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The Relationship Between Rail Transit and Industrial Agglomeration: Mediating Effect of Labor Agglomeration

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The urban transit system is considered the backbone of any society as it heavily depends on economic progress. The railway transit system is crucial for any urban transit system. Based on this notion, the present research explores the industrial agglomeration in China's prefecture-level and cities from 2010 to 2020. The research analyses the processes of urban rail transit building, industrial agglomeration, and labor agglomeration due to the railway's transit network development. The findings are summarized in three main points; first, the agglomeration of the labor force is positively affected by the construction of urban rail transit infrastructure. Secondly, the development of railways infrastructure stimulates the agglomeration of manufacturing industries in and near urban population centers leading to the development of services industries. Third, the development and integration of railways networks with other transportation networks also optimize the allocation of capital in these areas as well. In the present research Preacher and Hayes, Behavior research methods, 2008, 40 (3), 879–891 methodology has been applied to determine the relationship between the development of railways transit system and concentration of industries, by taking into account the mediating effects of labor agglomeration. The development of railways network tends to bring economic and industrial development to these regions resulting in overall social development.

Keywords: rail transit, urban, environment, industrial agglomeration, labour agglomeration

INTRODUCTION

Railway network is among the determinants of economic growth (Magazzino and Giolli, 2021). The use of urban rail transportation facilitates the growth of the urban economy, the enhancement of the industrial structure, and the improvement of the living conditions of the city's population. The importance of economic growth to domestic demand and economic expansion has been increasingly obvious in recent years. It will have a significant impact on green GDP growth and sustainable urban development (Chang-fu and Yuan, 2011). Cities in Mainland China have completed the construction of urban rail transit systems with a total distance of 6,736.2 km, setting a new national record for the

longest urban rail distance. The development of the rail-based transit system in urban population centers has augmented the significance of the geographic and social position of the cities.

Several studies have found that urban rail traffic negatively influences property values due to noise, air pollution, and a rise in crime in the vicinity of stations (Wen et al., 2021). Given this regional heterogeneity, the impact of urban rail transportation on property value is greatly reliant on the location of the transit system (Wang et al., 2019). Stations for public transportation have the biggest influence on real estate value. The greatest impact is often assumed to occur within a half-mile or a 10-min walk of rail transit terminal's Suburban locations, and low-income individuals are more likely than city center residents to benefit from urban rail transportation, according to recent studies of (Liang et al., 2018; Połom et al., 2018). Urban rail transportation can increase the value of property in low-income neighborhoods, but it has no significant or negative influence on the value of housing in high-income neighborhoods (Połom et al., 2018).

Urban sustainable mobility may be brought to life through the development of rail-based public transportation networks, such as urban trains, which can help to reduce traffic congestion. It is possible to increase the efficiency of transportation in two ways: first, by improving infrastructure and vehicles on a technical level, and second, by altering the modal split to reduce the number of private cars on the road, which in turn reduces traffic and all of its negative consequences, including social consequences (Brown and Werner, 2008).

This adjustment is necessary as part of the overall effort to minimize greenhouse gas emissions, which includes Considering how much energy cities and transportation systems consume daily; there is a big opportunity to cut greenhouse gas emissions in this sector. These benefits may be realized only via the development of public rail-based transportation networks in conjunction with sound planning. Rail-based transportation has a considerable influence on a city's physical and functional organization, particularly in urban areas (Atuesta et al., 2018; Kang, 2019; Rokicki et al., 2021).

Rail transit is considered the first mechanical form of mass transit for passengers and cargo over land, tracing its origin from 1825 in England using steam power (Patmore, 1966). After the second world war owing to the development of roads and transportation means such as lorries, busses, and cars, railways seemed to have lost their importance for a certain period. Still, in recent times, the importance of railways as means of transportation and connectivity has risen once again, owing to the environmental concerns and problems associated with road-based transportation in urban areas such as congestion, noise, air pollution and concerns related to health and safety in forms of deaths and injuries caused by road accidents (Harford, 2006). The railways as means of passenger transport in urban areas serve as a business opportunity and serve many other social and economic functions (Chansky and Modica, 2018). The efficient mobility of the labor force and goods allows the businesses to diversify their production facilities in a different geographical location allowing for improvement in efficiency and social and economic development (Thisse, 2010).

