Research Article

The Impact of Urban Rail Transit on Industrial Agglomeration Based on the Intermediary Effects of Factor Agglomeration

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Urban rail transit is an important form of infrastructure for a city or even a country. This paper uses location entropy to measure the industrial agglomeration level of cities at the prefecture level or above in China from 2006 to 2018 and empirically tests the mechanisms of urban rail transit construction, factor agglomeration, and industrial agglomeration. The empirical results show the following: (1) the construction of urban rail transit infrastructure has a significant positive effect on the agglomeration of the labor force, capital, and technological innovation; (2) urban rail transit construction effectively induces agglomeration in the urban manufacturing industry and consumer service industry; and (3) the impact of urban rail transit construction on agglomeration in the urban manufacturing industry and consumer services industry is primarily due to the intermediary effects of factor agglomeration. The results show that gradually improving the urban rail transit network, strengthening the construction of comprehensive rail transit hubs, and optimizing capital allocation within urban rail transit allow for the full utilization of urban rail transit construction in promoting industrial agglomeration.

1. Introduction

Urban rail transit is the main artery of a country's economic and social development as well as an important emerging strategic industry and has profound socioeconomic impacts in many areas. Urban rail transit can enhance a city's regional advantages, and the continual agglomeration of capital, population, and technology could cause more factors of production to flow into cities with a higher rate of return, which could in turn expand production, increase aggregate demand, and improve the cities' industrial structure and industrial agglomeration. As of the end of 2019, a total of 40 cities in Mainland China had opened urban rail transit systems, and these systems had a collective total of 6,736.2 km of urban rail mileage, setting a historic record. The construction of urban rail transit makes the city's location advantage more important. The continuous agglomeration of industry, population, and technology makes more capital tend to flow to these cities with

higher return rate, which brings a lot of investment, expands production, and improves the urban infrastructure and investment environment. Urban rail transit is an important transportation foundation of urban integration, regional coordination, and economic intensification, which plays a great role in industrial agglomeration.

Under the real-world background of the rapid development of urban rail transit in China, what effect could urban rail transit have on industrial agglomeration? Are any mediating variables involved in this effect? Answering these questions could help improve the development of urban rail transit in China and provide governments with a reference for the more precise positioning of cities' features and functions.

2. Research Overview

Research on the topic of urban rail transit and economic benefit began during the 1960s with the research of Liszt

(1961) [1] on the relationship between transportation and regional economics, which incorporated transportation as a major constituent factor and found that Britain's economic growth benefited to a large extent from increases in transportation capacity. Starting from the state of urban rail transit development in the United States and referring to relationships between the rail transit construction, the economy, and the population, Cervero (1996) [2] pointed out that the construction and development of rail transit promoted the development of whole countries and regions and that rail transit had a significant impact on the population, industry, and overall economic development under its radiation scope. Prasertsubpakij and Nitivattananon (2012) [3] pointed out that metro systems served as fast and efficient transit systems in numerous modern cities, and the traditional research methods of metro rail accessibility had not fully considered the equal right of users to enjoy the metro system. Therefore, they suggested that it was necessary to use multidimensional criteria to assess the accessibility of the Bangkok Metro system to users and the equal right of users to the metro. They found that the development of metro lines had not fully satisfied the travel needs of different types of users and had not promoted population concentration.

The price of land in urban centers has increased rapidly with steadily growing populations, so growing numbers of people working in city centers have been forced to live in outlying areas, which has resulted in home-work separation. Cervero (1994) [4] found that the implementation of rail transit projects brought about a significant increase in peripheral real estate prices. McMillen and McDonald (2004) [5] showed that housing markets can predict the development of transport lines, and this development can cause home prices to rise. The study of Kim and Zhang (2005) [6] discovered that rail transit projects had a greater impact on real estate prices in city centers than in other areas. Lee and Hong (2013) [7] analyzed the relationship between Seoul Metro passenger traffic and land uses around metro stations, with the goal of testing the hypothesis that the passenger volume of bus stations at both ends of the city under the influence of density is conducive to land-use diversity. They found that land-use diversity had a major impact on passenger traffic between stations, and metro passenger traffic in both Seoul's central business district and fringe areas was chiefly affected by population density, while central areas were uniformly influenced by intermodal bus transit. The studies of Liu, Li, and Deng (2015) [8] and Wang and Chen (2017) [9] verified this rule and discovered that rail transit projects had different impacts on the increases in the price of land in areas along transit lines during the construction and development stages, with transit projects bringing about a greater increase in land prices during construction than during the development or operation period.

