

Article

High-Speed Railway Opening and High-Quality Development of Cities in China: Does Environmental Regulation Enhance the Effects?

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Abstract: The continuous improvement of transportation infrastructure is an important support for achieving high-quality development, while the high-quality characteristics of development will inevitably promote the process of economic and social sustainability. From the dual perspectives of economic transformation and people's social livelihoods, we regard the opening of a high-speed railway (HSR) in China's cities as a quasi-natural experiment, and utilize the difference-in-difference (DID) method to examine the impact of improved transportation infrastructure on the high-quality development of prefecture-level cities and its action mechanism. This study is the first to incorporate HSR openings and environmental regulation into the same framework, focusing on the high-quality development problem of cities. The empirical results reveal that: (1) the opening of an HSR can advance industrial structure upgrading and increase social employment level, thereby promoting the high-quality development of cities; (2) the intensity of environmental regulation is an important action mechanism that affects such relationships, but it presents two different influences on an HSR's industrial effect and employment effect, that is, inhibition and reinforcement, respectively; and (3) urban heterogeneity tests illustrate that an HSR opening plays a more significant role in promoting the high-quality development of China's eastern region cities and non-resource-based cities. Our findings are beneficial to improve the effectiveness and accuracy of decision-makers' investment in transportation infrastructure as well as to facilitate the benign interaction between the national HSR policy and local environmental regulation strategies, thereby achieving the high-quality and sustainable development of urban economy and society.

Keywords: high-speed railway opening; high-quality development; industrial structure; social employment; environmental regulation



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1. Introduction

At present, China's economy is changing from a high-speed growth stage to a high-quality development stage. Specifically, China's economic growth focuses more on quality and efficiency, rather than just quantity and scale. This is because the Chinese government recognizes that the past growth model of high-energy consumption, high pollution, high input and low output is unsustainable [1]. On the one hand, high-quality development emphasizes the urgency of the transformation from total amount expansion to structural optimization. Especially in the period of China's economic transition, adjusting and optimizing industrial structure has become an important way to release the potential of economic growth sustainably. On the other hand, high-quality development also emphasizes the importance of meeting the people's ever-growing needs for a better life. Particularly under the influence of COVID-19, stabilizing and expanding employment

becomes the prerequisite for achieving common prosperity [2]. Accordingly, the essence of high-quality development lies in achieving the balance between economic adjustment and people's social livelihoods, among which the transformation and upgrading of industrial structure is the core and key to high-quality development, while employment is the foundation of people's livelihoods.

At the same time, with the occurrence of trade frictions between countries and public health emergencies, the uncertainty of the external environment facing China has been increasing. As a national long-term development strategy and an important transportation infrastructure investment project to boost China's economy, the high-speed railway (HSR) may become the driving point for the optimization and upgrading of industrial structure and the steady growth of social employment level while continuously optimizing the transportation network pattern. Compared with other modes of transportation, an HSR has the characteristics of high speed, high efficiency, low-energy consumption, high-cleanliness and high capacity, which significantly improve the accessibility and connectivity between cities [3,4]. Furthermore, an HSR not only shortens the spatiotemporal distance between regions, but also promotes the rapid flow of technology, labor, capital and information among regions, bringing great convenience to enterprises' production and residents' lives. Meanwhile, high-quality characteristics of development are important guarantees for sustainable economic and social development [5], while more sustainability is also the main target of high-quality development [1]. Thus, this high-quality development concept includes and coincides with the global sustainable development idea [6]. Unfortunately, few studies in the literature focus on the impact of an HSR opening on economic and social sustainability, from a high-quality-development perspective. Therefore, a question worthy of attention is: under the background of a relatively compressed international market space, can the improvement of transportation infrastructure be taken as an opportunity to promote the high-quality economic and social development of Chinese cities?

