Impact of Urban Built Environment on Commuting Mode Choice from the Perspective of Residential Self-Selection: A Case Study of the Main Urban Area of Lanzhou (Postprint)

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Abstract

Research on transportation mode choice is crucial for efficient, sustainable, and safe urban transportation planning. Taking the main urban area of Lanzhou City as an example, and based on distributed cognition theory, this study employs survey questionnaire data, road network data, and POI data to investigate, through a structural equation model, the influence of non-random heterogeneous built environments on commuting mode choice under the influence of residential self-selection effects. The results indicate: (1) Residents choose residential neighborhoods with different built environment characteristics based on their socioeconomic attributes and attitudinal preferences, subsequently forming specific commuting patterns, which demonstrates that residential self-selection exhibits preference heterogeneity and that the residential self-selection effect exists. (2) After controlling for residential self-selection effects, the built environment still has a significant impact on commuting mode choice. Specifically, population density, road network density, and the number of parking spaces directly influence commuting mode choice, while road network density, bus stop accessibility, subway station accessibility, and the number of parking spaces indirectly influence commuting mode choice through the mediating variables of commuting distance and car ownership. (3) Built environments with high population density, dense road networks, and high accessibility further promote active commuting mode and public transportation commuting mode choices by enhancing road network connectivity and the connectivity between walking and public transit, guiding residents toward a travel structure dominated by active commuting modes.

Full Text

Preamble

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Impact of Urban Built Environment on Commuting Mode Choices from the Residential Self-Selection Perspective: A Case Study of Lanzhou' s Main Urban Area

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Abstract: Research on travel mode choice is essential for efficient, sustainable, and safe urban traffic planning. This study selected the main urban area of Lanzhou City as the study area. Based on distributed cognition theory and using questionnaire data, road network data, and POI data, a structural equation model was employed to explore the impact of non-random heterogeneity in the built environment on commuting mode selection under the influence of residential self-selection effects. The results indicate that: (1) Residents select residential communities with different built-environment characteristics according to their socioeconomic attributes and attitude preferences, subsequently forming specific commuting patterns. This demonstrates preference heterogeneity in residential self-selection and confirms the existence of the residential self-selection effect. (2) After controlling for residential self-selection effects, the built environment continues to exert significant influence on commuting mode choice. Specifically, population density, road network density, and parking space quantity directly affect commuting mode choice, while road network density, bus stop accessibility, subway station accessibility, and parking space quantity indirectly influence commuting mode choice through the mediating variables of commuting distance and car ownership. (3) Built environments characterized by high population density, dense road networks, and high accessibility promote active commuting and public transit commuting modes by enhancing road network connectivity and the integration between walking and public transportation, thereby guiding residents toward a travel structure dominated by active commuting patterns.

Keywords: built environment; commuting mode choices; residential self-selection; structural equation model (SEM); Lanzhou City

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1. Introduction

Since the turn of the 21st century, rapid urbanization, urban spatial expansion, and increasing motorization levels have gradually shifted residents' daily travel modes from active travel (i.e., walking and cycling) to motor vehicle travel, causing a series of urban problems including traffic congestion, accidents, and environmental pollution. Excessive dependence on motor vehicles has also led to increased energy consumption and carbon emissions. According to the International Energy Agency (IEA), transportation has become the second-largest source of carbon emissions, accounting for 39.31% of global carbon emissions. In China, commuting trips constitute a significant portion of daily travel. The 2018 Baidu Map Urban Transportation Report indicates that commuting travel accounts for approximately 40% of residents' daily travel volume in major Chinese cities.

In response to these challenges, research on influencing factors of residents' travel behavior has gradually deepened since the 1990s, when developed countries' "extensive" urban expansion models led to rapid growth in automobile demand. These factors can be broadly categorized into four domains: socioeconomic and demographic attributes; travel type and trip characteristics; urban spatial structure and built environment; and attitudes and psychological factors. From a geographical and planning perspective, scholars have focused more on how different travel mode choices affect the built environment to adjust and optimize travel mode structures. The built environment can be quantitatively characterized through five dimensions: density, diversity, design, destination accessibility, and distance to transit. However, consensus has not yet been reached regarding the impact of different built-environment variables on mode choice behavior. Consequently, how to guide residents to shift commuting modes to solve urban problems and achieve sustainable transportation development has become a focus for scholars and urban managers.

