selectivity at the 3 km scale. The interaction between income and nearby service density is positive and statistically significant, indicating that higher-income neighborhoods exhibit stronger expansion beyond the hyperlocal catchment when local opportunities are abundant. This pattern aligns with a voluntary selectivity mechanism: proximity does not necessarily confine activity when residents have the capacity to choose across a broader neighborhood radius.

By contrast, the interaction attenuates at 5 km, suggesting that expansion at larger urban scales reflects additional structural factors beyond neighborhood-level opportunity. Moreover, a higher share of essential services within 1.25 km is associated with lower overshooting at both distances, indicating that nearby essential amenities anchor activity within the immediate catchment. Car-oriented built environments also shape spatial reach, particularly at 5 km, where parking availability is associated with less mobility being contained within local thresholds.

[Table 6 about here]

Table 6 assesses whether these results reflect differences in the absolute extent of spatial expansion or instead differences in how mobility is distributed within local travel ranges. Using a relative overshooting ratio that conditions on trips remaining within 3 km or 5 km, we find that greater service density and temporal availability within 1.25 km are associated with lower relative overshooting. In other words, abundant nearby opportunities increase the concentration of mobility within the hyperlocal catchment.

Importantly, the income interaction is no longer statistically significant in this specification. This suggests that income-conditioned selectivity operates primarily through differences in the overall extent of spatial expansion rather than through the internal allocation of trips within the local radius. Taken together, Tables 5 and 6 indicate that higher-income neighborhoods exhibit greater absolute spatial expansion at intermediate scales, consistent with voluntary selectivity, while the internal distribution of local trips is more strongly structured by the built environment and the availability of essential services.

The results reveal a scale-dependent pattern of socioeconomic heterogeneity in effective local mobility. Income differences are most salient within neighborhood-sized catchments (1.25–3 km), where higher-income areas exhibit stronger responsiveness to proximate service environments and greater spatial expansion beyond the hyperlocal anchor. However, this heterogeneity attenuates at broader urban scales (5 km), suggesting that metropolitan mobility is shaped more strongly by structural factors than by selective neighborhood-level opportunity use. The overshooting analysis further clarifies this mechanism. While higher-income neighborhoods display greater absolute expansion beyond the hyperlocal radius, income differences disappear when conditioning on trips within a comparable local range. This indicates that socioeconomic heterogeneity operates primarily through differences in the extensiveness of activity-space expansion rather than through differential allocation of trips within similar spatial bounds. In sum, inequality in local mobility appears to reflect variation in how far activity spaces extend, not how mobility is internally distributed once a given local radius is reached.

Conclusions

The growing literature on the 15-minute city emphasizes proximity as a normative goal for sustainable and resilient urban development. However, recent empirical research has highlighted a persistent gap between potential accessibility and realized mobility, as well as substantial spatial and socioeconomic heterogeneity in how proximity translates into behavior. This paper contributes to that debate by providing a behavioral interpretation of localized mobility grounded in observed activity patterns.

Building on the distinction between potential and effective accessibility, we show that realized local mobility reflects both opportunity and constraint. Service density and

temporal availability are positively associated with hyperlocal use, consistent with proximity-based facilitation. Yet lower-income and less car-dependent neighborhoods exhibit higher baseline levels of local mobility, suggesting that proximity may also reflect restricted spatial reach. By examining heterogeneous responsiveness, we demonstrate that higher-income neighborhoods respond more strongly to improvements in nearby opportunity structures. This combination of lower baseline local use but stronger responsiveness among higher-income areas is consistent with a dual mechanism in which proximity may reflect voluntary selectivity in some contexts and structural confinement in others.