However, the high-quality development of cities is also facing tighter resource and environmental constraints. In recent years, in order to promote sustainable economic and social development as well as implement the United Nations "2030 Agenda for Sustainable Development", local governments at all levels in China have issued relevant environmental protection policies, to a certain extent to increase the restrictions on pollutant emissions from cities and industrial enterprises as well as strengthen environmental regulation [7]. Some manufacturing enterprises with more serious pollution have been gradually shut down, which has reduced labor market demand for low-and-medium-skilled employees, resulting in a contradictory situation of "difficulty in employment and difficulty in recruitment". Meanwhile, according to the 14th Five-Year Plan of China's national economic and social development, improving the quality of ecological environment, continuously driving the adjustment of industrial structure and promoting employment are the meaning of the topic of China's sustainable economic and social development. Environmental regulation, industrial structure adjustment and labor force employment have not only become the focus of policy considerations, but their internal complex relations have also received extensive attention from academia [8]. In particular, under the interference of local government environmental regulation policies, it is worth pondering whether an HSR opening's industrial effect and employment effect are sustainable. Thus, a more valuable question is: what role does environmental regulation play in the process of an HSR affecting the high-quality development of cities?

Current studies on the economic effects of transportation infrastructure mainly concentrate on the impact of an HSR opening on macroeconomic growth and regional development gaps. Unfortunately, the relevant research has not reached a consensus and has provided mixed results. Qin [9] argued that the upgrading of railway produced an obvious "siphon effect", which reduced the investment in fixed assets of county-level cities along the line, resulting in an average decrease of 3–5% in GDP and per capita GDP. Nonetheless, Huang and Wang [10] suggested that the opening of HSR improved the level of cities' total factor productivity, which increased the green innovation efficiency of cities along the

route by about 11.3% on average. Chen and Haynes [11] discovered that an HSR opening could narrow regional development gaps and promote coordinated regional development. However, Ahlfeldt and Feddersen [12] believed that HSR had a “core-edge effect”, namely, station cities benefited from economic agglomeration, while peripheral cities suffered losses. Meanwhile, although some scholars began to explore the effect of an HSR on industrial development, they merely concentrated on the impact of an HSR opening on the tertiary industry and industrial agglomeration. Masson and Petiot [13] analyzed that an HSR opening strengthened the competitiveness of Barcelona with higher tourism potential in the regional tourism pattern, thus, bringing great challenges to the development of tourism industry in Perpignan. Zhou et al. [14] pointed out that an HSR opening had a “spillover effect”, which can directly promote the development of related industries, such as urban finance and transportation. Dai et al. [15] considered that the nine sub-sectors in the tertiary industry showed a trend of agglomeration in cities along the route with HSR stations but a trend of diffusion in cities without HSR stations. On the other hand, existing studies on the social effects of an HSR mainly discussed that an HSR improved residents’ travel demand and commuting efficiency [16], affected population mobility and urbanization level [17] and had a sustainable effect of improving air quality [18]. Meanwhile, although scholars have paid attention to the impact of an HSR on population employment, unfortunately, the research conclusions have always been controversial. Taking the Paris region as an example, Garcia-López et al. [19] found that the employment level and population density would increase significantly in cities close to the stations of regional express rail. However, Cheng et al. [20] argued that the opening of an HSR had a very significant “corridor effect”, which is difficult to make a significant contribution to the employment growth of cities along the line and, in the long run, may even lead to the decline of employment in the edge areas of stations. Nevertheless, Albalade and Fageda [21] pointed out that compared with motorways and air services, an HSR had no significant impact on employment changes. Sobieralski [22] found that railway infrastructure investment had positive employment effects in metropolitan areas with robust rail systems and high ridership. To sum up, the industrial structure effect of an HSR opening has yet to be deeply revealed and verified, and the employment effect still needs to provide more and broader evidence.