China's urban residential planning has transformed from the "unit allocation system" with strict functional zoning to a market-oriented, "people-centered" personalized supply model, resulting in significant changes in living environments and travel patterns. Early studies typically adopted a holistic approach, dividing communities into different types to compare residents' travel behaviors or the impact of community types on travel behavior. Research found that residents in unit housing spent significantly less time in private cars and had higher probabilities of active travel, indicating that jobs-housing imbalance is a primary determinant of commuting time, distance, and motor vehicle dependence. Later studies gradually analyzed residents' travel behavior from different dimensions of the built environment. Regarding density, areas with high intensity of human activities per unit land area help shorten travel distances; high population and building density correlate with shorter travel times and higher non-motorized travel rates. In terms of diversity, high land-use mix and diverse urban functions reduce the probability of motorized travel. Regarding design, areas with high road network density, small block sizes, and numerous intersections encourage residents to choose active travel modes. For distance to transit, proximity to bus stops increases the likelihood of choosing public transportation. In terms of destination accessibility, the distance from residence to city center significantly affects motor vehicle commuting mode choice; as this distance increases, the probability of public transit use decreases while motor vehicle use increases. However, research matching infrastructure supply with commuting modes has received relatively less attention.

In summary, most studies have focused on the direct impact of the built environment on commuting behavior while ignoring the indirect effects of mediating variables. Meanwhile, only a few studies domestically and internationally have considered residential self-selection issues. Residential self-selection refers to the phenomenon where residents, based on their socioeconomic attributes and attitude preferences, choose residences in different built environments, and their commuting modes are subject to selection bias. However, the resulting direct and indirect impacts may produce complementary rebound effects. Therefore, examining the impact mechanism of built environment on commuting mode choice from the perspective of residential self-selection can provide new policy entry points for green transportation modes and residents' travel behavior transformation.

Existing research has mostly focused on economically and culturally developed cities such as Beijing and Shanghai, with less attention paid to underdeveloped regions in central and western China. Therefore, this study takes Lanzhou's main urban area as a case study. Based on the distributed cognition theoretical framework, a structural equation model is constructed to examine the impact mechanism of the built environment on commuting mode choice, considering the mediating effects of commuting distance and car ownership while controlling for residential self-selection effects.

1.1 Study Area Overview

As an important central city in northwestern China and the only provincial capital through which the Yellow River flows, Lanzhou's urban form is constrained by valley topography and mountains to its north and south, creating a ribbon-like "two mountains flanking a river" morphology. The main urban area, serving as the primary population agglomeration region, accounts for 84.05% of the city's total population and exhibits the following characteristics: (1) The arterial road network is incomplete, with bottlenecks forming at the city's narrow waist sections and river/railway crossing points. "East-west congestion and north-south obstruction" remain persistent problems. Road network density (4.13 $km \cdot km^{-2}$) is far below the national average for major cities (5.96 $km \cdot km^{-2}$). (2) The urban rail transit system is limited to a single east-west line with a daily average passenger volume of 5 人次 and a 分担率仅为公交出行的 (the 分担率 is only…- this seems incomplete, but I'll preserve the structure). The connection rate with the bus network is insufficient. (3) Traffic flow shows significant directional characteristics with unbalanced road loads. Constrained by the narrow east-west terrain, major traffic arteries primarily extend along both banks of the Yellow River, with east-west traffic volume accounting for over 70% of total traffic, causing severe congestion during peak commuting hours.

Therefore, this study selected the main urban area as the research region, including Chengguan District, Qilihe District, Anning District, and Xigu District

(Figure 1).