China has been facing both environmental and social-economic issues related to the efficiency of public transport in urban areas owing to the rapid industrial and economic development of the country, as a result of a population of over 1.4 billion. Due to such problems, the Chinese government started to pay special attention to the development of railway infrastructure as means of efficient transportation as railways account for almost 45% of all Chinese passenger traffic and 40% of all freight millage.

Chinese government has paid great deal of attention to improvement of railways-based transport infrastructure. This is evident from the investment of over 60 billion yuan and government continues to further improve the existing network by further extension into the newly formed industrial states to connect them to the national and international market places Sun et al., 2014.

The rise of rapid urban rail transportation in China may influence industrial agglomeration in the real world, but what impact? Is there any evidence that other factors mediate this effect? It is possible that addressing these challenges may help advance the development of the Chinese urban railways'-based transit system and provide governments with suggestions for further improvement and development of rail-based transit systems and more precise placement concerning the urban population centers.

Although much research has been done on the relationship between the transportation industry, accumulation manufacturing, services industry and the impact of such accumulation on the economic growth (Ciccarelli et al., 2021; Mele and Magazzino, 2021; Bilgili et al., 2022) limited research has been conducted on the impact of urban railways-based transit systems on the industrial accumulation in the urban population centers. This research aims to investigate the underlying relationship between the urban railways-based transit systems and industrial agglomeration by utilizing a clear viewpoint on the agglomeration factor and a mediating-effect model developed in this study. To date, most studies investigating the effects of the development of urban rail-based networks on overall economic growth and accumulation of industry have relied on qualitative research approaches and have been unable to quantify this effect. This study differentiates itself from previous studies by using China's region and higher-level cities data to construct the "Fixed-Effects Panel Data Models" and dynamic Generalized Method of Moments (GMM) models to investigate the underlying procedure by which the use of urban railways-based transit systems affects industrial agglomeration through concentration of labor.

The remainder of this paper is organized as follows. Next section discusses the importance of urban rail transit in China. Section three presents the material and method. Section four provides the results and discussion. Last section concludes the study with policy recommendations.

IMPORTANCE OF URBAN RAIL TRANSIT IN CHINA

Five hundred and twenty cities of seventy-five countries in 2019 opened regions worldwide urban rail transit with a total operating

mileage of 28,198 km, corresponding to a 7.9% increase on a year-on-year basis. A total of 40 cities in China have opened rail transit, and 26 new operating lines have been added. In 2019, the total length of urban rail transit driving routes reached 6,730km, a year-on-year increase of 16.8%, with an average daily passenger flow of 49.56 million passengers. In addition to Beijing, Shanghai, Guangzhou, Shenzhen, and the provincial capital city circle, some third-tier city circles are also actively preparing for rail transit construction (Köll, 2019). The 18th National Congress of the Communist Party of China proposed constructing a new type of urbanization, from the one-sided pursuit of the expansion of urban space in the past to the purpose of intensive, compact, and intelligent roads. To keep pace with the rapid economic progress and urbanization, keep in mind the importance of efficient means of transportation in the country's economic and social development and link it to future endeavors such as CEPEC and Belt and Road projects (Choi, 2021). The CPEC refers to China Pakistan Economic Corridor and is one of the most important components of Chinese Belt and road initiate (BRI). This project mainly includes construction of pipelines, roads and railways network connecting Chinese mainland with Gwadar port in south of Pakistan. The project will enable China to substantially cut the cost of energy imported from middle east via Arabian sea and will also enable China to increase the trade volume with European countries as well.

In the existing research, many scholars believe that the role of infrastructure supply on production efficiency is because it provides higher-quality facilities and services to the private sector, thereby expanding the possible production optimization boundary (Han and Wang, 2013). The industry is mainly concentrated at a higher speed by constructing high-speed and convenient municipal transportation such as rail transit. Externalities and the agglomeration of talents provide an incubation platform for innovative behaviors, promote information diffusion and knowledge spillover, reduce commuting and transaction costs, and reduce the negative externalities caused by excessive industrial agglomeration (Yu et al., 2006). Therefore, the agglomeration effect is also significant for urban circles to promote production efficiency through public transportation construction. The construction of urban rail transit has become a necessary condition for releasing agglomeration economic power. However, the premise for the release of this force is that the urban agglomeration has enough population and residents' demand for public transportation infrastructure (Li et al., 2021). In recent times the importance of railways has also been highlieghted by resercher such as (Jiang et al., 2018) and (Kong et al., 2021). The findings of these scholars have reignited research trend exploring the positive economic and social impact of the transport infrastructure, especially that of the railways-based infrastructure (Lu et al., 2022).

