

Postprint: NIMBY Impact Characteristics of Railway Facilities in Linear Cities Based on Residential Property Prices

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Abstract

Railways are important external transportation infrastructure in modern cities, playing a critical role in urban development, but also exerting negative impacts such as fragmentation of urban spatial patterns and disturbance to residents' lives. Taking the "belt-shaped" city of Lanzhou as the research case, this study investigates the NIMBY (Not In My Back Yard) impacts and characteristics of railway facilities in 2024 using methods including the hedonic price model and geographically weighted regression model. The results indicate that: (1) Railway facilities have a significant negative impact on surrounding housing prices; for every 1% reduction in distance to railway lines and railway stations, housing prices decrease by 0.175% and 0.017%, respectively. (2) The NIMBY impact range of railway lines is approximately 1.2 km, while that of railway stations is about 0.6 km. Under the combined influence of the belt-shaped urban morphology and the alignment of railway line direction, the number of residential communities within the NIMBY impact range is substantial, accounting for 55.24% of the total number of communities in Lanzhou. (3) The impact ranges of railway lines and stations exhibit significant spatial heterogeneity. Residential communities on the side closer to the core development area are more severely affected by railways, and housing prices in high-value areas experience greater impact intensity than those in peripheral regions. (4) The maximum NIMBY effect impact range of railway station yard areas is 1.6 km, while that of municipal supporting facilities is 0.8 km; the positive effects of stations significantly offset the NIMBY effects.

Full Text

1. Data and Methods

Railways serve as crucial external transportation infrastructure for cities, undertaking large-scale intercity transport functions. In recent years, China's railway construction has developed rapidly; by the end of 2019, national railway mileage reached 15.9×10^4 km, with high-speed rail accounting for 4.5×10^4 km. Railways facilitate resource circulation between cities and promote development along urban corridors, while railway stations also drive surrounding land development. However, due to their operational characteristics and service requirements, railway lines typically traverse urban core areas, occupying substantial urban land resources and generating negative externalities for residents along the corridors, including congestion, noise, pedestrian chaos, and other NIMBY (Not In My Back Yard) impacts. Some scholars argue from a "node-place" perspective that railway stations exert positive effects on cities, while others contend that large transport stations create significant negative externalities. Research indicates that railway stations have negative impacts on housing prices within certain ranges, yet positive effects within others. Debrezion et al. found that railway stations in eastern Norway had positive effects on surrounding housing prices, with the impact closely related to station grade. Strand and Gawande's research demonstrated that railway lines strongly influence housing prices within 100 m, while nuclear fuel transport railway lines affect prices within 12 km. Overall, NIMBY impacts vary considerably across railway facilities of different functions and grades.

NIMBY facilities are defined as infrastructure that brings positive benefits to a region but imposes negative impacts on nearby residents due to their negative externalities. These facilities are categorized as either point-based or linear, with common linear NIMBY facilities including urban expressways, railways, and highways. The 2007 Shanghai Maglev incident sparked domestic concern over railway NIMBY impacts, as residents believed railway lines would create barriers to transportation, noise, and vibration. Railway stations, due to their urban "node" function, exhibit strong positive attraction effects but also generate NIMBY impacts. Existing NIMBY research has been primarily qualitative, though quantitative studies have increased with advances in network technology and geographic information systems. Current quantitative research mainly employs hedonic pricing methods, Kriging interpolation, and geographically weighted regression (GWR). Scholars have used hedonic pricing to examine the impact of environmental facilities in suburban areas, finding that urban green open spaces and recreational facilities positively affect housing prices, while railways, highways, high-voltage substations, and landfills have negative effects. In summary, few studies have investigated the magnitude, scope, and spatial heterogeneity of railway NIMBY impacts from a housing price perspective.

1.1.1 Study Area Overview

Lanzhou City (102°36' ~104°35' E, 35°34' ~37°00' N), the capital of Gansu Province, is an important central city in northwestern China. Constrained by the Qilian Mountains to the south and north and traversed by the Yellow River, Lanzhou's built-up area exhibits a distinctive "two mountains sandwiching a river" linear morphology, stretching approximately 50 km east-west and 5–15 km north-south. Integrating natural boundaries and existing development, this study defines the research scope as Lanzhou's central urban area comprising Chengguan, Qilihe, Anning, and Xigu districts, covering 237.34 km².