[Figure 1: see original paper]

1.2 Data Sources

Data include spatial data on the built environment and field questionnaire survey data. Built environment data comprise POI data from Amap, Worldpop population raster data, and basic geographic information spatial data obtained from Google remote sensing imagery.

Socioeconomic attribute data and residents' commuting mode data were derived from questionnaire surveys. To ensure scientific rigor and representativeness, a combination of random sampling and cross-control quota sampling (by gender and age) was employed according to street-level population density distributions. A pilot survey was conducted among residents of nearby communities before the formal survey, and the questionnaire was revised based on feedback. Formal face-to-face, random-intercept surveys were conducted in community activity centers and open spaces from [dates not fully specified], recording commuting modes, travel attitudes, and socioeconomic attributes of residents aged 18 and above. A total of [number not specified] valid questionnaires were obtained. The socioeconomic attributes of the sample are shown in Table 1. Reliability testing was conducted using Cronbach's alpha, with results indicating the questionnaire data passed reliability tests.

1.3 Research Methods

The structural equation model (SEM) is a multivariate data analysis tool based on variable covariance matrices that can measure multiple relationships among variables, where a variable can serve as an outcome (dependent variable) in one set of relationships and as a predictor (independent variable) in others. This study explores the impact of the built environment on commuting mode choice, where commuting mode is a four-category variable with both direct and indirect relationships among variables. Therefore, SEM was constructed and estimated using maximum likelihood estimation to analyze the effects.

2.1 Theoretical Foundation and Research Hypotheses

Distributed cognition theory, a new branch of cognitive science, originates from research on cognitive activities in classroom settings. Hatch and Gardner proposed the concentric circle model of distributed cognition (Figure 2), which takes the comprehensive system of interaction and 博弈 between individuals and their environment as the theoretical foundation for analyzing cognitive phenomena from three perspectives: "personal force," "local force," and "cultural force." This provides strong explanatory power for individual cognitive activities in complex social environments. "Personal force" refers to individual characteristics influenced by subjective experiences and tendencies in a given environment, including gender, age, household size, education, household registration, household income, car ownership, and housing tenure, forming the core of the concentric circle. "Local force" comprises regional resources and objective environments that interact with cognitive activities in local contexts, serving as the key layer of the concentric circle. Compared to workplace built environments, residential built environments have more significant impacts on commuting mode choice. Therefore, in this study, "local force" refers to the residential built environment. "Cultural force" consists of conventions, preferences, and other evaluations that indirectly influence cognitive activities beyond specific contexts; this study analyzes it through residents' attitudes and preferences toward commuting modes, forming the abstract connotation of the concentric circle.

The three functional systems of "personal force," "local force," and "cultural force" influence and interconnect with each other, ultimately affecting individual commuting mode choices. Residents simultaneously selecting residential environments and travel modes that match their preferences is influenced by underlying cognition. That is, "local force" is directly or indirectly affected by "personal force" and "cultural force" to form specific commuting mode choices —this constitutes the residential self-selection effect. Therefore, we propose:

Hypothesis 1: Residential self-selection has an endogenous impact on the relationship between built environment and commuting mode choice.

Hypothesis 2: The built environment has a direct impact on residents' commuting mode choice.

Additionally, car ownership serves as a key determinant of motor vehicle use and should not be treated merely as an exogenous socioeconomic attribute variable. Ignoring the mediating roles of car ownership and commuting distance may reduce the estimated impact of built-environment variables on commuting mode choice and underestimate the importance of urban land-use planning and transportation policies. Therefore, we propose:

Hypothesis 3: Through the mediating effects of car ownership and commuting distance, the built environment indirectly influences residents' commuting mode choice.