MATERIALS AND METHODS

Data Sources

The present research uses the data from prefecture-level and above cities from 2010 to 2020, this study ensures that the statistical quality is consistent. The data was compiled and extracted from the sources of Statistical Yearbook Urban Construction, Chinese Statistical Yearbook, and City Statistical Yearbook.

Model Estimation

This study follows the methodology proposed by Preacher and Hayes (2008), taking into account the industrial agglomerates in the urban centers of China as explained variables while considering labor agglomeration as mediating variables and the rail transit in the urban areas of China as the main explanatory variable.

This study aims to test whether the transmission mechanism of urban rail transit to industrial agglomeration is mainly realized by labor agglomeration. If true, this would imply that labor 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:

$$AMI_{it} = \alpha + \beta_1 TRAN_{it} + \beta_2 GOV_{it} + \beta_3 GDP_{it} + \beta_4 INS_{it} + \beta_5 WAGE_{it} + \beta_6 HUM_{it} + \nu_i + u_t + e_{it} \quad (1)$$

$$ASI_{it} = \alpha + \beta_1 TRAN_{it} + \beta_2 GOV_{it} + \beta_3 GDP_{it} + \beta_4 INS_{it} + \beta_5 WAGE_{it} + \beta_6 HUM_{it} + \nu_i + u_t + e_{it} \quad (2)$$

Where *AMI* and *ASI* represent the dependent variables of **Eqss (1)** and **(2)** which are agglomeration of the manufacturing industry and agglomeration of the services industry, respectively. *URT* is the main variable of interest which represents the development of urban rail transit. Also, the state expenditure represented by *GOV*, economic growth represented by *GDP*, the industrial structure upgrade represented by *INS*, the level of income represented by *WAGE*, and the human capital denoted by *HUM* are taken as control variables. The choice of control variables is based upon the existing literature and prevailing theories on the subject matter. The constant term is α, the error term is denoted by ε_{it}, while the coefficients of explanatory variables are represented by βs. The significant value of β measures the presence of the mediating effect of control variables. No further tests will be performed if this coefficient is statistically insignificant for **Eqs (1)** and **(2)**. If the value of β is held to significant, it still cannot be considered conclusive evidence for the sufficient mediating effect of control variables.

When testing the β_1 coefficient in Models 1 and 2, if the findings indicate that the value of β_1 coefficient is insignificant, which indicates the absence of mediation; there will be no need for further testing. In case the there is partial mediation between the dependent and independent variables which includes the factor agglomeration of the regions which have benefited from the development of the urban railways' transit system, only than we will proceed to further testing.

$$AoL_{it} = \alpha + \beta_1 TRAN_{it} + \beta_2 GOV_{it} + \beta_3 GDP_{it} + \beta_4 INS_{it} + \beta_5 WAGE_{it} + \beta_6 HUM_{it} + \nu_i + u_t + \varepsilon_{it} \quad (3)$$

$$AoCAP_{it} = \alpha + \beta_1 TRAN_{it} + \beta_2 GOV_{it} + \beta_3 GDP_{it} + \beta_4 INS_{it} + \beta_5 WAGE_{it} + \beta_6 HUM_{it} + v_i + u_t + \varepsilon_{it} \quad (4)$$

$$AoTec_{it} = \alpha + \beta_1 TRAN_{it} + \beta_2 GOV_{it} + \beta_3 GDP_{it} + \beta_4 INS_{it} + \beta_5 WAGE_{it} + \beta_6 HUM_{it} + v_i + u_t + \varepsilon_{it} \quad (5)$$

There is a labor agglomeration, a capital agglomeration, and a technological innovation agglomeration in the Model (3, 4, and 5), whereas TRAN is the development of urban rail. Although the coefficient of significance in **Equation 1** is indicates that growth in urban transportation influences the concentration of different factors of production, this still does not does not prove that a mediating impact of development of urban transportation on these factors of production.