Several studies have examined the capitalization effect of rail transit on home prices and land prices. For instance, in a study of the effect of metro systems on housing and commercial real estate, Mohammad et al. (2017) [10] found that metro systems had a significant promoting effect on the prices of both housing and commercial real estate, and this promoting effect was significantly greater in the case of commercial real estate than in the case of housing. In a study of the Sydney's Inner West Light Rail line, Mulley and Tsai (2018) [11] found that light rail service increased the value of peripheral land by improving accessibility. In their analysis of the spatial and temporal effect of metro availability on apartment prices, Trojanek and Gluszak (2018) [12] discovered that metro systems raised apartment prices before they opened, and this effect also gradually but significantly increased with the passage of time. Luo Jia and Mo Shuang Ning (2019) [13] analyzed the influence mechanism of subway station on the price of surrounding houses. Subway station can increase the use value and utility of surrounding houses by improving the travel convenience of surrounding residents, thus driving the rise of house prices. This paper empirically tests the "premium effect" by using the panel data of 964 second-hand commercial houses in Shanghai from 2013 to 2018 The closer to the subway station, the higher the price of second-hand commercial housing; in addition, the existence of affordable housing nearby can weaken the premium effect of subway station on commercial housing, but the weakening effect is very weak.

Based on the "center-periphery" theory, Wang Wei and Ma Hui (2019) [14] analyzed the industrial agglomeration effect of rapid transit network from the perspective of labor transfer. The research shows that the opening of high-speed railway significantly reduces the industrial agglomeration level of regional noncentral cities and strengthens the industrial agglomeration level of central cities through labor transfer channels. Iordanka Stateva (2019) [15] believes that after the UK decided to leave the EU, with the decentralization of financial services, the financial capital of London financial center is attracted by the network of smaller financial centers such as Frankfurt and Paris. The overall competitiveness of the emerging capital network depends on the degree of financial capital concentration and technological innovation.

After performing a careful review of existing research, we saw that while there has been much research employing traditional theories addressing the relationships between the transport industry and industrial agglomeration and between industrial agglomeration and economic growth, there has been little research on the effect of urban rail transit on urban industrial agglomeration. Also, refer to the studies of Gu and Chen(2020) [16], Yuan and Ding et al.(2020) [17], Y. Shu et al.(2020) [18], Chen et al.(2014) [19], Li et al.(2018) [20], and Ji Wei et al. (2019) [21]. This paper therefore analyzes the relationship between urban rail transit and industrial agglomeration from the new perspective of factor agglomeration, while incorporating a mediating effect model. Most previous studies have employed qualitative research methods to investigate the effect of urban rail development on economic growth or industrial agglomeration and have failed to quantify this effect. To provide empirical support for the effect of urban rail development on industrial agglomeration, this study employs the data of Chinese cities at the prefecture level and above during 2006–2018 and consequently constructs fixed-effects panel-data models and dynamic generalized methods of moments

(GMM) models to analyze the mechanism by which urban rail transit affects industrial agglomeration via factor agglomeration.

3. Empirical Design

3.1. Model Construction. Adopting the principles of the mediating effect testing method proposed by Preacher and Hayes (2008) [22], this study takes urban industrial agglomeration as the explained variable, factor agglomeration as a mediating variable, and urban rail transit as the core explanatory variable. This study aims to test whether the transmission mechanism of urban rail transit to industrial agglomeration is mainly realized by factor agglomeration. If true, this would imply that factor agglomeration is the model's mediating variable. Specifically, a mediating effect is tested via a three-step quantitative model.

In this model, the first step is to test the effect of urban rail transit on industrial agglomeration:

$$LQ1_{it} = \alpha + \beta_1 TRAN_{it} + \beta_2 GDP_{it} + \beta_3 INS_{it} + \beta_4 GOV_{it} + \beta_5 WAGE_{it} + \beta_6 HUM_{it} + v_i + u_t + \varepsilon_{it}, \tag{1}$$

$$LQ2_{it} = \alpha + \beta_1 TRAN_{it} + \beta_2 GDP_{it} + \beta_3 INS_{it} + \beta_4 GOV_{it} + \beta_5 WAGE_{it} + \beta_6 HUM_{it} + v_i + u_t + \varepsilon_{it}, \tag{2}$$

where *LQ1* is the industrial agglomeration of manufacturing industries, *LQ2* is the industrial agglomeration of consumer service industries, and *TRAN* is urban rail development. At the same time, to maximally lessen the effect of endogenous issues caused by omissions, this study also controls for other major variables affecting urban economic growth. After taking theory and the availability of data into consideration, this study adopts economic growth (*GDP*), upgrading of the industrial structure (*INS*), government expenditures (*GOV*), wage level (*WAGE*), and human capital (*HUM*) as the control variables; α is a constant term; β is the estimated coefficient of the explanatory variable; i is the entity; t is the year; v_i and u_t indicate the individual effect and time effect, respectively; and ε_{it} is a random error term.