[Figure 2: see original paper]

2.2 Variable Selection and Model Construction

Based on the above theory, individuals can choose residential locations according to their socioeconomic attributes and commuting mode preferences, which may obscure the built environment' s impact on commuting modes. To account for the relationships among "personal force," "cultural force," and "local force" and address the endogenous impact of residential self-selection on commuting modes, socioeconomic attributes and attitude preferences were set as exogenous variables, while built environment, commuting distance, car ownership, and commuting mode choice were set as endogenous variables. Commuting distance and car ownership do not affect commuting mode choice independently; their impacts are also mediated by socioeconomic attributes, attitude preferences, and built environment. Therefore, commuting distance and car ownership were designated as mediating variables. Using AMOS software, a complete structural equation model was constructed (Figure 3) to explore the effects of exogenous variables on endogenous variables and relationships among endogenous variables.

[Figure 3: see original paper]

2.2.1 Exogenous Variables

Socioeconomic attributes and attitude preference variables that may generate residential self-selection effects were set as exogenous variables. Socioeconomic attributes include gender, age, household size, education, household registration, household income, and housing tenure. Attitude preference variables include "importance of green travel" (AP1), "willingness for active commuting mode" (AP2), "willingness for public commuting mode" (AP3), "willingness for motorcycle/electric vehicle commuting mode" (AP4), and "willingness for car commuting mode" (AP5). A five-point Likert scale was used, assigning values from 1 to 5 corresponding to "unimportant to important" or "unwilling to willing."

2.2.2 Endogenous Variables

Built environment, commuting distance, car ownership, and commuting mode choice were set as endogenous variables. As the core endogenous variable, built environment evaluation was based on the "5D" dimensions within a 15-minute travel circle around sample points. The 15-minute travel circle was generated using the residential community main entrance as the center, based on road network data and origin-destination matrices constructed through network analysis (Figure 4), with spatial join used to match attribute data. Density includes population density and public service facility density; diversity uses entropy index to characterize land-use mix; design is measured by road network density and intersection ratio; destination accessibility is measured by path distance from sample points to public square centers; and distance to transit uses walking score indices based on distance decay 规律 to reflect residents' opportunities to use transportation.

Additionally, most studies have not focused on the important impact of parking spaces on car ownership and car commuting modes; therefore, parking space quantity was added as a variable. To eliminate dimensional inconsistencies among indicators, range standardization was applied to proportionally unify all indicators within the [0, 1] interval for comparability.

Commuting mode choice was obtained from survey questionnaire data on "your primary transportation tool to workplace." Based on energy consumption and carbon emissions of different commuting modes, walking and cycling, with minimal energy consumption and carbon emissions, were classified as active commuting mode; buses, subways, shuttles, or combined trips with large passenger capacity and low per-capita energy consumption and carbon emissions were classified as public transit commuting mode; electric vehicles and motorcycles, common commuting tools in Chinese cities with relatively small energy consumption and carbon emissions compared to large motor vehicles, were classified as electric vehicle commuting mode; and private cars and taxis, with the highest energy consumption and carbon emissions, were classified as car commuting mode.

[Figure 4: see original paper]

Table 2 Built environmental variables measurement and description

Variable	Measurement Description
Population Density	Worldpop population raster data corrected based on the Seventh Census, calculating population per unit area within 15-min travel circle
Public Service Facility Density	Count of education services, transportation facilities, entertainment facilities, dining/shopping, and living services within 15-min travel circle
Land-Use Mix	Entropy index of various land-use types within 15-min travel circle, ranging [0,1]
Road Network Density	Total road length within 15-min travel circle ($km \cdot km^{-2}$)
Intersection Ratio	Number of intersections within 15-min travel circle
Bus Stop Accessibility	Walking score index based on path distance from sample points to bus stops within 15-min travel circle, calculated using distance decay 规律
Subway Station Accessibility	Walking score index based on path distance from sample points to subway stations within 15-min travel circle, calculated using distance decay 规律
Destination Distance	Path distance from residence to main public square (Xiguan Shizi)
Parking Space Quantity	Number of parking spaces within 15-min travel circle

Table 3 Specific energy consumption and CO_2 emission factor for motorized travel modes

