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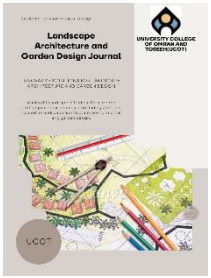

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Analysis of the Impacts of Rail Transit Development on the Spatial Divide of Urban Fabrics

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Detailed abstract

Introduction

Urban rail transport is one of the most influential infrastructures shaping the spatial organization of contemporary cities. Beyond its primary function of moving people, a metro system reconfigures land use, land value, the distribution of economic activities, and, ultimately, patterns of access to urban opportunities. As cities grow in population and geographic extent, and as travel demand intensifies, the expansion of public transportparticularly rail-based systemsbecomes an unavoidable policy response. However, the impacts of metro development are not uniform across urban space; they are mediated by the physical, social, economic, and managerial conditions of each district.

The central problem addressed by this research is the dual nature of metro development. On one hand, rail transit can regenerate declining urban fabrics, increase vitality, and improve accessibility for residents. On the other hand, in the absence of integrated planning and land management, the same infrastructure can trigger capital concentration, uneven density growth, and an unequal distribution of urban resources and opportunities. In Tehran specifically, despite extensive metro expansion over recent decades, there remains a notable gap in systematic studies examining the relationship between metro development and spatial inequality between the northern and southern parts of the city.

This gap is particularly significant given Tehran's well-documented north–south socioeconomic divide, in which northern districts generally possess higher land values, better infrastructure, and greater economic capacity, while southern districts face comparatively lower investment and slower urban renewal. The introduction of metro stations in both types of districts raises an important empirical question: does the presence of a metro station produce comparable benefits regardless of a district's pre-existing socioeconomic status, or does it instead amplify pre-existing disparities by disproportionately benefiting already-advantaged areas?

To address this question, the present study analyzes the impact of rail transport development on spatial gaps within urban fabrics across four key dimensions: physical-spatial, economic, social-cultural, and traffic-accessibility. The study compares two contrasting casesthe area surrounding Shahid Sadr metro station in North Tehran and the area surrounding Khazaneh metro station in South Tehranin order to determine whether metro development functions as a converging force that narrows spatial inequality or as a diverging force that deepens it. The underlying hypothesis guiding this research is that while metro infrastructure reduces transport friction and enhances mobility in both contexts, its distributive effects on land value, economic opportunity, and spatial justice depend heavily on complementary station-area management and urban development policy, rather than on the infrastructure itself.

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Materials and Methods

This research is applied in nature and adopts a descriptive-analytical method combined with a mixed quantitative–qualitative approach, allowing for both statistical generalization and contextual, in-depth understanding of local dynamics.

The study area comprises two urban zones surrounding metro stations with contrasting socioeconomic profiles: the vicinity of Shahid Sadr station in North Tehran, representing a relatively affluent urban fabric, and the vicinity of Khazaneh station in South Tehran, representing a lower-income, historically under-invested urban fabric. The statistical population consists of residents and daily users of the areas surrounding both stations.

For the quantitative component, a sample of 300 individuals was selected through random sampling, with the sample size determined using Cochran's formula. Data were collected through a five-point Likert-scale questionnaire designed to measure perceptions and observed changes across the four analytical dimensions (economic, social-cultural, physical-spatial, and traffic-accessibility).

For the qualitative component, purposive sampling was employed to select experts, local urban managers, real estate market actors, property consultants, and long-term residents with in-depth knowledge of neighborhood change. Semi-structured interviews were conducted with these informants to capture nuanced, experiential insights that quantitative instruments alone could not reveal. In addition, direct field observation, photographic documentation, and analysis of land and housing market data were used to triangulate and validate the findings.

Quantitative data were analyzed using SPSS version 19. Descriptive statistics were first employed to summarize the sample characteristics and general trends. The Kolmogorov–Smirnov test was used to assess the normality of data distribution, informing the choice of subsequent parametric tests. An independent samples t-test was applied to compare the two station areas across each of the four dimensions, allowing the research team to determine whether observed differences between Shahid Sadr and Khazaneh were statistically significant. Pearson correlation and linear regression analyses were used to examine relationships between metro proximity, land value change, and indicators of spatial inequality.

Qualitative data from interviews and observations were analyzed thematically, with recurring themes and patterns extracted and subsequently integrated with the statistical findings. This triangulation strategy allowed the study to move beyond surface-level statistical comparison and to interpret the underlying social and institutional mechanisms driving observed disparities between the two areas.

Findings

The results reveal a consistent pattern across the four dimensions of analysis, indicating that metro development produces both convergent and divergent effects depending on the pre-existing socioeconomic character of each area.