Importantly, this dual mechanism is scale-dependent. Income-conditioned responsiveness emerges most clearly within short and intermediate neighborhood-sized radii (1.25–3 km) but attenuates at larger urban scales (5 km), where mobility patterns are more strongly structured by metropolitan employment geography and citywide transport systems. The overshooting analysis further clarifies this mechanism. Higher-income neighborhoods expand their activity spaces beyond the hyperlocal anchor when proximate opportunities are abundant, indicating greater spatial extensiveness. However, when conditioning on trips within a comparable local range, income differences disappear. This suggests that socioeconomic heterogeneity operates primarily through differences in how far activity spaces extend, rather than through differential allocation of trips once a given spatial radius is reached.

Taken together, these findings imply that proximity should not be treated as an unambiguous indicator of urban success. High levels of localized mobility may reflect accessibility-enhancing planning in some neighborhoods, but constrained spatial reach in others. The policy implications are therefore asymmetric. Improving the quality and diversity of services in lower-income areas may transform constrained proximity into genuine spatial choice, whereas promoting localism without addressing inequality risks normalizing restricted mobility conditions. By shifting the focus from how much local mobility exists to how far activity spaces extend—and for whom proximity translates into realized use—this paper reframes localized mobility not as an intrinsic urban virtue, but as an outcome whose welfare meaning depends critically on socioeconomic context and spatial scale.

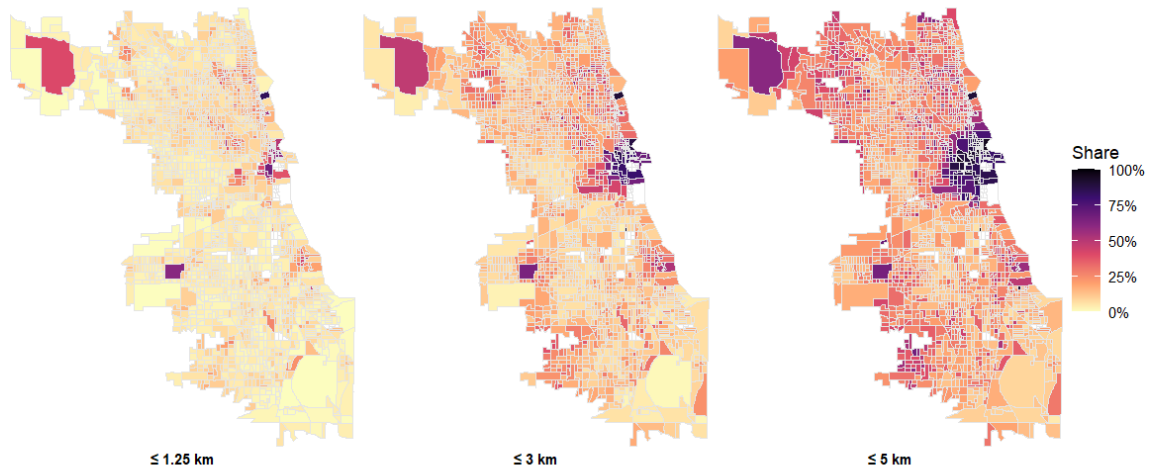
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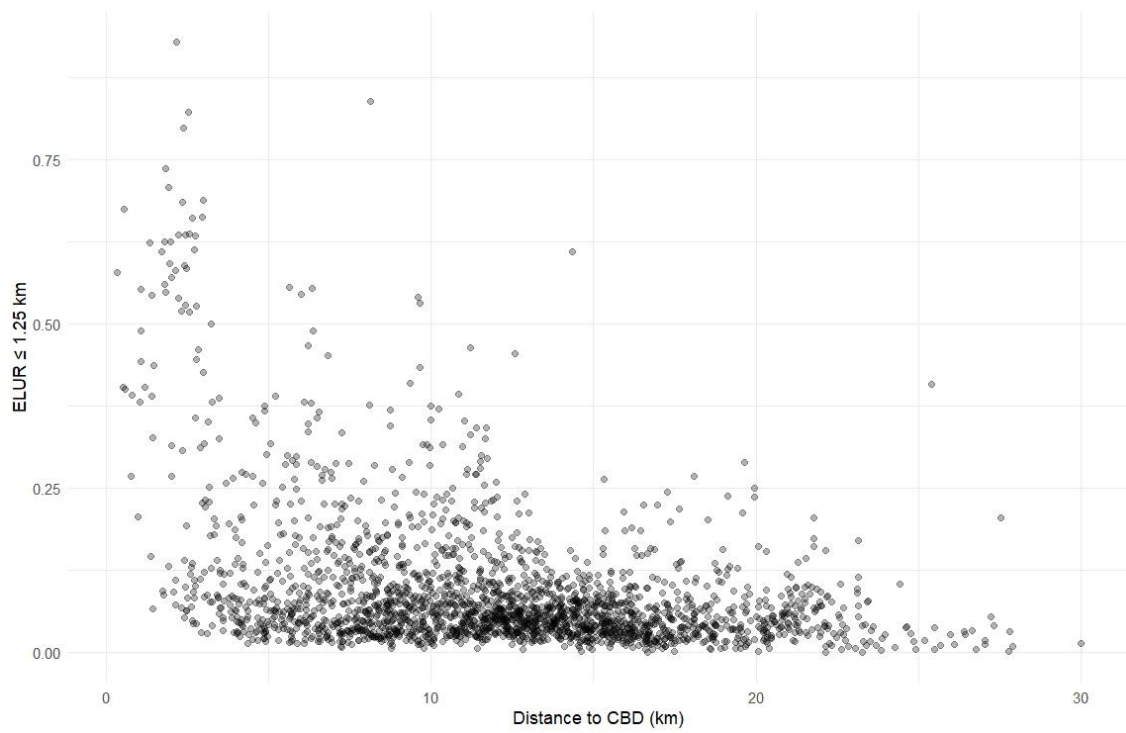
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Figure 1. Local mobility share by radius in Chicago