Motorized Travel Mode	Final Energy Consumption	Primary Energy Consumption	CO_2 Emission Factor
(Data compiled from Chinese transportation carbon emission studies; direct emissions only)			

3.1 Sample Characteristics

3.1.1 Socioeconomic Characteristics

Different socioeconomic attributes correlate with different commuting mode choices (Figure 5). Age distributions show consistency across commuting mode types, with average ages between 31-40 years. Gender differences exist: females exceed males in active and public transit commuting modes (35.8% vs. 31.3% for active; 40.4% vs. 35.0% for public). Residents with college degrees or higher show different probabilities in commuting mode selection compared to those with technical school education or below, who have higher active commuting rates (39.1%). Non-local household registration residents more frequently choose motorcycle/electric vehicle commuting than local residents. Regarding housing tenure, non-owners have higher active commuting rates (53.7%) compared to owners (31.6%), possibly because renters prioritize commuting distance. As household size increases, the proportion choosing active commuting shows a "U-shaped" distribution, with singles and six-person households having the highest rates (48.7% and 44.5%, respectively). The proportion of active commuters gradually decreases with higher household income levels, with those earning $ $2000 RMB/month having the highest active commuting rate (60.0%). Conversely, car commuting proportions increase with income, reaching 42.0% among those earning >15,000 RMB/month, likely reflecting affordability of car commuting costs.

[Figure 5: see original paper]

3.1.2 Commuting Mode Choice Characteristics

Survey results show uneven distribution of commuting mode choices, with active commuting and public transit commuting having relatively high probabilities at 35.0% and 38.7%, respectively—totaling 73.7%. This indicates Lanzhou residents prefer green commuting for daily travel. The probability of green commuting is slightly lower in urban fringe areas and locations constrained by river/railway crossings, while car commuting modes offer advantages for long-distance commuting in the context of Lanzhou' s elongated east-west urban form. Among the four commuting modes, motorcycle/electric vehicle commuting serves as an alternative for longer-distance trips but has a low probability at just 10.2%. This may relate to Lanzhou' s special climatic conditions: its temperate semi-arid continental climate results in dry, loose surface soil, and the narrow valley topography not only increases wind speeds but also hinders airborne particulates, causing prolonged sandstorm periods with low visibility. Additionally, Lanzhou's long, cold winters with late warming periods discourage electric vehicle/motorcycle commuting.

3.2 Model Results

3.2.1 SEM Fit Testing and Modification

The structural equation model (Figure 6) was constructed and estimated using sample data. Confirmatory factor analysis showed standardized path coefficients less than 1.0. Without violating theoretical assumptions, the model chi-square value was effectively reduced. After modification, model fit indices (Table 4) all met threshold requirements, indicating good model fit and robustness.

[Figure 6: see original paper]

Table 4 Model fitness indexes

Fit Index	Threshold	Value
CMIN/DF (^{2}/df ratio)	<3.0	[value]
GFI (Goodness-of-Fit Index)	>0.90	[value]
AGFI (Adjusted Goodness-of-Fit Index)	>0.90	[value]
RMSEA (Root Mean Square Error of Approximation)	<0.05	[value]
NFI (Normed Fit Index)	>0.90	[value]
IFI (Incremental Fit Index)	>0.90	[value]
TLI (Tucker-Lewis Index)	>0.90	[value]
CFI (Comparative Fit Index)	>0.90	[value]
PGFI (Parsimony Goodness-of-Fit Index)	>0.50	[value]
PNFI (Parsimony Normed Fit Index)	>0.50	[value]

3.2.2 Interpretation of Residential Self-Selection Effects

Residents' selection of residential community built environments is significantly influenced by socioeconomic attributes and attitude preference variables (Table 5), while these exogenous variables also significantly affect commuting distance, car ownership, and commuting mode choice. This means "local force" is influenced by "personal force" and "cultural force" to form specific commuting patterns—confirming the residential self-selection effect.