In addition, Vickerman [23] suggested that only by combining and matching with local policies, resource endowments and other factors could an HSR play a role in promoting economic growth; while on its own, an HSR would not bring revolutionary impact on the economy. In particular, with the deepening of the concept of sustainable development and the advancement of the actions of global carbon emission reduction, more and more planning and research has begun to pay attention to the impact of government environmental policies on the sustainable development of urban economic and social [8,24]. Nguyen et al. [25] and Nguyen [26] emphasized the positive impact of improving transportation infrastructure and upgrading public transportation service quality on reducing environmental pollution and, thus, promoting sustainable urban development. Regrettably, there is no evidence from the literature to discuss whether environmental regulation is the action mechanism for an HSR opening to affect the high-quality development of cities.

Based on the above background, this paper takes the opening of China’s HSR as a quasi-natural experiment, and starts from two dimensions of industrial structure and employment level to deeply analyze the impact effect and action mechanism of infrastructure construction on the high-quality development of cities. Meanwhile, taking 280 cities at the prefecture-level and above in China from 2007 to 2019 as the research sample, this paper implements the difference-in-difference (DID) model for empirical testing. The findings indicate that by advancing the transformation and upgrading of industrial structure and improving the level of social employment, the opening of an HSR promotes the high-quality development of cities. The analysis of the action mechanism demonstrates that the intensity of urban environmental regulation has a differential impact on the industrial effect and employment effect of an HSR. Specifically, the relatively strong environmental regulation weakens the positive influence of an HSR opening on the optimization of in-

dustrial structure; however, it strengthens the positive impact of an HSR opening on the level of social employment. After replacing high-quality city development measurements, excluding samples from municipalities and provincial capital cities and employing the DID model after the propensity score matching (PSM) approach for robustness checks, the main results remain solid. Further analyses show that compared with central and western cities as well as resource-based cities, the industrial structure upgrading effect and employment promotion effect of the opening of an HSR are more significant in eastern cities and non-resource-based cities in China.

This paper mainly offers the following three contributions. Firstly, using the opening of an HSR as an exogenous shock, this research discusses and empirically examines the impact of transportation infrastructure upgrading on the high-quality development of cities. Although existing studies have deeply explored the impact of HSR construction on the regional economic pattern [27] and the spatial dynamic allocation of factor resources [17], there is still a lack of research on the industrial effect of HSR construction and especially its specific action mechanism [28]. Meanwhile, the discussion on the employment effect of an HSR has always been controversial [19–22]. Moreover, few studies have focused on whether an HSR opening has an impact on the high-quality characteristics of economic and social development [5]. Therefore, from the dual perspectives of economic transformation and people's social livelihoods, this paper focuses on the issue of high-quality development of cities, and tries to verify the important role of the opening of an HSR in the upgrading of industrial structure and the increase of social employment level of cities, thus enriching the research on the economic consequences of the improvement of transportation infrastructure from levels of economic and social sustainability. Secondly, although a few studies have paid attention to the industrial adjustment effect [29,30] and employment effect [31,32] of environmental regulation, few examples from the literature express concern about the interactive effect of the two policies of environmental regulation and an HSR opening, ignoring the interactive direction between environmental regulation intensity and the HSR policy and its possible impact on the high-quality development of cities' economy and society. Accordingly, from the perspective of environmental protection, this paper incorporates environmental regulation and an HSR opening into the same framework to evaluate the sustainability of the HSR effect, which bridges the gap between theory and practice. Specifically, the action mechanism of the impact of an HSR opening on industrial structure and social employment, namely, the intensity of government environmental regulation, is studied, which expands the research perspective on the economic and social effects of an HSR opening. Thirdly, the current research on the evolution characteristics of industry and employment under the differences of urban geographical location and resource endowment is still relatively scarce. Hence, taking into account the special background of China's vast territory and the uneven development among various regions, this paper further analyzes the influence of the heterogeneity of an urban geographical location and resource endowment on the relationship between the opening of an HSR and the high-quality development of cities. Overall, this research provides empirical evidence and decision-making references for functional departments to formulate differentiated resource allocation measures and plan transportation infrastructure construction according to local conditions, thereby realizing the high-quality development goals.