Notes: The figure maps the Effective Local Use Rate (ELUR), defined as the share of trips originating in each Census Block Group (CBG) that occur within the indicated radius (≤ 1.25 km, ≤ 3 km, and ≤ 5 km) from the CBG centroid. Each panel computes both the outcome and the corresponding local service environment within the same spatial radius. Darker colors indicate a higher share of short-distance trips. Values are expressed as percentages. Author's calculations based on mobile device mobility data and Census geography.

Figure 2 Scatter plot: Local mobility vs Distance to CBD



Notes: The figure plots the Effective Local Use Rate (ELUR \leq 1.25 km), defined as the share of trips originating in each Census Block Group (CBG) that occur within 1.25 km of the CBG centroid, against distance to the Central Business District (CBD), measured in kilometers. Each point represents one CBG. The figure illustrates the bivariate association between spatial centrality and local mobility patterns. Author's calculations.

Table 1. Descriptives

VARIABLES	(1) mean	(2) sd	(3) N
Panel A: Mobility outcomes			
Total trips from CBG	58,087.349	126,731.991	2,264.000
ELUR: share of trips within 1.25 km	0.092	0.105	2,264.000
ELUR: share of trips within 3 km	0.197	0.154	2,264.000
ELUR: share of trips within 5 km	0.301	0.186	2,264.000
Panel B: Local service environment (1.25 km)			
Log number of POIs (1.25 km)	4.579	0.878	2,259.000
log POIs avg. open minutes within 1.25km from centroid	8.327	0.089	1,854.000
Log avg. dwell time of POIs within 1.25 km	3.620	0.331	2,213.000
% POIs with parking space within 1.25km from centroid	0.033	0.022	2,259.000
Share essential POIs (edu+health) (1.25 km)	0.149	0.065	2,259.000
Share recreational POIs (1.25 km)	0.306	0.069	2,259.000
Panel C: Socioeconomic and structural characteristics			
Log population density	8.655	0.845	2,260.000
Distance to CBD (KM)	12.167	5.312	2,264.000
Log median household income	11.141	0.589	1,990.000
Share of children aged 0-4	0.291	0.241	2,175.000
Car commuting share	0.598	0.220	2,258.000
Racial diversity index	0.355	0.250	2,260.000
% Bachelor's degree or higher (+25 years old)	0.382	0.268	2,260.000
Car commuting share	0.598	0.220	2,258.000
Median Age of CBG	38.116	9.114	2,260.000
Share of workers working from home	0.132	0.118	2,258.000
Unemployment rate of CBG	0.095	0.101	2,259.000

