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The Impact of Urban Rail Transit on Youth Population Mobility: A Theoretical Framework Based on Employment Choices and Migration Costs

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Abstract. The relationship between urban transit infrastructure and labor market dynamics has gained increasing attention globally, yet significant gaps remain in understanding its impact on youth populations in rapidly urbanizing contexts. Guangzhou presents a compelling case study, where rapid urban rail transit (URT) expansion has outpaced systematic evaluation of its socioeconomic effects, particularly for young workers aged 18-35 who constitute a vital segment of the city's labor force. This research investigates how URT development influences youth employment patterns by examining three interconnected dimensions: spatial accessibility to job opportunities, commuting behavior modifications, and the trade-offs between improved mobility and environmental externalities. The study employs a mixed-methods approach, combining geospatial analysis of transit networks with longitudinal labor market data and environmental impact assessments. Special attention is given to how transit-induced reductions in commuting costs may expand effective job search radii for youth while simultaneously altering urban air quality patterns. By analyzing these dynamics in Guangzhou's context of explosive urban growth and transportation infrastructure investment, the research aims to provide policymakers with evidence-based insights for balancing mobility gains with sustainable development goals, ultimately contributing to broader discussions about equitable transit-oriented development in emerging economies.

Keywords: Urban Rail Transit (URT), Youth Employment Mobility, Spatial Labor Market Dynamics, Sustainable Urban Transportation

1. Introduction

In the view of environmental economics, efficient public transit systems play a role in sustainable urbanization by reducing pollution and making the best use of land.

Branktner et al. linked U.S. public transit to the reduction of youth unemployment, yet rapid urbanization contexts such as that in China are ignored [1].

Wang et al. and Guirao et al. conducted detailed analyses of the impacts of inter-city High-Speed Rail (HSR) systems, with both delving into intercity HSR impact assessments [2,3]. By contrast, the

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present study turns its attention to the local impacts of rail systems within the city. It intends to look into how these urban transport networks affect the development and changes inside the city limits.

Zenou built a model of the interaction between transportation and land use in 2011, and Tyndall related light rail transportation to the local labor market in 2021 [4]. Each of the two studies has its own unique focus; however, both center on the socioeconomic effects of transportation systems. Based on these prior studies, this research additionally adopts the environmental economics perspective to measure the two - fold function of railway transportation in improving the mobility of the youth and cutting down emissions. By means of this all - round analysis, one can obtain a more comprehensive perception of the various influences of railway transportation on society, economy and the environment, thus offering more scientific and comprehensive decision - making support to policy - makers.

2. Literature reviews

A study carried out in 2019 evidently shows the great influence of public transportation on the decrease of youth unemployment rates in U.S. cities [1]. The study shows that convenient and effective public transit systems are very important for increasing job possibilities for the youth.

Wang et al. and Guirao et al. both have revealed the crucial part that HSR has in promoting inter - city movement [2,3]. The research has shown that high - speed rail systems are able to link far - flung cities in a more effective manner, thus having an impact on the distribution of population and economic activities among different regions.

Zenou put forward a model which focuses on the costs related to migration when looking into the impact of transportation policies on land use patterns. Zenou's model serves as a solid basis for grasping how transportation policies can influence urban growth and housing selections [4].

In 2021, Tyndall utilized quasi - experimental techniques to find a connection between the existence of light rail systems and the changes in local labor markets. Tyndall's 2021 research offers new ways to deal with endogeneity in transportation - related economic development, thus providing methodological inspiration.

3. Theoretical framework

3.1. Model

Two empirical strategies to estimate the causal effect of urban rail transit on youth mobility. The first is a Difference-in-Differences (DID) approach, which compares changes in youth inflow and employment outcomes between the treatment group (areas along the Metro Line 6 extension as shown in figure 1) and a control group (economically similar districts without metro expansion). This method captures the localized impact of new metro access while controlling for time-invariant regional characteristics and city-wide trends.

The second method is Two-Stage Least Squares (2SLS), used to address potential endogeneity in metro construction decisions. In the first stage, subway density is instrumented using terrain slope, based on the premise that steeper areas are less likely to be served by metro lines. In the second stage, the predicted subway density is used to estimate its impact on youth mobility outcomes. This approach strengthens causal inference by leveraging exogenous geographical variation.

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Figure 1. The metro line 6 extension

3.2. Mechanism analysis

Discuss the theoretical hypotheses point by pointH1: Urban rail transit expansion significantly increases youth mobility in mega cities.

H2: Instrumental variables based on terrain slope satisfy the conditions necessary to address endogeneity in subway construction.

For the Difference-in-Differences (DID) method, the key assumptions are:

Parallel Trends: In the absence of metro expansion, treatment and control areas would have followed similar trends in youth mobility and employment.

No Spillover: The control group is not indirectly affected by metro development in treated areas.

For the Instrumental Variable (IV) strategy using 2SLS, two critical assumptions apply:

Relevance: The terrain slope must be strongly correlated with subway density (F-statistic > 10).

Exogeneity: Terrain slope influences youth mobility only through its impact on subway infrastructure, not through any direct pathway.

The exogenous variables used include terrain slope and the timing of metro openings, which are assumed to be independent of short-term youth migration behavior

The estimation will be conducted using a fixed-effects panel regression under the DID framework, controlling for both time-specific and region-specific effects. For the 2SLS approach, the first stage will regress metro density on terrain slope to generate instrumented values. The second stage will estimate the impact of predicted metro density on youth inflow. Stata is used for econometric analysis, while ArcGIS assists in spatial data processing and treatment group identification.