1.1.2 Railway Facilities in Lanzhou

Lanzhou is a critical railway transportation hub in northwestern China, with central urban lines including the Longhai Railway (first-grade), Lanzhou–Xinjiang Railway (first-grade), Baolan Railway (first-grade), Lanzhou–Chongqing Railway (first-grade), Baoji–Lanzhou Passenger Dedicated Line (first-grade), Lanzhou–Xinjiang Passenger Dedicated Line (first-grade), and the Zhongchuan Line (Lanzhou–Lanzhou New Area). Railway facilities intersect with urban residential areas along the southern corridor, with lines running east-west through Chengguan, Qilihe, and Xigu districts [Figure 1: see original paper]. The city has two major passenger stations (Lanzhou Railway Station and Lanzhou West High-Speed Railway Station) and two freight stations (Lanzhou North Station and Yingchuanbao Freight Yard). Analysis of residential distribution and land use reveals that Lanzhou North Station and Yingchuanbao Freight Yard are located in industrial zones without surrounding residential communities; therefore, this study focuses exclusively on the NIMBY effect characteristics of the southern passenger stations.

1.2 Data Sources

Research data primarily include Lanzhou railway facility data, residential property data, and GIS base data. Railway facility data were obtained from Baidu Maps, with station boundaries delineated according to current construction footprints. Residential data, including housing prices, building age, floor numbers, plot ratio, green space ratio, and total households, were scraped from the Lanzhou Lianjia website (<https://bj.lianjia.com/>) for properties listed in June 2023. After cleaning, correction, and deduplication, 1,234 residential property records were obtained. GIS base data were acquired from the planning cloud platform (<http://guihuayun.com/>), and distances to facilities were calculated using ArcGIS proximity analysis.

1.3 Research Methods

1.3.1 Hedonic Price Model The hedonic price model comprehensively evaluates external factors' impacts on housing prices, based on the theory that

commodity prices reflect integrated characteristics. When a product's characteristic changes, its price adjusts accordingly, enabling controlled examination of NIMBY facility impacts. The model employs linear, logarithmic, and exponential functions; this study selected a linear hedonic price model based on computational analysis:

$$P = \alpha + \sum_i \alpha_i Z_i + \sum_j \alpha_j Z_j + \varepsilon$$

where P represents housing price (yuan); Z_i denotes continuous characteristic variables; Z_j indicates dummy characteristic variables; and ε is the error term.

1.3.2 Geographically Weighted Regression Model The GWR model embeds spatial location attributes within traditional regression frameworks to explain spatial heterogeneity. This study employs GWR to examine spatial heterogeneity between housing prices and distances to NIMBY facilities:

$$y_i = \beta_0(v_i) + \sum_j \beta_j(v_i) x_{ij} + \varepsilon_i$$

where y_i is the housing price for residential community i (yuan); (v_i) represents spatial coordinates; $\beta_0(v_i)$ is the local regression constant; x_{ij} is the j th characteristic variable for community i ; $\beta_j(v_i)$ is the local regression coefficient; k is the number of characteristic variables; and ε_i is the error term.

2. Results

2.1 Lanzhou Housing Price Distribution Characteristics

Kriging interpolation and ArcGIS cluster analysis reveal significant east-west differentiation in Lanzhou's housing prices. High-value clusters are concentrated around Dongfanghong Plaza in Chengguan District, followed by Qilihe District. Low-value clusters align primarily with mountainous terrain in southern urban areas, coinciding with railway line layouts. Railway facilities are predominantly located in low-price zones, suggesting that NIMBY impacts are disproportionately borne by lower-income populations, consistent with existing research.