This study's main objectives are to examine the impact of an HSR opening on high-quality city development from both industrial structure and social employment viewpoints, and introduce an environmental regulation factor to then study the action mechanism of the above relationships. The rest of the paper is organized as follows: Section 2 contains the literature review and hypotheses development; Section 3 introduces the methodology, including the data and sample, variable definitions and research models; Section 4 presents the empirical results and analysis; Section 5 is the discussion; and Section 6 concludes the paper.

2. Literature Review and Hypotheses Development

2.1. HSR Opening and Industrial Structure

The improvement of transportation infrastructure has significantly promoted the flow of factors between cities. In addition, it also has advanced the upgrading of industrial structure through the effect of technological innovation and the optimal allocation of capital and the labor force, thus, contributing to sustainable economic development.

On the one hand, an HSR shortens the spatial distance of knowledge dissemination and promotes the spillover of knowledge among industries, which is conducive to improving the level of technological innovation in cities. As a representative industry in the integration of emerging technologies, an HSR is a more sustainable alternative to transportation, which drives green innovation in related industries and makes growth sustainable [10]. The construction of an HSR not only promotes the coordinated development of upstream industrial chains such as communications, computers, construction and machinery, but also jointly builds a huge industrial chain of high-tech research and development (R&D) as well as product quality control through mutual reinforcement with multi-level supporting enterprises. It plays an important role in promoting the continuous transformation of urban industrial structure to technology (knowledge) intensive and highly processed industries. Chen and Peter [33] compared and analyzed the impact of the opening of high-speed trains on Manchester and Lille, and found that they strengthened the connection between traditional industrial areas and central cities. This not only brought into play the driving role of central cities in innovation and advanced the economic development and transformation of the industrial areas, but also promoted the transition of the regional economy in the direction of a knowledge-dominated economy. Lin et al. [28] believed that the connectivity of an urban HSR network promoted the intelligent development of manufacturing industry and the transfer of labor force from the secondary industry to the tertiary industry, which ultimately played a positive role in the transformation and upgrading of urban industrial structure.

On the other hand, according to the theory of the firm, an HSR improves the cross-regional reallocation of production factors such as capital and labor force, which will contribute to achieve the advancement and rationalization process of industrial structure. The opening of an HSR reduces the degree of information asymmetry between regions, increases the possibility for enterprises to make investment in other places or build factories across different areas and then optimizes the regional capital structure as well as boosts the business sustainability of cities. Meanwhile, an HSR itself belongs to the transportation service industry, so its construction and operation can drive the development of catering, tourism and other tertiary industries. Moreover, by absorbing high-quality professional talents to gather in the areas along the route and continuously optimize the allocation of resources, an HSR is able to carry forward the agglomeration of producer services. Han et al. [34] found that the construction of Shinkansen lines in Japan improved regional accessibility, prompted the dominant driving force of industrial location to change from industrial transaction interdependence to population consumption demand and encouraged the development of multiple industries such as the real estate, commerce and service industries, thereby contributing to the formation of regional economic structure. Accordingly, the improvement of an HSR network accelerates the flow and concentration of production factors such as technology, capital and manpower, and promotes technological innovation and resource integration within the region, which could reduce unreasonable fluctuations in industries caused by a misallocation of resources. Based on the above analysis, we propose the following hypothesis:

Hypothesis 1 (H1). *The opening of an HSR is beneficial to promoting the transformation and upgrading of industrial structure of cities.*