When testing coefficient β_1 in equations (1 and 2), if β_1 is not significant, this indicates that no mediating effect exists, and testing stops; but if β_1 is significant, this is still not sufficient to indicate that a mediating effect exists. At that time, it is necessary to perform the second testing step, which involves the city's factor agglomeration:

$$LA_{it} = \alpha + \beta_1 TRAN_{it} + \beta_2 GDP_{it} + \beta_3 INS_{it} + \beta_4 GOV_{it} + \beta_5 WAGE_{it} + \beta_6 HUM_{it} + v_i + u_t + \varepsilon_{it}, \tag{3}$$

$$CA_{it} = \alpha + \beta_1 TRAN_{it} + \beta_2 GDP_{it} + \beta_3 INS_{it} + \beta_4 GOV_{it} + \beta_5 WAGE_{it} + \beta_6 HUM_{it} + v_i + u_t + \varepsilon_{it}, \tag{4}$$

$$TA_{it} = \alpha + \beta_1 TRAN_{it} + \beta_2 GDP_{it} + \beta_3 INS_{it} + \beta_4 GOV_{it} + \beta_5 WAGE_{it} + \beta_6 HUM_{it} + v_i + u_t + \varepsilon_{it}. \tag{5}$$

In equations (3)–(5), *LA*, *CA*, and *TA* are, respectively, labor agglomeration, capital agglomeration, and technical innovation agglomeration and *TRAN* is urban rail development. If coefficient β_1 is significant, this indicates that urban rail development can indeed affect factor agglomeration in the city, but this is not sufficient to show that a mediating effect exists.

It is therefore necessary to proceed to the third step, which consists of testing of the relationships between urban rail development, factor agglomeration, and industrial agglomeration:

$$LQ1_{it}/LQ2_{it} = \alpha + \beta_1 TRAN_{it} + \beta_2 LA_{it} + \beta_3 GDP_{it} + \beta_4 INS_{it} + \beta_5 GOV_{it} + \beta_5 WAGE_{it} + \beta_6 HUM_{it} + v_i + u_t + \varepsilon_{it}, \tag{6}$$

$$LQ1_{it}/LQ2_{it} = \alpha + \beta_1 TRAN_{it} + \beta_2 CA_{it} + \beta_3 GDP_{it} + \beta_4 INS_{it} + \beta_5 GOV_{it} + \beta_5 WAGE_{it} + \beta_6 HUM_{it} + v_i + u_t + \varepsilon_{it}, \tag{7}$$

$$LQ1_{it}/LQ2_{it} = \alpha + \beta_1 TRAN_{it} + \beta_2 TA_{it} + \beta_3 GDP_{it} + \beta_4 INS_{it} + \beta_5 GOV_{it} + \beta_5 WAGE_{it} + \beta_6 HUM_{it} + v_i + u_t + \varepsilon_{it}. \tag{8}$$

Equations (6)–(8) chiefly serve to test the effect of factor agglomeration on industrial agglomeration. If, for instance, both β_1 and β_2 are significant, this verifies that a mediating effect exists; if either β_1 or β_2 is significant, but it is not known whether the other is significant, then the Sobel test must be performed. If the result of the Sobel test is significant, the existence of a mediating effect can be confirmed.

3.2. Explanation of Variables

3.2.1. Explained Variable. As industrial agglomeration theory has developed, scholars have come up with a number of methods for measuring industrial agglomeration. These methods, which include the industry share and industry concentration indicators (the simple ones) and the dynamic agglomeration indicator method, have been used to assess the level of industrial agglomeration, and all have their individual advantages and disadvantages. At present, many scholars choose to use the location quotient to assess the level of industrial agglomeration. Because the location quotient can eliminate factors associated with the differences in size between areas, it can truly express the spatial distribution of geographical factors. For instance, Liu and Xu (2010) [23], Chen et al.(2012) [24], Sun et al. (2012) [25], Yang and Liu (2019) [26], Mei and Ma et al.(2020) [27], Xia et al. (2020) [28] all employed the location quotient as their chief indicator for assessing industrial agglomeration. At the same time, when performing economic analysis of the agglomeration of an individual industry, the number of people working in a particular industry relates to the level of industrial agglomeration and can effectively reveal the specialized agglomeration effect in that industry. Accordingly, this study uses the location quotient to assess the level of industrial agglomeration:

$$LQ_{ij} = \left(Q_{ij}/\sum Q_{ij}\right)/\left(\sum Q_{ij}/\sum Q_i \sum Q_j\right). \qquad (9)$$

In equation (9), LQ_{ij} indicates the level of industrial agglomeration and Q_{ij} indicates the number of persons employed in industry j in city i. When $LQ_{ij} > 1$, this indicates that industry j in city i has a relative advantage over industry j in other cities. This study adopted the location quotient to quantify the level of the industrial agglomeration of cities' manufacturing industries and consumer service industries.

3.2.2. Core Explanatory Variable. Urban rail development: this study's core explanatory variable is the urban rail transit line length, where the greater a city's urban rail transit line length, the greater the city's urban rail transit development.

3.2.3. Mediating Variables. This study's mediating variables consist of factor agglomeration variables. In accordance with the general Cobb–Douglas production function model, mediating variables chiefly include labor agglomeration, capital agglomeration, and technical innovation agglomeration.