Notes: ELUR denotes the share of trips occurring within the specified radius from the CBG centroid. Opening minutes and dwell time are log-transformed. Sample size varies across variables due to missing information in establishment characteristics (e.g., opening hours).

Table 2. Baseline results

VARIABLES	(1) (1) Local Environment	(2) (2) + Urban & Socioeconomic Controls
Log number of POIs (1.25 km)	0.087*** (0.006)	0.068*** (0.008)
log POIs avg. open minutes within 1.25km from centroid	0.129*** (0.030)	0.096*** (0.026)
Log avg. dwell time of POIs within 1.25 km	0.026*** (0.006)	-0.008 (0.007)
% POIs with parking space within 1.25km from centroid	-0.210 (0.133)	-0.318** (0.143)
Share essential POIs (edu+health) (1.25 km)	0.351*** (0.039)	0.256*** (0.047)
Share recreational POIs (1.25 km)	0.035 (0.040)	-0.177*** (0.052)
Log population density		0.015*** (0.003)
Distance to CBD (KM)		0.002*** (0.001)
Log median household income		-0.023*** (0.005)
% Bachelor's degree or higher (+25 years old)		0.103*** (0.016)
Unemployment rate of CBG		-0.009 (0.022)
Share of children aged 0b4 among children (<18)		0.019* (0.011)
Car commuting share		-0.063*** (0.017)
Share of workers working from home		-0.045 (0.028)
Racial diversity index		-0.008 (0.009)
Constant	-1.539*** (0.260)	-0.865*** (0.259)
Observations	1,851	1,587
Adjusted R-squared	0.439	0.468

Notes: The dependent variable is the share of trips occurring within 1.25 km of the Census Block Group (CBG) centroid (ELUR). All regressions are estimated using OLS with heteroskedasticity-robust standard errors reported in parentheses. Log-transformed variables include the number of POIs, average weekly opening minutes, average dwell time, population density, and median household income. Service composition shares are measured relative to the total number of establishments within a 1.25 km radius. The omitted service category includes commercial, workplace, and residential/living-space establishments. *** p<0.01, ** p<0.05, * p<0.1.

Table 3. Heterogeneous Responsiveness of Local Mobility by Income

VARIABLES	(1) Income Interaction
Log number of POIs (1.25 km)	0.060*** (0.008)
Log income (centered)	-0.709* (0.363)
Log number of POIs (1.25 km) x Log Income (centered)	0.021* (0.011)
log POIs avg. open minutes within 1.25km from centroid	0.078*** (0.026)
log POIs avg. open minutes within 1.25km from centroid x Log Income	0.070* (0.041)
Share essential POIs (edu+health) (1.25 km)	0.256*** (0.047)
Share recreational POIs (1.25 km)	-0.170*** (0.052)
% POIs with parking space within 1.25km from centroid	-0.290** (0.137)
Log population density	0.016*** (0.003)
Distance to CBD (KM)	0.002*** (0.001)
% Bachelor's degree or higher (+25 years old)	0.101*** (0.015)
Unemployment rate of CBG	-0.026 (0.021)
Share of children aged 0-4 (<18)	0.018* (0.011)
Car commuting share	-0.065*** (0.016)
Share of workers working from home	-0.046* (0.027)
Racial diversity index	-0.003 (0.009)
Constant	-0.979*** (0.231)
Observations	1,590
Adjusted R-squared	0.470

Notes: The dependent variable is the share of trips occurring within 1.25 km of the Census Block Group (CBG) centroid (ELUR). Log income is mean-centered to facilitate interpretation of interaction effects.. All regressions are estimated using OLS with heteroskedasticity-robust standard errors reported in parentheses. Service composition shares are measured relative to the total number of establishments within a 1.25 km radius. *** p<0.01, ** p<0.05, * p<0.1.