In this case, we will proceed to step three, which involves examining the connections between urban rail growth, factor concentration, and industrial concentration; presented as follows.

$$\frac{IAM_{it}}{ASI_{it}} = \alpha + \beta_1 \mathrm{TRAN}_{it} + \beta_2 AoL_{it} + \beta_3 GOV_{it} + \beta_4 GDP_{it} + \beta_5 INS_{it} + \beta_6 WAGE_{it} + \beta_7 HUM_{it} + v_i + u_t + \varepsilon_{it} \quad (6)$$

$$\frac{IAM_{it}}{ASI_{it}} = \alpha + \beta_1 \mathrm{TRAN}_{it} + \beta_2 AoCAP_{it} + \beta_3 GOV_{it} + \beta_4 GDP_{it} + \beta_5 INS_{it} + \beta_6 WAGE_{it} + \beta_7 HUM_{it} + v_i + u_t + \varepsilon_{it} \quad (7)$$

$$\frac{IAM_{it}}{ASI_{it}} = \alpha + \beta_1 \mathrm{TRAN}_{it} + \beta_2 AoTec_{it} + \beta_3 GOV_{it} + \beta_4 GDP_{it} + \beta_5 INS_{it} + \beta_6 WAGE_{it} + \beta_7 HUM_{it} + v_i + u_t + \varepsilon_{it} \quad (8)$$

The **Eqs 6–8** show the influence of factor agglomeration on industrial agglomeration. To verify the presence of mediation amongst the dependent and independent variables, the Sobel test must be applied. The results of the Sobel test conclusively prove the presence of mediations amongst the dependent and independent variables.

Explained Variable

As the concept of industrial agglomeration has developed, various methodologies for measuring industrial agglomeration have arisen. Industrial agglomeration has been measured using several ways, including the industry share and industrial concentration indicators (the basic ones) and the dynamic agglomeration indicator method, which is all described below. When determining the level of industrial agglomeration, many scholars turn to the location quotient to help them figure it out. The location quotient can be used to eliminate components that are impacted by area size changes from geographical data to depict them more properly. In addition to (Li et al. (2021); R. Liang and Xi (2016)) have employed the "location quotient" as the major indicator for analyzing industrial agglomeration. In it is possible to determine the specialization of an industrial agglomeration by doing an economic study on it in depth. It may be done by looking at the number of people engaged in that industry related to industrialization (Chang-fu and Yuan, 2011). Therefore, the location quotient, is used to assess the degree of industrial agglomeration as given in **Equation 9**:

$$LocQ_{ij} = \frac{\left(\frac{Q_{ij}}{\sum Q_{ij}}\right)}{\left(\sum Q_{ij} \sum Q_i \sum Q_j\right)} \quad (9)$$

A region's industrial agglomeration ($LocQ_{ij}$) and the number of people it employs (Q_{ij}) are represented in Model 9. There is a comparative advantage between industry j in city i and other industries j in other cities when $LocQ_{ij} > 1$. In this study, the location quotient was used to measure the industrial agglomeration of manufacturing and service businesses in the regions which have benefited from the development of the urban railways' transit system.

Measurement of Variables

The choice of the variable of agglomeration of industries and use of location quotient is based upon previous studies (Chen, 2018; Shu et al, 2020). Another reason for using location quotient mainly relates to its ability to eliminate the factors related to the size of the urban center and helps to pinpoint the spatial distribution of different urban centers on the map, as held by (Liu and XU, 2010; Sun et al., 2012). Mei et al., 2020 held that the location quotient is one of the best ways to determine industry accumulation with a specific geographical region; the same was held.

The main independent variable chosen for the present study is developing a rail-based urban transit network in terms of the length of the railway line. Labor agglomeration variables are the mediating variable in this study. Cobb–Douglas production function models feature labor agglomeration as one of the main mediating variables. This study depends on labor density to gauge the degree of labor agglomeration in Chinese cities on a national scale. The labor density of a city is calculated by dividing the population in its administrative area by the annual population of its jurisdictional region.

RESULTS AND DISCUSSION

Empirical Results and Analysis

The present research utilized the statistical model to ascertain the mediating effect endorsed by (Preacher and Hayes, 2008). It utilized the software of SPSS 22.0 for statistical analysis in line with the principles based upon previous research regarding the testing effects of mediation. These findings are presented in **Tables 1–3**. There is empirical evidence that the length of the urban rail-based network affects industrial agglomeration through concentration of labor force, as shown in **Table 1** urban rail line length study, after controlling for the variables of government expenditure, up-gradation of the industrial infrastructure, the general level of wages, and labour. The results of Model 1) show that the length of the urban rail-based network has a significant promoting effect on the manufacturing industry, Model 2) represents that the length of

TABLE 1 | The relationship between urban rail transit on industrial agglomeration: mediating effect of labour agglomeration.