First, to broadly compare the labor agglomeration characteristics of Chinese cities, this study chiefly relies on the concept of labor density to measure the level of labor agglomeration in cities. Labor density is obtained by dividing the population in each city's area of jurisdiction at the end of each year by the area of the city's administrative area:

$$\text{labor agglomeration} = \frac{\text{population in each city's area of jurisdiction at year} - \text{end}}{\text{area of the city's jurisdiction}} \times 100\%. \qquad (10)$$

Second, regarding capital agglomeration, this study constructs a comprehensive capital agglomeration assessment indicator system and uses the factor analysis method to assess this indicator:

As shown in Table 1, the primary indicator of foreign capital agglomeration is the amount of foreign capital actually used in a city at the end of the year (RMB 10,000), which is denoted K1. The primary indicator of fixed capital agglomeration is the state of all social fixed asset investments in a city at year-end (RMB 10,000), which is denoted K2. The primary indicator of financial capital agglomeration is the balance of all RMB deposits in a city at year-end (RMB 10,000) and the balance of all RMB loans in a city at year-end (RMB 10,000), which are denoted K3 and K4, respectively.

Lastly, the indicator of technical innovation agglomeration consists of a city's level of technical innovation agglomeration, which is calculated by the patent updating model of Kou and Liu (2020) [29]. The first step is to estimate the value of all expired utility patents that were applied for in 1987–1997. The parameter obtained by this estimation process is used to model the distribution of patent value. This allows the calculation of the average values of patents of different ages, and these values serve as weighting coefficients for the values of relevant patents. Taking the end of each year (December 31) as the observation time for that year, utility patents that are still valid at that point in time (approved and still within the period of validity) are selected, and a patent value inventory is obtained after adding up the values of patents in different cities (or industries). Normalizing the country's aggregate patent value in 2001 to 100, each cities' technical innovation agglomeration indicators for the period of 2006–2018 are calculated.

3.2.4. Control Variables. Economic growth: China has already entered a key period of slowing economic growth and economic structural adjustment. Since conventional aggregate indicators of economic growth are inadequate to accurately portray the state of economic activities, this study employs the actual GDP per capital of city residents as an indicator of cities' levels of economic growth.

TABLE 1: Comprehensive capital agglomeration indicator system.

Primary indicator	Secondary indicator	Unit	Code
Foreign capital agglomeration	Amount of foreign capital actually used in a city at the end of the year	RMB 10, 000	K1
Fixed capital agglomeration	State of all social fixed asset investment in city at the end of the year	RMB 10, 000	K2
Financial capital agglomeration	Balance of all RMB deposits in city at the end of the year	RMB 10, 000	K3
	Balance of all RMB loans in city at the end of the year	RMB 10, 000	K4

Note: data are chiefly obtained from the China City Statistical Yearbook.

Upgrading of the industrial structure: upgrading of the industrial structure is an important step in the promotion of rapid economic development. This study chiefly employs the ratio of the sum of the value added by secondary and tertiary industries to GDP as the indicator of industrial structure upgrade.

Government expenditures: because local governments in China usually pursue local economic growth as their paramount goal, these governments use a portion of their fiscal revenue for public expenditures to promote economic growth. A series of fiscal policies adopted by governments to participate in economic activities could inevitably have an impact on their cities' economic growth. This study therefore chiefly employs the ratio of government expenditures to GDP as a proxy variable for government expenditures.

Wage level: the wage level constitutes the labor remuneration paid to employees by enterprises during a certain period. Generally, the higher the wage level in a city, the greater the city's appeal to workers, and the more it can attract high-end talent. Since this agglomeration of talent can promote the city's economic growth, wage level is an important indicator of local development and developmental ability. This study consequently adopts the average wage level of in-service employees as a proxy variable for a city's wage level.

Human capital: human capital has an extremely important promoting effect on the level of factor agglomeration. Some scholars have used average years of education to assess human capital, while others employ the share of persons at each educational level to assess this metric. Since the China City Statistical Yearbook published by the National Bureau of Statistics does not contain detailed data on the level of education of city residents, this study takes the number of in-school university students per 10,000 persons in each city as a proxy variable for human capital.

3.3. Data Sources. To maintain consistency in the statistical caliber, this study employs data for cities at the prefecture level and above in the period of 2006–2018. All data are obtained from the China Statistical Yearbook, China City Statistical Yearbook, and China Urban Construction Statistical Yearbook for the period of 2006–2018.

4. Empirical Results

4.1. Empirical Results and Analysis. In accordance with the theoretical principles of mediating effect testing, SPSS 22.0 software and the mediating effect model testing procedures proposed by Preacher and Hayes (2008) [16] are used to perform empirical analysis. The obtained empirical results are shown in Tables 2–4. The analysis of urban rail line length in Table 2 yields the following empirical results concerning the effect of urban rail line length on the industrial agglomeration of manufacturing and consumer service via labor agglomeration.

First, from the empirical results on urban rail line length, labor agglomeration, and manufacturing industry agglomeration, after controlling for the upgrading of the industrial structure, government expenditures, wage level, and human capital, model (1) indicates that urban rail line length has a significant promoting effect on manufacturing industry agglomeration; model (2) indicates that urban rail line length also has a significant promoting effect on labor agglomeration; and model (3) indicates that urban rail line length and labor agglomeration have a significant promoting effect on manufacturing industry agglomeration. These findings suggest that urban rail line length can promote manufacturing industry agglomeration via labor agglomeration.