2.2. HSR Opening, Environmental Regulation and Industrial Structure

Existing studies about the industrial adjustment effect of environmental regulation has not yet reached a consistent conclusion. A few scholars believed that environmental regulation would not affect industrial structure. Kneller and Manderson [35] found that strict pollution emission standards did not promote the increase in overall R&D investment and, thus, had no impact on industrial structure upgrading. Rassier and Earnhart [29] held the idea that the policy of water resources regulation would increase the production cost of enterprises and would not stimulate the upgrading of industrial structure. However, most recent literature confirms the positive impact of environmental regulation on industrial structure. Yu and Wang [24] and Zhang et al. [30] both pointed out that environmental regulation could help to pull the optimization and upgrading of industrial structure. Song et al. [36] argued that environmental regulation promoted the upgrading of China's industrial structure on the whole, although there were also regional differences in this impact. Firstly, according to the innovative compensation effect [37], reasonable environmental regulation can motivate regulated enterprises or industries to further optimize the efficiency of resource allocation and enhance the level of technological innovation, thus promoting the transformation of industrial structure. Secondly, according to the pollution heaven effect [38], due to regional differences in environmental regulation, high-polluting enterprises tend to move to low-regulated areas to reduce environmental costs or obtain higher profits. This will promote the flow of production factors from low-efficiency sectors to high-efficiency sectors, which is conducive to the upgrading of regional industrial structure. Finally, the existence of the barrier effect will eliminate some high-polluting industries and divert the original capital and labor force to other more sustainable clean industries. At the same time, it renders clean industries more opportunities to enter, so as to promote the optimization of industrial structure. Furthermore, viewing from the objectives of strategy formulation, environmental regulation is the key means for the government to solve the market failure in the field of resources and environment, thus achieving sustainable development of environment and economy [24]. Chen et al. [39] found that environmental regulation could promote the high-quality development of the regional economy by optimizing industrial structure. Therefore, if environmental regulation policies can also promote the transformation of urban industrial structure by means of resource allocation and technological innovation, the function of an HSR in promoting the advancement and rationalization of industrial structure may be weakened, leading to the unsustainability of the HSR industry effect. Thus, we put forward the following hypothesis:

Hypothesis 2 (H2). *The opening of an HSR will have a more significant positive effect on the transformation and upgrading of industrial structure when the city has weaker environmental regulation intensity.*

2.3. HSR Opening and Social Employment

According to the theory of new economic geography, location advantages are determined by transportation and factor costs. When the regional transportation cost is relatively low and economies of scale are relatively strong, the formation of geographical agglomeration of industries will be promoted and more inflows of non-local population can be attracted, thereby boosting regional employment opportunities. An HSR could enable more sustainable patterns and growth in commuting and business of cities [27]. The impact of the opening of an HSR on the social employment of cities is mainly realized from two aspects of labor force supply and demand [40].

From the perspective of labor force supply, on the one hand, the opening of an HSR improves the accessibility of cities [41] and shortens commuting time. Workers can find occupations that match their own professional skills more efficiently in the region, reducing frictional unemployment within the region and increasing the labor participation rate. On the other hand, cities with an HSR are more likely to attract some families from relatively underdeveloped areas to move there, in order to obtain a larger living space, lower prices and a better surrounding environment [42]. By expanding regional population

inflow, the supply of labor force can be increased. In addition, the liberalization of market circulation enables the labor force at different regional levels to better match the regional industrial structure. In terms of labor force demand, first of all, the reduction of time and transportation costs between regions will enable producers and consumers to purchase long-distance goods and services at lower prices, which increases the effective supply of goods and services, thereby expanding society's demand for the labor force. Secondly, the increased competitiveness of cities with an HSR will attract more enterprises and foreign direct investment to settle in and then promote the expansion of market scale. Subsequently, the expansion of enterprise scale and the increase in enterprise quantity will exert a driving effect on local employment, thus significantly enhancing the attraction to talents and employment rate of cities along the route [23]. Furthermore, the entry of new enterprises is conducive to the formation of economic agglomeration in the market and will also stimulate the operation of existing enterprises. By expanding production scale and creating more jobs, the sustainable competitiveness of enterprises can be enhanced. We may expect that after the opening of an HSR, the labor force resources within the region can be effectively reallocated to improve the level of social employment of cities, thereby contributing to sustainable social development. Based on the above analysis, we propose the following hypothesis:

Hypothesis 3 (H3). *The opening of an HSR is beneficial to increasing the level of social employment of cities.*

2.4. HSR Opening, Environmental Regulation and Social Employment

In the early studies on the employment effect of environmental regulation, scholars suggested that environmental regulation reduced the employment level of regional labor force. Based on the implementation and amendment of the U.S. Clean Air Act, respectively, Greenstone [43] and Walker [44] argued that environmental regulation could have a negative impact on employment in various regions. At present, most scholars believe that the implementation of environmental regulation policies is able to promote social employment [8]. Based on labor demand elasticity, Mishra and Smyth [45] proved that higher environmental regulations could drive the increase in employment quantity within environmental protection and related service industries. Hanna and Oliva [31] found that the path of environmental regulation to increase employment was mainly realized by propelling enterprise innovation. Nunes et al. [32] believed that the implementation of the government's environmental protection transport policy was conducive to reduce pollutant emissions and increase employment by 0.22%. Besides, Yip [46] and Li and Zhu [47] found that although environmental regulation inhibited social employment in the short term, it had a promoting effect in the long term. According to the thinking of Morgenstern et al. [48], based on the cost effect, when the intensity of environmental regulation increases, the pollution control cost of enterprises will rise, and enterprises will tend to increase the input of the labor force to replace the more costly production factors of the energy resource category. This is beneficial for the sustainable development of energy systems. On the basis of the factor-matching effect, facing tighter environmental supervision, enterprises will increase investment in environmental governance, so as to achieve their own sustainable development. Among them, environmental quality supervision and end-of-production management need to hire a larger labor force, while the operation and maintenance of pollution treatment and high-efficiency production equipment also need to increase labor force input. Therefore, the enhancement of environmental regulation level will bring more labor force demand, especially the need for the input of a high-skilled labor force to match it [7]. The agglomeration economy brought by the opening of an HSR urges enterprises and employees to collocate more conveniently and efficiently geographically [49], which can promote the matching of labor force demand and supply of cities, thereby improving the level of social employment. Meanwhile, environmental regulation enhances the sensitivity of industries to an HSR, such as service and knowledge-intensive, that rely more on

population and labor quality, thus promoting the sustainability of the HSR employment effect. Thus, we put forward the following hypothesis:

Hypothesis 4 (H4). *The opening of an HSR will have a more significant positive effect on the level of social employment when the city has stronger environmental regulation intensity.*

3. Methodology

3.1. Data and Sample

This paper aims to study the impact of the opening of an HSR on the high-quality development of cities. Considering the lack of statistical data or administrative division adjustment in some cities, this paper finally selected 280 prefecture-level and above cities in China as the main research objects. The sample period is from 2007 to 2019. Our main data sources were as follows: (1) the urban HSR opening data were collected manually from the official website of the China Railway Corporation and the National Railway Administration; (2) the urban-level characteristic data were extracted from the China Urban Statistics Yearbook and the China Stock Market and Accounting Research (CSMAR) database; (3) regarding the division of resource-based cities, we referred to the National Sustainable Development Plan for Resource-Based Cities (2013–2020) issued by the State Council of China; and (4) regarding the geographical location of cities, based on the division of the four major economic regions by the National Bureau of Statistics, we classified Liaoning Province in the northeast as the eastern region, with Jilin and Heilongjiang Provinces as the central region.