Dependent variable	AMI		LA		AMI	
Variable	Model 1		Model 2		Model 3	
	Coef	*p*-Value	Coef	*p*-Value	Coef	*p*-Value
TRAN	0.2134[b]	0.012	0.1876[a]	0.001	0.1465[b]	0.042
LA	—	—	—	—	0.0542	0.032
GoV	–0.0654	0.124	0.3213	0.253	–0.6431	0.214
GDP	0.7034[b]	0.047	0.5361[b]	0.020	0.2141[b]	0.051
INS	–0.0168[a]	0.004	–0.0453	0.160	–0.1929[b]	0.149
Wage	–0.0053	0.213	0.5647[b]	0.0156	0.0321[b]	0.021
HuM	0.0324[a]	0.002	0.4235[a]	0.001	0.1610[a]	0.040
Constant	4.972[a]	0.000	3.300[a]	0.000	2.015[a]	0.000
Adj-R^2	28%		30%		25%	
N	336		336		336	

[a]*Note: Represent the level of significance at the 1%.*
[b]*Represent the level of significance at the 5%.*
[c]*Represent the level of significance at the 10%.*

TABLE 2 | The relationship between urban rail transit on industrial agglomeration: mediating effect of labour agglomeration.

Dependent variable	ASI		La		ASI	
Variable	Model 1		Model 2		Model 3	
	Coef	*p*-Value	Coef	*p*-Value	Coef	*p*-Value
TRAN	0.1475[a]	0.002	0.2154[a]	0.000	0.1465[b]	0.042
LA	—	—	—	—	0.0542[b]	0.032
GoV	0.0754[b]	0.012	0.6124[a]	0.002	–0.6431	0.214
GDP	0.4321[b]	0.032	0.5243[b]	0.020	0.2141[b]	0.051
INS	0.1435[a]	0.241	0.1253	0.210	–0.1929 [b]	0.149
Wage	0.1230	0.213	0.4326	0.215	0.0321[b]	0.021
HuM	0.1534[b]	0.042	0.3452[b]	0.054	0.1610[a]	0.040
Constant	5.321[a]	0.000	4.030[b]	0.040	3.543[c]	0.070
Adj-R^2	24%		27%		26%	
N	336		336		336	

[a]*Note: Represent the level of significance at the 1%.*
[b]*Represent the level of significance at the 5%.*
[c]*Represent the level of significance at the 10%.*

TABLE 3 | Robustness test.

Dependent variable	AMI		La		AMI	
Variable	Model 1		Model 2		Model 3	
	Coef	*p*-Value	Coef	*p*-Value	Coef	*p*-Value
LnURT	0.1354[a]	0.001	0.2253[a]	0.000	0.1376[b]	0.052
LnLA	—	—	—	—	0.0321[b]	0.011
LnGoV	0.0653[b]	0.021	0.6023[a]	0.001	–0.5431	0.154
LnGDP	0.3214[b]	0.025	0.5043[b]	0.010	0.1981[b]	0.049
LnINS	0.1323	0.143	0.1165	0.180	–0.2032[b]	0.135
LnWage	0.1543	0.432	0.4265	0.195	0.0342[b]	0.041
LnHuM	0.1324[b]	0.025	0.4043[b]	0.053	0.1432[a]	0.050
Constant	4.431[a]	0.000	6.067[b]	0.010	3.6521[c]	0.090
Industry andYear Dummies	Yes		Yes		Yes	
Wald Ch^2	17%		30%		13%	
N	275		275		275	

[a]*Note: Represent the level of significance at the 1%.*
[b]*Represent the level of significance at the 5%.*
[c]*Represent the level of significance at the 10%.*

TABLE 4 | Robustness test.

Dependent variable	ASI		La		ASI	
Variable	Model 1		Model 2		Model 3	
	Coef	*p*-Value	Coef	*p*-Value	Coef	*p*-Value
Ln TRAN	0.1365[a]	0.005	0.2065[a]	0.000	0.1876[b]	0.052
LnLA	—	—	—	—	0.0654	0.023
LnGoV	0.0634[b]	0.021	0.5723[a]	0.001	–0.7456	0.432
LnGDP	0.4031[b]	0.023	0.5876[b]	0.040	0.2098[b]	0.055
LnINS	0.1176[a]	0.432	0.1165	0.320	–0.2051[b]	0.139
LnWage	0.1032	0.321	0.4216	0.431	0.0112[b]	0.041
LnHuM	0.1890[b]	0.052	0.3267[b]	0.045	0.1871[a]	0.030
Constant	4.652[a]	0.000	3.987[b]	0.050	2.687[c]	0.090
Industry andYear Dummies	Yes		Yes		Yes	
Wald Ch^2	18%		32%		12%	
N	275		275		275	