Second, from the empirical results on urban rail line length, labor agglomeration, and consumer service industry agglomeration, model (4) indicates that urban rail line length has a significant promoting effect on consumer service industry agglomeration; model (5) indicates that urban rail line length also has a significant promoting effect on labor agglomeration; and model (6) indicates that urban rail line length and labor agglomeration have a significant promoting effect on consumer service industry agglomeration. These results suggest that urban rail line length can promote consumer service industry agglomeration via labor agglomeration.

Thirdly, from the empirical results of control variables, GDP, wage level, and human capital can promote the manufacturing industry agglomeration, consumer service industry agglomeration, and labor agglomeration; industrial technology upgrading can inhibit the manufacturing industry agglomeration; government expenditure can promote the consumer service industry agglomeration and labor agglomeration.

The analysis of urban rail line length in Table 3 yields the following empirical results concerning the effect of capital agglomeration on the industrial agglomeration of manufacturing and customer services.

First, from the empirical results on urban rail line length, capital agglomeration, and manufacturing industry agglomeration, model (7) indicates that urban rail line length has a significant promoting effect on manufacturing industry agglomeration; model (8) indicates that urban rail line length has a significant promoting effect on capital

TABLE 2: Empirical analysis results 1.

	Model (1) LQ_{1it}	Model (2) $LnLA_{it}$	Model (3) LQ_{1it}	Model (4) LQ_{2it}	Model (5) $LnLA_{it}$	Model (6) LQ_{2it}
$LnTRAN_{it}$	0.1628** (2.23)	0.2781*** (3.31)	0.1398** (2.26)	0.2318*** (5.56)	0.2331*** (3.41)	0.2205*** (4.75)
$LnLA_{it}$			0.0723** (2.41)			0.0681*** (2.92)
$LnGDP_{it}$	0.6590*** (4.19)	0.6397*** (3.28)	0.6431*** (3.66)	0.6019** (2.35)	0.5747*** (2.80)	0.5746*** (2.55)
$LnINS_{it}$	−0.3142*** (−6.38)	−0.0302 (−1.38)	−0.3292*** (−6.28)	0.0735 (1.06)	0.0634 (0.86)	0.0655 (0.92)
$LnGOV_{it}$	−0.0748 (−1.03)	0.0165 (0.19)	−0.0736 (−1.01)	0.8668*** (3.02)	0.7040*** (2.91)	0.1169 (0.46)
$LnWAGE_{it}$	0.0577 (1.11)	0.1121*** (4.61)	0.1073*** (4.41)	0.0340 (0.44)	0.0648 (0.73)	0.7722*** (3.09)
$LnHUM_{it}$	0.3005*** (4.56)	0.5137*** (2.62)	0.2852*** (4.25)	0.2726** (2.02)	0.2959** (2.09)	0.3044** (2.11)
$CONSTANT_{it}$	5.2378*** (15.91)	3.8542*** (4.42)	4.9153*** (11.21)	6.0183*** (4.54)	5. 0818** (2.08)	0.0534 (0.68)
R-squared	0.36	0.48	0.33	0.31	0.46	0.34
Obs.	230	230	230	230	230	230

Note: *, **, and *** indicate 10%, 5%, and 1% levels of significance; t values are in parentheses.

TABLE 3: Empirical analysis results 2.

	Model (7) LQ_{1it}	Model (8) $LnCA_{it}$	Model (9) LQ_{1it}	Model (10) LQ_{2it}	Model (11) $LnCA_{it}$	Model (12) LQ_{2it}
$LnTRAN_{it}$	0.0091** (2.19)	0.1324** (2.34)	0.1142* (1.85)	0.2519*** (6.57)	0.0091** (2.19)	0.2551*** (6.82)
$LnCA_{it}$			0.2033* (1.72)			0.3471** (2.34)
$LnGDP_{it}$	0.0384*** (5.67)	0.2505** (2.45)	0.3274*** (2.91)	−0.1994*** (−3.14)	1.1264*** (9.10)	−0.3071*** (−4.23)
$LnINS_{it}$	0.0264*** (3.02)	−0.3057*** (−2.54)	−0.2528** (−2.16)	0.1421 (1.53)	0.5137*** (2.62)	0.0930 (1.01)
$LnGOV_{it}$	0.0055 (0.47)	−0.0748 (−1.03)	−0.0638 (−1.10)	0.0204 (0.34)	0.0165 (0.19)	0.0189 (0.32)
$LnWAGE_{it}$	0.0071 (1.49)	0.0577 (1.11)	0.0720 (1.26)	0.0246 (0.48)	0.1023 (0.85)	0.0148 (0.30)
$LnHUM_{it}$	−0.0012 (−0.22)	−0.1931*** (−2.85)	−0.1955*** (−2.92)	0.1148** (2.03)	−0.1357 (−1.17)	0.1278** (2.26)
$CONSTANT_{it}$	1.8061*** (17.87)	1.1578 (0.88)	4.7759 (1.57)	0.6563 (0.89)	−11.2270*** (−6.63)	1.7299** (2.22)
R-squared	0.37	0.39	0.38	0.31	0.47	0.33
Obs.	230	230	230	230	230	230

Note: *, **, and *** indicate 10%, 5%, and 1% levels of significance; t values are in parentheses.

agglomeration; and model (9) indicates that urban rail line length and capital agglomeration have a significant promoting effect on manufacturing industry agglomeration. These results suggest that urban rail line length can promote manufacturing industry agglomeration via capital agglomeration.