2.2 Model Results

2.2.1 Model Testing The linear regression model achieved an adjusted R^2 of 0.6316, indicating that the hedonic price model explains 63.16% of housing price variation. All variables except "distance to nearest large supermarket" have variance inflation factors below 10, suggesting minimal multicollinearity. Variables including building age, green space ratio, distance to nearest subway station, distance to city center and commercial center, distance to nearest large

shopping mall, distance to nearest park plaza, presence of middle school, presence of primary school, distance to nearest railway line, and distance to nearest railway station all passed significance tests, confirming the model's statistical validity.

2.2.3 Impact of Other Characteristic Variables Building characteristics show limited significant impact on housing prices, with only building age and green space ratio passing significance tests. Each additional year of building age reduces prices by 0.045%, while each 1% increase in green space ratio raises prices by 0.018%. Among locational characteristics, “distance to nearest subway station” and “distance to city center and commercial center” significantly affect prices, with linear regression coefficients of -0.018 and -0.045, respectively. Neighborhood characteristics exhibit stronger effects, with “distance to nearest large shopping mall” and “distance to nearest park plaza” showing the most significant impacts (coefficients: -0.089 and -0.067). The presence of middle and primary schools within 1,000 m also significantly influences housing prices, with coefficients of 0.089 and 0.067. Large shopping malls provide comprehensive functions meeting residents' daily needs, parks offer recreational space, and educational resources represent key considerations for homebuyers due to current enrollment policies.

2.3 Analysis of Railway Facility NIMBY Impact Range

Based on the above model, railway lines and stations were incorporated as dummy variables to analyze impact ranges. Using railway lines as central axes and station areas as central planes, we examined impacts across different spatial ranges.

2.3.1 Railway Line NIMBY Impact Range Regression results indicate the railway line's NIMBY impact extends approximately 1.2 km. Beyond this distance, impacts become insignificant, with housing prices positively correlating with distance, suggesting other urban functions offset NIMBY effects. Buffer zone analysis reveals 681 residential communities within 1.2 km of railway lines, representing 55.24% of all communities in central Lanzhou. Distribution across distance intervals shows: 0–0.2 km (23 communities), 0.2–0.4 km (132), 0.4–0.6 km (165), 0.6–0.8 km (156), 0.8–1.0 km (126), and 1.0–1.2 km (79). The 0.2–0.4 km interval contains the most communities, indicating substantial NIMBY issues requiring effective solutions.

Further analysis by district (Chengguan, Qilihe, Xigu; Anning communities fall outside impact zones) reveals varying impacts: Chengguan (456 communities, 47.15% of district total), Qilihe (194, 81.28%), and Xigu (31, 96.68%). As Lanzhou's core development area with dense population and housing, Chengguan contains the most affected communities but the lowest proportion. Xigu, located on the city's southern flank with relatively fewer but evenly distributed communities, sees the highest proportion affected.

2.3.2 Railway Station NIMBY Impact Range Regression results show railway stations' NIMBY impact extends approximately 0.6 km, with impact intensity first increasing then decreasing within this range. Significant negative impacts occur within 0.6 km, positive impacts emerge at 1.0–1.4 km, and insignificance appears beyond 1.4 km. A total of 89 residential communities fall within the 0.6 km impact zone, comprising 7.21% of central Lanzhou's communities. The 0.2–0.4 km interval contains the most affected communities.

The railway station's NIMBY impact range is smaller than the railway line's. According to node-place theory and TOD (Transit-Oriented Development) principles, railway stations generate pedestrian flow and foster commercial agglomeration, promoting land value appreciation that offsets NIMBY effects.

2.4 Spatial Heterogeneity of Railway Facility NIMBY Effects

2.4.1 Spatial Heterogeneity of Railway Line Impacts Using average community housing price as the dependent variable and distance to nearest railway line as the independent variable, GWR analysis was conducted for communities within the impact zone. Average price positively correlates with distance for 301 communities (44.22% of affected communities), with regression coefficients ranging 0.001–3.294. In Chengguan and Qilihe, positive-correlation clusters appear north of the railway; in Xigu, they appear south. High coefficient zones are located west of Lanzhou Railway Station and east of Lanzhou West High-Speed Railway Station. Overall, regression coefficients are higher in eastern Lanzhou, with greater railway NIMBY impacts on Chengguan and Qilihe districts.