Regarding "personal force," socioeconomic attributes significantly impact residential built environment selection and commuting mode choice. Age shows significant positive correlation with population density, road network density, and intersection ratio, but significant negative correlation with commuting distance and car commuting mode choice. As household size increases, bus accessibility within the 15-min travel circle significantly decreases while car ownership significantly increases. Compared to less-educated residents, highly educated residents tend to live in areas with lower intersection ratios and show significant negative correlation with car commuting mode. Compared to low-income renters, high-income owners prefer communities with high land-use mix and complete infrastructure, showing significant positive correlation with car ownership and car commuting mode.

Regarding "cultural force," residents' attitude preferences toward travel modes also significantly affect built environment selection and commuting mode choice. Willingness for active commuting shows significant positive correlation with land-use mix and road network density, but significant negative correlation with car commuting mode. Willingness for public transit commuting shows significant positive correlation with road network density, intersection ratio, and bus stop accessibility, but significant negative correlation with car commuting mode. Car commuting mode willingness shows significant positive correlation with parking space quantity, car ownership, and car commuting mode. Importance of green travel and motorcycle/electric vehicle commuting willingness show significant positive correlation with bus stop accessibility and distance to public square center, respectively, but their correlations with commuting mode choice are not significant.

Table 5 Standardized estimates of exogenous variables on endogenous variables

(Note: , , represent P<0.01, P<0.05, P<0.1 respectively; rows represent dependent variables, columns independent variables. AP1-AP5 represent importance of green travel, active commuting willingness, public transit commuting willingness, motorcycle/electric vehicle commuting willingness, and car commuting willingness; TD=commuting distance; CM=commuting mode choice.)

3.2.3 Analysis of Influencing Factors

After controlling for residential self-selection effects, path relationships among built environment indicators, commuting distance, car ownership, and commuting modes were examined. Results show that the built environment directly influences commuting mode choice while also exerting indirect effects through the mediating roles of commuting distance and car ownership (Table 6).

Population density, road network density, and parking space quantity have significant direct effects on commuting mode choice. Specifically, population density has a significant negative direct effect on commuting mode choice. Excessively high population density may cause more severe traffic congestion during peak hours, negatively affecting car use and thus guiding more commuters toward active commuting modes. Road network density has a significant negative effect on commuting mode choice. Higher road network density typically creates more walkable and cycling-friendly environments, increasing active commuting. However, this differs slightly from Zhang' s findings for Boston, where car commuting also showed significant positive correlation with road network density. This may relate to China' s high building density context, where "small blocks and dense networks" improve pedestrian accessibility and public transit integration, but narrow roads also create obstacles for car commuting and parking, increasing driving costs and reducing car commuting probability. Parking space quantity has a significant positive effect on commuting mode choice, as ample parking facilities increase convenience for car commuting and residents' willingness to choose this mode.

Road network density, bus stop accessibility, subway station accessibility, and parking space quantity have significant indirect effects on commuting mode choice through commuting distance and car ownership. Road network density has a significant negative direct effect on commuting distance and a significant negative indirect effect on commuting mode choice. Areas with high road network density within the 15-min travel circle may reduce commuting distance, indirectly decreasing car commuting probability, demonstrating that increasing road network density effectively promotes active commuting. Bus and subway accessibility have significant negative direct effects on car ownership and significant negative indirect effects on commuting mode choice. Higher transit accessibility reduces car ownership and increases active commuting probability, indicating that compact urban development centered on public transit can shift travel structures away from car dominance. Parking space quantity has a significant positive direct effect on commuting distance and a significant positive indirect effect on commuting mode choice. More parking spaces correlate with longer commuting distances and higher car commuting probability.

Thus, commuting distance and car ownership mediate the relationship between built environment and commuting mode choice, particularly for road network density, bus stop accessibility, and subway station accessibility. Bus and subway accessibility exert fully mediating effects on commuting mode choice, while road network density' s indirect effect is more significant than its direct effect, accounting for approximately 35.55% of the total effect. Additionally, public service facility density and intersection ratio have some direct effects on car ownership and commuting distance, respectively, but these indirect effects are not significant.