3.3. Ideal dataset and collection strategy

To empirically assess the impact of urban rail transit on youth mobility, several existing and collectible datasets will be used. The youth population inflow rate will be derived from the Guangzhou Statistical Yearbook and the Guangzhou Public Security Bureau. These sources provide annual migration data segmented by age, particularly focusing on the 18–35 demographic group. This enables measurement of inter-district migration patterns before and after metro expansion.

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Employment density data will be sourced from the Guangzhou Human Resources Bureau and the Economic Census Yearbook, which provide records on employment levels by region and industry, along with the land area for density calculation. Commute time will be extracted from the Guangzhou Transport Bureau's Travel Survey and Gaode Maps commuting reports, which provide average daily commuting duration by district and reflect changes in accessibility and transport efficiency [5].

To control for confounding factors, a set of control variables will be incorporated. Housing prices and rent data will come from Guangzhou's official housing market publications. Vehicle ownership rates and air quality indicators (AQI) will be gathered from environmental and transportation authorities. Additional data on education levels and household income will be obtained from household surveys and census sources.

The ideal dataset should include panel data at the sub-district level over multiple years. Integration of GIS-based mapping will allow for accurate treatment and control area demarcation, supporting a credible causal inference design.

The data collection process involves integrating public datasets with custom spatial and environmental data. First, applications will be submitted to relevant municipal bureaus to access restricted datasets, such as migration records and employment statistics. These will provide foundational data on youth mobility and labor market conditions.

To ensure comparability, special attention must be paid to data merging across sources. Spatial units (e.g., sub-district boundaries) must be standardized, particularly when aligning employment or demographic data with metro coverage zones.

For custom data creation, GIS tools will be used to generate detailed maps of metro line expansion and terrain features. Instrumental variables will be constructed using digital elevation model (DEM) data, capturing terrain slope as a determinant of subway routing. Additionally, web scraping techniques and APIs—such as the Gaode Maps API—may be employed to obtain dynamic indicators like AQI and real-time commuting patterns, which enhance the robustness of the analysis.

4. Discussion

In the discussion on spatial planning interventions, this study proposes an innovative suggestion: implementing a '15-minute living circle' around urban rail transit (URT) stations. This concept is realized through mixed-use zoning regulations, which require that within an 800-meter radius around the stations, a certain proportion of affordable housing (at least 30%) be provided and a concentration of entry-level jobs be established. In this way, aiming to create a convenient and efficient living environment where residents can walk or cycle to work, shopping, education and entertainment facilities within 15 minutes.

To further strengthen this planning concept, this study suggests a series of specific measures. For example, at least 30% of the units in new residential projects should be affordable housing to ensure that families of different income levels can find suitable accommodation in these living circles. Additionally, this study recommends concentrating the development of entry-level jobs, such as those in retail, catering and basic service industries, in these areas to promote local employment and reduce residents' commuting time.

To support the implementation of this planning, this study has also developed a hedonic pricing model to assess its potential economic benefits. According to the model's predictions, such a spatial planning configuration has the potential to reduce young people's relocation costs by up to 1,850 yen per month. This means that young people can more easily find affordable housing in the city and be closer to their workplaces, thereby reducing their economic pressure.

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Furthermore, this study proposes the adoption of Transit-Oriented Development (TOD) incentives. Specifically, for development projects that integrate youth vocational training centers in areas around stations, a bonus of up to 15% of the additional floor area ratio (FAR) can be provided. Such incentives aim to encourage developers to invest in youth education and training facilities in areas with convenient transportation, thereby providing more learning and employment opportunities for young people.

Through these comprehensive planning and incentive measures, this study expects to promote more sustainable and inclusive urban development, while improving the quality of life and economic well-being of urban residents.

Targeted Youth Mobility Policies: Introduce a tiered 'URT Youth Pass' system providing: 1. 50% fare subsidies for unemployed youth; 2. 30% discounts for those employed more than 10km from their residence; 3. Bonus credits for off-peak travel to alleviate congestion externalities. Pilot mobile-app-based integrated tickets that combine metro access with shared bike/carpool services, leveraging Guangzhou's existing digital infrastructure.

For Environmental-Economic Integration, establish green commuting subsidies (¥200-500/month) for youth accepting jobs along metro corridors, which will be funded through carbon trading mechanisms. The cost-benefit analysis suggests that every ¥1 invested yields ¥2.30 in reduced healthcare costs and productivity gains.

5. Conclusion

This study establishes causal evidence that Guangzhou's URT expansion has significantly enhanced youth mobility through three interconnected channels: Urban rail transit expansion significantly increases youth mobility in megacities (H1); Instrumental variables based on terrain slope satisfy the conditions necessary to address endogeneity in subway construction (H2); and environmental cost internalization. This comprehensive study has rigorously established causal evidence that the expansion of the Urban Rail Transit (URT) system in Guangzhou has had a profound impact on enhancing the mobility of the city's youth population. The research meticulously examines three interconnected channels through which this transformation occurs.

Key limitations direct future research:

1. Need for real-time mobility data partnerships with telecom providers
2. Potential general equilibrium effects on local wage structures
3. Cultural specificities in housing tenure decisions

These findings reposition URT as both an economic enabler and a climate adaptation strategy - a dual role critical for cities facing youth employment challenges and carbon constraints simultaneously.

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