Table 4. Income Heterogeneity in Local Mobility Across Spatial Scales

VARIABLES	(1) 1.25 km	(2) 3 km	(3) 5 km
Log number of POIs	0.058*** (0.008)	0.046*** (0.010)	-0.003 (0.015)
Log income (centered)	-0.683* (0.362)	-2.835*** (0.898)	-1.117 (1.249)
Log number of POIs x Log Income (centered)	0.021** (0.011)	0.058*** (0.012)	0.017 (0.013)
log POIs avg. open minute	0.088*** (0.025)	0.206*** (0.076)	0.913*** (0.142)
log POIs avg. open minute x Log income (centered)	0.067* (0.040)	0.295*** (0.103)	0.121 (0.143)
Share essential POIs (edu+health)	0.263*** (0.047)	0.438*** (0.098)	2.142*** (0.229)
Share recreational POIs	-0.168*** (0.052)	-0.738*** (0.118)	-0.831*** (0.142)
% POIs with parking space from centroid	-0.300** (0.135)	-0.713 (0.488)	-6.192*** (0.924)
Log population density	0.015*** (0.003)	0.016*** (0.004)	0.003 (0.005)
Distance to CBD (KM)	0.002*** (0.001)	0.001 (0.001)	-0.005*** (0.001)
% Bachelor's degree or higher (+25 years old)	0.093*** (0.015)	0.240*** (0.024)	0.205*** (0.026)
Unemployment rate of CBG	-0.019 (0.021)	-0.036 (0.028)	-0.038 (0.037)
Share of children aged 0-4	0.018 (0.011)	0.023* (0.013)	0.008 (0.015)
Car commuting share	-0.067*** (0.016)	-0.104*** (0.020)	-0.043* (0.026)
Share of workers working from home	-0.048* (0.028)	-0.099*** (0.035)	-0.077* (0.043)
Racial diversity index	-0.006 (0.010)	-0.006 (0.012)	0.009 (0.014)
Missig data on POIs	-0.072* (0.038)	-0.122* (0.071)	-0.455*** (0.136)
Constant	-1.001*** (0.224)	-1.744*** (0.650)	-6.915*** (1.210)
Observations	1,590	1,872	1,909
Adj. R-squared	0.470	0.452	0.443

Notes: The dependent variable is the Effective Local Use Rate (ELUR), defined as the share of trips occurring within the radius indicated in each column (1.25 km, 3 km, and 5 km) from the Census Block Group (CBG) centroid. Local service-environment variables (log number of POIs, log average weekly opening minutes, parking share, and service composition shares) are computed within the same radius as the outcome in each column. Log household income is mean-centered; hence, the main effects for local service variables correspond to the effect at average income, while interaction terms capture differential responsiveness by income. "Missing data on POIs" denotes the share of establishments within the relevant radius with missing opening-hours information. All models are estimated using OLS with heteroskedasticity-robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 5. Determinants of Spatial Overshooting at 3 km and 5 km