Second, from the empirical results on urban rail line length, capital agglomeration, and consumer service industry agglomeration, model (10) indicates that urban rail line length has a significant promoting effect on consumer service industry agglomeration; model (11) indicates that urban rail line length has a significant promoting effect on capital agglomeration; and model (12) indicates that urban rail line length and capital

agglomeration have a significant promoting effect on consumer service industry agglomeration. These results suggest that urban rail line length can promote consumer service industry agglomeration via capital agglomeration.

Third, from the empirical results of the control variables, only GDP can promote capital agglomeration and manufacturing agglomeration, and the effect of other variables cannot be judged.

The analysis of the effect of urban rail line length on industrial agglomeration via technical innovation agglomeration in Table 4 yields the following empirical results.

First, from the empirical results on urban rail line length, technical innovation agglomeration, and manufacturing

TABLE 4: Empirical analysis results 3.

	Model (13) LQ_{1it}	Model (14) $LnTA_{it}$	Model (15) LQ_{1it}	Model (16) LQ_{2it}	Model (17) $LnTA_{it}$	Model (18) LQ_{2it}
$LnTRAN_{it}$	0.1324*** (2.34)	0.1870*** (3.32)	0.1096* (1.77)	0.0382** (2.11)	0.1870*** (3.32)	0.0346* (1.84)
$LnTA_{it}$			0.1218* (1.67)			0.0193*** (2.66)
$LnGDP_{it}$	0.2505** (2.45)	1.2624*** (11.72)	0.4042*** (3.21)	0.2579* (1.93)	0.2801** (2.02)	0.2810** (1.98)
$LnINS_{it}$	−0.3057*** (−2.54)	1.1247*** (6.26)	−0.1687 (−1.24)	−0.1602** (−2.24)	−0.1901** (−2.40)	−0.1945** (−2.42)
$LnGOV_{it}$	−0.0748 (−1.03)	0.2214 (1.08)	−0.0478 (−0.81)	0.0445 (1.30)	0.0413 (1.19)	0.0438 (1.24)
$LnWAGE_{it}$	0.0577 (1.11)	0.1096** (2.04)	0.0710 (1.27)	0.1068*** (6.94)	0.1065*** (6.99)	0.1070*** (7.21)
$LnHUM_{it}$	−0.1931*** (−2.85)	−0.0860 (−0.77)	−0.2036*** (−2.92)	0.0503 (1.52)	0.0475 (1.44)	0.0497 (1.47)
$CONSTANT_{it}$	1.1578* (1.88)	−17.6493*** (−10.12)	−0.9911 (−0.63)	7.2990*** (7.63)	3.1011*** (2.52)	8.0390*** (8.17)
R-squared	0.38	0.66	0.30	0.43	0.56	0.57
Obs.	230	230	230	230	230	230

Note: *, **, and *** indicate 10%, 5%, and 1% levels of significance; t values are in parentheses.

TABLE 5: Empirical analysis results 4.

	Model (19) LQ_{1it}	Model (20) $LnLA_{it}$	Model (21) LQ_{1it}	Model (22) LQ_{2it}	Model (23) $LnLA_{it}$	Model (24) LQ_{2it}
LQ_{it-1}	0.3437** (2.13)	0.0853*** (2.79)	0.3281*** (2.58)	0.2323** (1.97)	0.0715** (2.28)	0.1590*** (7.15)
$LnTRAN_{it}$			0.1227*** (3.15)			0.0379*** (3.69)
$LnLA_{it}$			0.6261*** (5.85)			0.1121** (2.32)
$LnGDP_{it}$	0.2451 (1.62)	−0.2708* (−1.75)	−0.0617 (−0.95)	−0.2075 (−1.60)	−0.0414* (−1.76)	0.0258*** (3.72)
$LnINS_{it}$	−0.1903 (−1.03)	0.0839 (0.30)	0.2145* (1.75)	0.3127 (1.63)	0.0842 (1.22)	0.0029 (0.25)
$LnGOV_{it}$	−0.0131 (−0.26)	0.0915*** (2.68)	0.0118 (0.83)	−0.0203 (−0.57)	−0.0143 (−1.26)	0.0108 (0.79)
$LnWAGE_{it}$	0.0263 (0.75)	−0.0275 (−0.41)	−0.0477 (−0.82)	−0.1675** (−2.24)	0.0316 (1.63)	0.0026 (0.74)
$LnHUM_{it}$	−0.0421 (−0.42)	−0.0389 (−0.32)	0.0133 (0.28)	−0.0487 (−0.60)	0.0197 (0.57)	−0.0009 (−0.16)
$CONSTANT_{it}$	0.0482 (0.03)	4.3551* (1.89)	0.2280 (0.25)	2.9495** (2.29)	0.7388* (1.67)	2.0719*** (19.70)
Dum_Individual	YES	YES	YES	YES	YES	YES
Dum_Year	YES	YES	YES	YES	YES	YES
Wald value	16.47***	33.96***	15.10***	40.95***	44.52***	48.98***
Obs.	196	196	196	196	196	196