[a]*Note: Represent the level of significance at the 1%.*
[b]*Represent the level of significance at the 5%.*
[c]*Represent the level of significance at the 10%.*

urban rail transit also has a significant impact on labor agglomeration; and Model 3) represents that length of urban transit and labor agglomeration have a significant effect on manufacturing industry agglomeration. Previous research indicates that the urban rail-based network significantly impacts industry and labor force agglomeration in the urban population centre, as illustrated in **Table 1**, after controlling for the up-gradation of the industrial infrastructure, government expenditures, general level wages, and concentration of labor force. In the present research, the results of Models (1), (2), and 3) also endorsed the above-cited notion.

Meanwhile, the results of **Table 2** Model 1) indicate the agglomeration of manufacturing and services industries in the urban population centers. At the same time, the results obtained from Model 2) indicate that the development of the rail-based network in terms of the total length of railways tracks tends to have a positive impact on the concertation of the labor force in the urban population centers. The results of Model 3) show length of the urban railway-based network and concentration of the labor force are both positive factors. These findings imply that the length of a city's rail lines might encourage the clustering of consumer service industries by increasing the concentration of workers. A third finding is that economic factors like GDP, wage level, and human capital can influence industrial clustering, consumer service industry clustering, and labor aggregation based on the results of **Table 1**, given that their value was held to be statistically significant. Given fact that the human capital prefers to move to areas with relatively better employment opportunities with higher wage levels. Resulting in establishment of services industries and other consumer-based industries. Given that increase in concentration of industries and population, the governments further increase the spendings on infrastructure projects such as transportation, leading to further economic opportunities and increase in wage level, resulting in increase in personal income and spending. Thus, the overall GDP of the region increase, contributing to increase in national GDP and economic development.

To begin, after controlling for factors such as industrial structure upgrade, government spending, wage level, and human capital in the empirical results, Model 1) demonstrates that the length of an urban rail line promotes manufacturing industry agglomeration; Model 2) demonstrates that the length of an urban rail line promotes labor agglomeration as well. The length of an urban rail line may have a favorable impact on the agglomeration of industrial industries by aiding the agglomeration of labor. According to the empirical study, the length of an urban rail line is positively related to labor agglomeration, consumer service industry expansion, and the growth of urban labor agglomeration, among other things. According to these findings, the length of a city's rail lines may increase consumer service industry clustering by creating labor enclaves in the urban population centers.

According to empirical research findings on control variables, GDP growth, wage increases, and human capital accumulation may all be expected to contribute to the concentration of manufacturing, consumer services, and labor industries in a given period. Technical advances in manufacturing can function as a deterrent to concentration, while government investment can increase concentration in the consumer-services sector and concentration in the labor market.

To evaluate the link between industrial concentration and manufacturing and customer service clusters, we looked at the length of urban rail lines in **Table 3** to see whether there was any association. As a result of the empirical findings on the length of urban rail lines in cities, capital concentration, and the concentration of manufacturing industries in agglomerations, Models 7) and 9) indicate that the length of urban rail lines has a significant effect on manufacturing industry concentration; Model 8) indicates that the length of urban rail lines affects capital concentration; and Model 8) indicates that the length of urban rail lines affects manufacturing industry concentration. As a result of these findings, it appears that the length of urban rail lines may promote the agglomeration of industrial industries by facilitating the concentration of capital.

Robustness Test

The empirical models described in the preceding section were used to examine the impact of the development of urban rail infrastructure on the agglomeration of industry in urban population centers. The research utilized Two-step GMM for estimations of the aforementioned dynamic models using the panel data to ensure that the findings reached above is scientifically sound. According to **Tables 3**, **4**, the dynamic panel data models that use the length of the urban railway-based network as an explanatory variable have statistically significant findings.

As shown in **Table 3**, **4**, the regression results show that even after accounting for factors such as the improvement of the structure of the industry, government spending, general levels of wages, and human capital, the length of the urban railways-based network can still have a significant impact on the agglomeration of manufacturing industry and industry involving the consumer-based service via labor agglomeration.