4. Discussion

The findings on built environment heterogeneity provide evidence for low-carbon transportation network development, green travel promotion, and urban ecological transportation policies aimed at reducing energy consumption. Considering heterogeneity in commuting modes across different built environments, governments should actively guide the optimization of infrastructure and public resource allocation in low-density, sparse-network, and low-accessibility areas. Transportation facilities should develop toward intensive, efficient, and tightly integrated models, constructing urban comprehensive transportation systems centered on rail transit. New core area stations should be developed with attention to spatial integration between transit stations and surrounding functions, improving residents' travel chains and providing good travel environments that meet diverse travel demands, thereby contributing transportation wisdom to urban ecological civilization construction.

The study aims to provide decision-making support for built environment impacts on commuting mode choice in northwestern China' s inland central cities. First, based on distributed cognition theory, the framework incorporating "personal force,""cultural force,"and "local force"combines respondents'socioeconomic attributes and attitude preferences to account for potential self-selection issues, avoiding overestimation of the built environment' s contribution. Second, compared to traditional regression analysis, SEM better reveals the mediating roles of commuting distance and car ownership and the internal relationships among commuting modes, built environment, commuting distance, and car ownership. Finally, regarding built environment indicators, beyond combining "5D" indicators with "local force," the study optimized the measurement of distance to transit stops by using walking score indices to characterize bus and subway accessibility, more comprehensively reflecting residents' opportunities to use specific travel modes.

However, some findings differ from expected hypotheses. For example, distance to public square center and land-use mix did not significantly affect commuting mode choice. A plausible explanation lies in Lanzhou' s unique urban spatial form and functional structure. The "two mountains flanking a valley" ribbon-like topography creates a "polycentric, cluster-based" urban spatial structure. Under the guidance of balanced development concepts, central city residents primarily commute within their administrative districts. The calculated entropy values for land-use mix around residential communities average 0.71, indicating relatively mixed land use within the 15-min travel circles.

These findings highlight the crucial role of "context" in the "built environment-commuting mode choice" relationship. Local context—particularly Lanzhou' s "ribbon-like polycentric cluster" urban form, high population density, and high dependence on walking and public transit—differs from Western cities' high automobile dependence, affecting the direction, significance, and elasticity thresholds of the built environment-commuting mode relationship. This underscores the necessity of studying northwestern inland cities similar to Lanzhou. Additionally, the relatively small effect sizes of built environment variables on commuting mode choice may align with Stevens' conclusion that built environment impacts on commuting modes may be inelastic and modest. However, the combined and synergistic effects of multiple built environment variables could be substantial, suggesting future research should examine interactive effects of built environment variable combinations.

5. Conclusions

1) Lanzhou residents' commuting mode choices concentrate on active commuting and public transit commuting. Socioeconomic attributes and atti-

tude preferences are inherently heterogeneous. Residents choosing active and public transit commuting modes tend to have lower education levels, non-local household registration, lower incomes, and are renters in single-person or large households.

2) "Local force" is influenced by "personal force" and "cultural force" to form specific commuting patterns, confirming the existence of residential self-selection effects in Lanzhou. Residents select residential communities with different built-environment characteristics based on their socioeconomic attributes and attitude preferences. High-income, small households tend to prefer dense networks, high accessibility, high land-use mix, and well-equipped infrastructure, subsequently forming stable commuting mode choices.

3) After controlling for residential self-selection effects, the built environment continues to significantly influence commuting mode choice. Population density, road network density, and parking space quantity directly affect commuting mode choice, while road network density, bus stop accessibility, subway station accessibility, and parking space quantity indirectly affect commuting mode choice through the mediating effects of commuting distance and car ownership.

4) Built environments with high density, dense networks, and high accessibility promote active and public transit commuting modes by improving road network connectivity and walking-public transit integration, guiding residents toward a travel structure dominated by active commuting patterns.

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Note: Figure translations are in progress. See original paper for figures.