Note: *, **, and *** indicate 10%, 5%, and 1% levels of significance; z values are in parentheses.

industry agglomeration, model (13) indicates that urban rail line length has a significant promoting effect on manufacturing industry agglomeration; model (14) indicates that urban rail line length has a significant promoting effect on technical innovation agglomeration; and model (15) indicates that urban rail line length and technical innovation agglomeration have a significant promoting effect on manufacturing industry agglomeration. These findings suggest that urban rail line length can promote manufacturing industry agglomeration via technical innovation agglomeration.

Second, from the empirical results on urban rail line length, technical innovation agglomeration, and consumer service industry agglomeration, model (16) indicates that urban rail line length has a significant promoting effect on consumer service industry agglomeration; model (17) indicates that urban rail line length has a significant promoting effect on technical innovation agglomeration; and model

TABLE 6: Empirical analysis results 5.

	Model (25) LQ_{1it}	Model (26) $LnCA_{it}$	Model (27) LQ_{1it}	Model (28) LQ_{2it}	Model (29) $LnCA_{it}$	Model (30) LQ_{2it}
LQ_{it-1}	−0.3528**	−0.2643*	0.2710**	0.2891**	−0.1052	0.0527*
	(−2.12)	(−1.78)	(2.21)	(2.31)	(−0.94)	(1.79)
$LnTRAN_{it}$	0.0740*	0.0464*	0.0925***	0.1367***	0.0467***	0.0646***
	(1.68)	(1.66)	(3.56)	(3.62)	(3.40)	(4.47)
$LnCA_{it}$			0.0781*			0.0190*
			(1.72)			(1.85)
$LnGDP_{it}$	0.3712***	−0.4654***	−0.1012**	−0.3096*	−0.0977***	0.1538***
	(3.23)	(−3.35)	(−2.20)	(−1.90)	(−2.92)	(5.81)
$LnINS_{it}$	−0.0048	−0.0741	0.1396	0.2624	−0.0204	−0.0902***
	(−0.02)	(−0.21)	(1.38)	(1.04)	(−0.37)	(−8.01)
$LnGOV_{it}$	0.0254	0.0952	−0.0076	−0.0879	−0.0161*	0.0637***
	(0.59)	(1.64)	(−0.29)	(−0.45)	(−1.69)	(8.60)
$LnWAGE_{it}$	0.0209	0.0157	−0.0319	−0.1190***	0.0405*	0.0534***
	(0.56)	(0.19)	(−0.83)	(−2.72)	(1.65)	(8.04)
$LnHUM_{it}$	−0.1886**	0.0995	0.0288	0.0974	0.0710***	0.0820***
	(−2.34)	(0.73)	(0.61)	(1.01)	(2.68)	(8.06)
$CONSTANT_{it}$	−1.2483	5.9138***	0.8837	3.2508	1.3719***	8.9015***
	(−0.93)	(3.67)	(1.45)	(1.48)	(2.67)	(62.07)
Dum_Individual	YES	YES	YES	YES	YES	YES
Dum_Year	YES	YES	YES	YES	YES	YES
Wald value	27.98***	76.38***	51.08***	125.42***	88.39***	190.23***
Obs.	196	196	196	196	196	196

Note: *, **, and *** indicate 10%, 5%, and 1% levels of significance; z values are in parentheses.

TABLE 7: Empirical analysis results 6.

	Model (31) LQ_{1it}	Model (32) $LnTA_{it}$	Model (33) LQ_{1it}	Model (34) LQ_{5it}	Model (35) $LnTA_{it}$	Model (36) LQ_{5it}
LQ_{it-1}	−0.6618**	−0.2513	0.4776***	0.2664***	0.0339	0.2103***
	(−2.28)	(−1.57)	(3.05)	(2.62)	(0.19)	(7.14)
$LnTRAN_{it}$	0.1620***	0.2184**	0.1684***	0.0366**	0.2184***	0.0342***
	(6.92)	(1.95)	(7.43)	(1.97)	(3.85)	(3.39)
$LnTA_{it}$			0.0297*			0.0107***
			(1.80)			(2.61)
$LnGDP_{it}$	0.5332***	−0.4726**	−0.0832	0.9308***	−0.3422***	−0.1923***
	(2.83)	(−2.11)	(−1.01)	(7.59)	(−3.35)	(−4.14)
$LnINS_{it}$	0.0368	0.1408	0.1295	0.5930**	−0.2642*	0.3554***
	(0.17)	(0.32)	(0.96)	(2.12)	(−1.78)	(5.71)
$LnGOV_{it}$	0.0069	0. 1282**	−0.0084	0.2506	0.2331**	−0.0217
	(0.13)	(2.42)	(−0.39)	(1.21)	(2.39)	(−0.99)
$LnWAGE_{it}$	0.0311	0.0110	0.0239	0.0420	−0.0008	−0.0080
	(0.36)	(0.08)	(0.41)	(1.09)	(−0.04)	(−1.33)
$LnHUM_{it}$	−0.0666	0.0525	−0.0020	0.0695	0.2393***	0.0421
	(−0.57)	(0.43)	(−0.04)	(0.56)	(2.52)	(1.25)
$CONSTANT_{it}$	−4.0070**	5.1434*	−0.1086	−12.0428***	4.0413***	1.0548**
	(−2.06)	(1.87)	(−0.09)	(−6.03)	(3.08)	(1.95)
Dum_Individual	YES	YES	YES	YES	YES	YES
Dum_Year	YES	YES	YES	YES	YES	YES
Wald value	14.25***	60.54***	31.86***	106.34***	106.23***	118.98***
Obs.	196	196	196	196	196	196