Xigu exhibits significant coefficients for 42 communities (48.83% of affected communities), with fewer affected communities overall. Large factories north of Xigu introduce complex factors like industrial production and freight transport, making housing price determinants more complex and reducing railway facilities' relative impact.

Chengguan shows the most significant coefficients (201 communities, 44.17% of affected communities), concentrated west of the railway station and at the Qilihe district boundary, forming a dumbbell-shaped cluster. This area surrounds commercial centers like Dongfanghong Plaza, Nanguan Cross, and Zhangye Road pedestrian street, with complex traffic conditions. Qilihe shows increasing coefficients from west to east, with 107 significant communities (52.44% of affected communities) concentrated east of the high-speed railway station near the urban core.

In summary, railway facility NIMBY effects exhibit significant heterogeneity, with core development zones showing higher-price areas more strongly affected than peripheral zones.

2.4.2 Spatial Heterogeneity of Railway Station Impacts Given different functional zones' varying impact characteristics, we divided Lanzhou Railway Station and Lanzhou West High-Speed Railway Station into “station yard areas”

and “municipal support areas.” Using boundaries as cores, we partitioned 2.0 km radius circles into 45° 扇形 sectors at 0.2 km intervals, applying hedonic models to examine NIMBY impact ranges across sectors.

The “station yard area” shows maximum impact range of 1.6 km, significantly greater than the “municipal support area” (0.8 km). Lanzhou Railway Station’s NIMBY impact extends 1.6 km in northwest and southeast directions (aligned with station yard and railway line), while municipal support areas extend 0.4 km. Lanzhou West High-Speed Railway Station shows similar patterns, with station yard impacts reaching 1.6 km in northwest/southeast directions and 1.4 km in west/southwest/south directions. Municipal support areas show 0.4–0.8 km impacts, with average distances below 0.6 km. Thus, rational layout of commercial, business, and mixed-use facilities in municipal support areas is crucial for offsetting railway station NIMBY effects.

3. Discussion

Lanzhou’s linear east-west morphology and parallel railway alignment substantially increase the proportion of affected communities. This study finds railway facility NIMBY impact ranges of 1.2 km for lines and 0.6 km for stations—smaller than some previous research but appropriate given Lanzhou’s built environment. The city’s narrow north-south width and Yellow River bisecting the urban core concentrate development between the river and railway, contributing to shorter impact distances. Under these geographical and developmental constraints, Lanzhou’s residential construction cannot avoid locating within impact zones, increasing NIMBY governance challenges.

Results confirm significant negative railway facility impacts on housing prices, consistent with existing literature. Railway lines exhibit stronger effects than stations. Each 1% distance reduction from railway lines and stations corresponds to 0.175% and 0.017% price reductions, respectively. The “station yard area” impact range (1.6 km) exceeds the “municipal support area” (0.8 km). Guided by node-place theory and TOD development, railway stations should be planned as future urban growth poles. Leveraging stations’ pedestrian flow to drive commercial agglomeration and rational land use arrangement can promote overall urban development.

Current Railway Safety Management Regulations designate 15 m and 12 m protection zones for high-speed and conventional railways—far narrower than this study’s 1.2 km and 0.6 km impact ranges. Future planning and management should consider these broader impact zones and regional characteristics to formulate tailored protection and compensation measures, employing innovative technologies like underground rail development to improve residential quality of life and create better living environments.

4. Conclusions

- 1) Lanzhou's railway NIMBY facilities significantly negatively impact surrounding housing prices. Railway lines and stations exhibit NIMBY impact ranges of approximately 1.2 km and 0.6 km, respectively. Affected communities account for 55.24% of central Lanzhou's total, exacerbated by the city's linear morphology aligning with railway orientation.
- 2) Railway facilities' negative impacts show significant spatial heterogeneity. Railway lines more strongly affect communities on core development zone sides and high-price areas. Station "municipal support areas" show smaller impact ranges than "station yard areas." Rational arrangement of commercial and business functions in municipal support areas is vital for offsetting NIMBY effects.

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