Economic effects. Both study areas experienced measurable increases in land value, housing prices, and rental rates following metro development. However, this increase was significantly greater in Shahid Sadr than in Khazaneh. This finding indicates that the economic benefits generated by rail transport infrastructure were disproportionately captured by the already more affluent northern district, reinforcing rather than reducing pre-existing economic disparities.

Social and cultural effects. In both districts, metro development led to increased pedestrian and vehicular traffic near stations, changes in patterns of service consumption, in-migration of non-resident users, and a gradual erosion of traditional neighborhood identity. Notably, no statistically significant

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difference was found between the two stations regarding these social-cultural effects, suggesting that this dimension of change is relatively uniform regardless of a district's economic status.

Physical and spatial effects. Both areas underwent land-use transformation, reduction of open and green spaces, increased building density, and rising visual and noise pollution, altering the overall urban landscape. Contrary to the economic findings, the intensity of physical-spatial change was significantly greater in Khazaneh than in Shahid Sadr, indicating that the less-regulated southern district experienced more disruptive and less-managed spatial transformation.

Traffic and accessibility effects. Despite the improved mobility that metro service is intended to provide, both areas continued to experience persistent traffic-related problems, including increased trip generation, parking shortages, reduced pedestrian space, and concentration of commercial activity around station entrances. Interestingly, these traffic-related impacts were reported as more severe in Shahid Sadr than in Khazaneh, possibly reflecting higher baseline demand and commercial intensity in the northern district.

Spatial inequality. The overarching finding is that metro development alone did not reduce the historic north–south spatial gap in Tehran. Rather, the higher pre-existing economic capacity of Shahid Sadr enabled that area to capture a disproportionate share of the increased land value, investment, and economic opportunity generated by the new infrastructure, while Khazaneh experienced more physical disruption without a commensurate economic upgrade.

Discussion and Conclusion

The findings collectively support the study's central argument that rail transport development has a dual and asymmetric effect on urban space. On one hand, metro infrastructure enhances accessibility, stimulates economic land value, and strengthens the functional role of station-adjacent areas in both advantaged and disadvantaged districts. On the other hand, in the absence of integrated land management, balanced service distribution, and explicit spatial-justice policy, the same infrastructure can deepen existing inequalities rather than resolve them.

The comparative analysis between Shahid Sadr and Khazaneh demonstrates that identical infrastructure investment does not produce identical outcomes when it is layered onto unequal starting conditions. Shahid Sadr, benefiting from stronger pre-existing economic capacity, was able to convert improved accessibility into substantially greater increases in land value and investment. Khazaneh, meanwhole, absorbed more physical and environmental disruptionland-use change, density increase, and loss of open spacewithout experiencing a comparable economic uplift. This divergence indicates that transport infrastructure functions primarily as a facilitator of pre-existing local capacities rather than as an independent equalizing force.

Regarding the two guiding hypotheses of the study, the first hypothesisthat northern Tehran areas would derive disproportionately greater economic benefit from metro developmentwas fully confirmed by the statistical and qualitative evidence. The second hypothesisthat metro development would reduce overall spatial inequality between the two areaswas only partially confirmed. While the metro did improve physical accessibility symmetrically across both districts, this improvement in access did not translate into a narrowing of the structural gap in land value, environmental quality, or broader economic development between the two urban fabrics.

These findings carry important implications for urban and transport policy in Tehran and comparable metropolitan contexts. First, metro development should not be treated as a self-sufficient tool for achieving spatial justice; it must be accompanied by targeted land-management instruments, such as

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value-capture mechanisms, that redirect a portion of metro-induced land value increases toward public reinvestment in less-advantaged station areas. Second, station-area planning should adopt Transit-Oriented Development (TOD) principles tailored to local socioeconomic conditions, ensuring that physical and functional upgrades in lower-income districts are matched by adequate economic and service investment, rather than by disruption alone. Third, policymakers should implement differentiated urban development strategies for northern and southern station areas, recognizing that a uniform approach to metro-area management will likely reproduce, rather than resolve, existing spatial disparities.

In conclusion, this study demonstrates that rail transport development in Tehran generates a connectivity paradox: improved physical connectivity does not automatically produce equitable spatial outcomes. Reducing spatial inequality requires deliberate policy interventionthrough land management, TOD strategies, and spatially sensitive urban governanceworking in tandem with, rather than in place of, transport infrastructure investment. Future research should extend this comparative framework to additional station pairs across Tehran and other metropolitan regions to test the generalizability of these findings and to refine policy tools for achieving genuinely inclusive metro-led urban development.

Declarations

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Conflict of Interest: Not specified in the available document.

Keywords: Urban rail transit; Spatial divide; Spatial justice; Transit-oriented development (TOD); Urban development; Urban fabrics.