Note: *, **, and *** indicate 10%, 5%, and 1% levels of significance; z values are in parentheses.

(18) indicates that urban rail line length and technical innovation agglomeration have a significant promoting effect on consumer service industry agglomeration. These findings suggest that urban rail line length can promote consumer service industry agglomeration via technical innovation agglomeration.

Thirdly, from the empirical results of control variables, GDP can promote the agglomeration of technological innovation, manufacturing, and consumer services; wage level can promote the agglomeration of technological innovation and consumer services; human capital can inhibit the agglomeration of manufacturing.

4.2. Robustness Test. The foregoing section describes the use of empirical models to analyze the effect of urban rail development on industrial agglomeration. To further test the rigor and scientific validity of the conclusions drawn above, this study uses the two-step method GMM to perform empirical estimates of the above dynamic models with panel data. Tables 5–7 provide quantitative empirical results for the dynamic panel data models, which take urban rail line length as the explanatory variable.

First, the regression results for urban rail development, labor agglomeration, and industrial agglomeration in Table 5 show that after controlling for the upgrading of the industrial structure, government expenditures, wage level, and human capital, urban rail line length can still exert a significant promoting effect on manufacturing industry agglomeration and consumer service industry agglomeration via labor agglomeration. This is consistent with the results shown in Table 2 and indicates that increases in urban rail line length can effectively induce manufacturing industry agglomeration and consumer service industry agglomeration in a city through labor agglomeration.

Second, the regression results for urban rail development, capital agglomeration, and industrial agglomeration in Table 6 show that urban rail line length still exerts a significant promoting effect on manufacturing industry agglomeration and consumer service industry agglomeration in a city. This is consistent with the results shown in Table 3 and indicates that urban rail line length can effectively induce manufacturing industry agglomeration and consumer service industry agglomeration in a city through capital agglomeration.

Third, the regression results for urban rail development, technical innovation agglomeration, and industrial agglomeration in Table 7 show that urban rail line length exerts a significant positive promoting effect on manufacturing industry agglomeration and consumer service industry agglomeration in a city. This is consistent with the results shown in Table 4 and indicates that increases in urban rail line length can effectively induce manufacturing industry agglomeration and consumer service industry agglomeration in a city through technical innovation agglomeration.

In summary, this study uses GMM-based dynamic panel models to convincingly verify that urban rail development affects industrial agglomeration via factor agglomeration, and this study's conclusions possess a certain degree of scientific validity and robustness.

5. Conclusions and Recommendations

This study uses location quotients to calculate levels of industrial agglomeration in Chinese cities of the prefecture level and above during 2006–2018 and conducts empirical analysis of the effect of urban rail line length on industrial agglomeration. This study draws the following conclusions: (1) urban rail development has a significant promoting effect on labor agglomeration, capital agglomeration, and technical innovation agglomeration; (2) urban rail development can effectively induce manufacturing industry agglomeration and consumer service industry agglomeration in cities;

(3) the influence of urban rail development on urban manufacturing industry agglomeration and consumer service industry agglomeration is chiefly attributable to the mediating effect of factor agglomeration (labor agglomeration, capital agglomeration, and technical innovation agglomeration). This study therefore makes the following recommendations:

(1) Progressively completing urban rail transit networks and promoting the coordinated development of urban rail transit: to achieve a strong economic stimulating effect from urban rail transit, urban centers should engage in coordinated rail transit planning and batchwise development and establish dedicated departments to manage and design rail transit systems.

(2) Strengthening the development of integrated rail transit hubs and the coordination of urban rail transit with other modes of transportation: the connection and convenience of rail transit systems and other modes of transportation should be constantly strengthened so that various modes of transportation can be organically combined to maximize network effects and provide more convenient services for urban agglomerations.

(3) Optimizing the allocation of capital to urban rail transit and improving the investment performance of rail transit capital: more functional, broader-coverage total factor markets should be established to promote the robust development of capital factor markets. This could allow capital to move more freely between different cities and between cities and their suburban districts, so that the radiating role of central cities could be fully promoted to increase the effectiveness of capital investment in rail transit.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Acknowledgments

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