VARIABLES	(1) 3 km	(2) 5 km
Log number of POIs (1.25 km)	0.014** (0.007)	-0.012 (0.010)
Log income (centered)	-0.510 (0.323)	-0.327 (0.458)
Log number of POIs x Log Income (centered)	0.023*** (0.008)	0.015 (0.011)
log POIs avg. open minutes within 1.25km from centroid	-0.005 (0.024)	-0.006 (0.039)
log POIs avg. open minute x Log income (centered)	0.050 (0.037)	0.035 (0.053)
Share essential POIs (edu+health) (1.25 km)	-0.090** (0.041)	-0.156** (0.067)
Share recreational POIs (1.25 km)	-0.122*** (0.047)	0.006 (0.071)
% POIs with parking space within 1.25km from centroid	-0.157 (0.118)	-0.645*** (0.202)
Log population density	-0.006 (0.004)	-0.019*** (0.006)
Distance to CBD (KM)	-0.000 (0.001)	-0.006*** (0.001)
% Bachelor's degree or higher (+25 years old)	0.091*** (0.015)	0.109*** (0.024)
Unemployment rate of CBG	0.016 (0.021)	-0.002 (0.036)
Share of children aged 0-4 among children (<18)	-0.005 (0.009)	-0.017 (0.015)
Car commuting share	-0.008 (0.013)	0.011 (0.025)
Share of workers working from home	-0.059** (0.024)	-0.075* (0.041)
Racial diversity index	-0.004 (0.009)	-0.021 (0.016)
Constant	0.219 (0.201)	0.717** (0.337)
Observations	1,590	1590
Adjusted R-squared	0.203	0.196

Notes: The dependent variables are spatial overshooting indices defined as the difference between the share of trips occurring within 3 km (Column 1) or 5 km (Column 2) and the share occurring within 1.25 km of the Census Block Group (CBG) centroid. Higher values indicate greater spatial expansion beyond the immediate neighborhood. Local service characteristics are measured within a 1.25 km radius to capture immediate opportunity structures. Log household income is mean-centered; hence, the main effects correspond to average income levels, and interaction terms capture heterogeneous responsiveness by income. All regressions are estimated using OLS with heteroskedasticity-robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 6. Determinants of Relative Spatial Overshooting

VARIABLES	(1) 3 km	(2) 5 km
Log number of POIs (1.25 km)	-0.060*** (0.014)	-0.064*** (0.011)
Log income (centered)	0.516 (0.755)	0.821 (0.567)
Log number of POIs x Log Income (centered)	0.009 (0.015)	-0.004 (0.012)
log POIs avg. open minutes within 1.25km from centroid	-0.131** (0.058)	-0.111** (0.046)
log POIs avg. open minute x Log income (centered)	-0.059 (0.089)	-0.088 (0.066)
Share essential POIs (edu+health) (1.25 km)	-0.409*** (0.100)	-0.461*** (0.087)
Share recreational POIs (1.25 km)	0.014 (0.096)	0.085 (0.081)
% POIs with parking space within 1.25km from centroid	-0.451 (0.313)	-0.339 (0.266)
Log population density	-0.040*** (0.007)	-0.037*** (0.006)
Distance to CBD (KM)	-0.001 (0.001)	-0.005*** (0.001)
% Bachelor's degree or higher (+25 years old)	0.023 (0.033)	-0.037 (0.028)
Unemployment rate of CBG	0.011 (0.056)	0.007 (0.045)
Share of children aged 0-4 among children (<18)	-0.015 (0.018)	-0.023 (0.016)
Car commuting share	0.103*** (0.034)	0.135*** (0.030)
Share of workers working from home	-0.025 (0.054)	0.022 (0.050)
Racial diversity index	0.012 (0.021)	-0.010 (0.018)
Missing data in POI's (share)	0.239*** (0.087)	0.281*** (0.069)
Constant	2.167*** (0.494)	2.141*** (0.394)
Observations	1,590	1,590
Adj. R-squared	0.190	0.278

Notes: The dependent variables are relative spatial overshooting indices defined as the proportion of trips occurring within 3 km (Column 1) or 5 km (Column 2) that take place beyond the immediate 1.25 km radius. Specifically, the overshooting ratio is computed as $(\text{share}_{\leq R} - \text{share}_{\leq 1.25}) / \text{share}_{\leq R}$, where $R \in \{3 \text{ km}, 5 \text{ km}\}$. Higher values indicate a greater share of local mobility occurring outside the hyperlocal catchment but still within the broader local radius. Local service characteristics are measured within 1.25 km to capture immediate opportunity structures. All models are estimated using OLS with heteroskedasticity-robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.