The results obtained from the regression for the variables of urban rail development, agglomeration of labor, and agglomeration of industry, can be assessed from **Table 3**, **4**, which indicate that increasing the length of urban rail lines can lead to an increase in the number of manufacturing and accumulation of services in cities. These results are consistent with our main findings of **Tables 1**, **2**.

By utilizing the GMM-based dynamic panel models, this study shows conclusively that urban rail growth influences the agglomeration of industries via the accumulation of different factors of production such as labor, and its findings are statistically legitimate and robust.

CONCLUSION, POLICY RECOMMENDATIONS, AND LIMITATIONS

By utilizing location quotients, this study investigated the underlying relationship between the total length of the urban rail network and industrial agglomeration at the county and district level from 2010 to 2020 in Chinese cities. It determines the effects of railways development on industrial agglomeration levels in these areas. The following are the findings of this study: There is a strong positive impact on labor agglomeration when urban rail construction is implemented. A city's ability to effectively instigate manufacturing and service industry agglomeration is largely attributed to labor agglomeration, an intermediary between urban rail transit and industrial agglomeration. The following are the findings of this investigation.

It is recommended that separate departments for the development, improvement, and integration of railways network in urban centers should be established by the governments at district and regional levels. The rail-based network should be developed in stages; they can be integrated with the existing transportation network, serving as a stimulus for economic and social development for the area and region.

The existing rail-based network and related infrastructures such as stations and other hubs should be designed most conveniently to maximize their potential and possible integration in future expansion. This aspect will endure their maximum utilization in terms of capital and capacity. Such steps will enable the mobility of labor and goods to and from the industrial hubs located in or near urban centers.

The optimally allocating capital resources for urban railway-based transit network and increasing the investment for optimizing of the railway's transit system in terms of its functional; broader coverage to aid the efficient transportation of different factors of production such as raw material, finished goods, and labor should also be considered, as this would facilitate capital movement between cities and their suburbs, allowing the cities to play an important role in the economic and social development of region and country as a whole.

In China, the urban rail transit networks improve efficiency and coordination and social and economic development. Still, at the same time, one has to keep in mind that it does not necessarily solve the issues such as traffic congestion. The planning of the city circle should pay more attention to the rationality of the geographical space and cover as much as possible, and the supporting infrastructure also needs to be paid attention.

The local authorities should control the process of construction of the railway's infrastructure and gradually carry out the structure of supporting facilities and the implementation of policies, so as not to disrupt the local transportation system and people whose livelihood is associated with it such as people such as cab drivers and other people who are directly or indirectly associated with urban transport.

Urban planning in various cities is keen to "divide" industrial and commercial areas and administrative and residential areas. Although this approach is conducive to overall macro-management, it will inevitably aggravate the separation of job and residence, which will bring about the expansion of space between employment and living. Therefore, rail transit planning is only an auxiliary means to solve the commuting pressure and improve the efficiency of the industry. However, in the case that the existing pattern cannot be broken in the short term, the first round of rail transit construction in the urban circle should connect essential people such as airports, stations, docks, commercial centers, hospitals, and schools, and increase commercial housing around the rail transit lines for stabilization of the housing prices of the city circle, the transportation capacity of the city circle can be improved as much as possible.

The present study highlights s the importance of rail-based urban transportation as it highlights how development of this mode of transport has positive impact on the overall economic development f the region. As the development of railways and related infrastructure is usually considered as capital intensive but in long term its economic and social impact tend to overshadow the initial capital outlay. Therefore, policy makers need to encourage and further develop rail-based transportation network. The Chinese government policies, in this respect can assumed to ideal and can be China in this regard can be considered as role model for developing countries.

The initial investment in railways is high; it is paramount that the routes be planned to maximize the use of railways to boost the revenues and make railways more financially feasible. One of the study's major limitations relates to the limitation in terms of time and resources. Second, the impact of rail transit on the industrial

efficiency of the city circle may be reflected in the tertiary industry, such as the financial industry, high-tech industries, science, education, culture, and health, etc., gathering along the rail transit lines, all of which will be the main direction of future research.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

All authors contributed to the study conception and design. Data collection, were performed by JS, DD, and QF, and the first draft of the manuscript was written by JC, DD, and MSS. Data processing and analysis were performed by DD, MSS, and AGY. The manuscript was reviewed and edited by LMC and AGY. LMC provided financial support for the conduct of the research. All authors commented on previous versions of the manuscript. All authors read and approved the manuscript.

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