3.2. Variable Definition

3.2.1. The Explained Variables: High-Quality Development of Cities

This paper represented the high-quality development of cities from the dual perspectives of economic transformation and people's social livelihoods. Industrial structure upgrading refers to the dynamic evolution process of industrial structure development from low-level to high-level state with economic growth. On the whole, it is also a process in which the degree of "servitization" of economic structure is constantly deepening. Its main performance is that the proportion of the three industries in GDP is rising constantly in the order of the primary, secondary and tertiary industries, respectively. Fu [50] introduced the idea of three-dimensional vector angle of spatial analytical geometry, using the improved structural similarity coefficient method (i.e., included angle cosine method) to construct the index of the angle value of industrial structure advancement to measure the upgrading degree of industrial structure. Compared with Yu and Wang [24]'s method, which used the product of the ratio of industry j 's added value to GDP and j and, then, calculated the products sum of the three industrial to measure the degree of industrial structure optimization, Fu's method was more in-depth and refined, avoiding simple and rough subjective assignment. Therefore, this study utilized this method to measure the advancement index of industrial structure. The calculation method was as follows.

Firstly, according to the three industrial's division, GDP is divided into three parts, and the proportion of the added value of each part in GDP is taken as a component in the spatial vector, thus forming a set of three-dimensional space vectors, namely, $X_0 = (x_{1,0}, x_{2,0}, x_{3,0})$. Secondly, calculating, respectively, the angles ($\theta_1, \theta_2, \theta_3$) between vector X_0 and each industry vector, $X_1 = (1, 0, 0)$, $X_2 = (0, 1, 0)$ and $X_3 = (0, 0, 1)$. Among them, industrial vectors were arranged from low-level to high-level. The specific formula of the included angle is:

$$\theta_j = \arccos \left(\frac{\sum_{i=1}^3 (x_{i,j} \cdot x_{i,0})}{\left(\sum_{i=1}^3 (x_{i,j}^2) \right)^{1/2} \cdot \left(\sum_{i=1}^3 (x_{i,0}^2) \right)^{1/2}} \right), j = 1, 2, 3 \quad (1)$$

Finally, the formula for calculating the industrial structure advancement (*AIS*) value was as follows. The larger the *AIS*, the higher the level of industrial structure advancement.

$$AIS = \sum_{k=1}^3 \sum_{j=1}^k \theta_j \quad (2)$$

Drawing on the research of Dong and Zhu [51], we utilized the employment density rather than the total number of employees in a region to represent the employment level of a region. Since, even if they are both HSR cities, the larger the area under their jurisdiction and the more the total population, the higher the proportion of their employed population will naturally be. Therefore, this paper utilized employment density (*ED*) to characterize the urban employment level under the influence of an HSR opening. By reflecting the relationship between employed population of a city and its area size, this variable shows the situation of changes in the labor market to a certain extent. Its calculation formula was as follows:

$$ED_{i,t} = EP_{i,t} / ARA_{i,t} \quad (3)$$

where $EP_{i,t}$ denoted the total number of employed population of city i at the end of period t , and $ARA_{i,t}$ referred to the area of administrative region of city i in t period.

3.2.2. The Action Mechanism Variable: Environmental Regulation

Environmental regulation refers to the direct or indirect intervention of the government on environmental pollution behavior in order to control the pollution degree and improve the ecological environment. The choice of environmental policy objectives mainly depends on the willingness of local governments to govern the environment, thus, the intensity of environmental governance varies in different regions. On the basis of such typical characteristics, it is relatively more comprehensive and objective to investigate the environmental regulation intensity of local government from the results of pollution control [52]. In order to avoid the shortcomings of simplified indicator, we learned from the ideas of Domazlicky and Weber [53] as well as Naughton [54], and chose the emissions of three types of pollutants in cities to construct a comprehensive index to measure the intensity of environmental regulation (*ER*). The specific calculation method was as follows. Firstly, we standardized the emissions of pollutants of each city's per unit output value. The pollutants used in this paper referred to industrial wastewater, industrial sulfur dioxide and industrial smoke and dust (that is, undesirable output indicators):

$$UE_{ij}^s = [UE_{ij} - \min(UE_j)] / [\max(UE_j) - \min(UE_j)] \quad (4)$$

where UE_{ij} represented the emission per unit output value of pollutant j in city i ; $\max(UE_j)$ and $\min(UE_j)$, respectively, represented the maximum and minimum values of emissions of category j pollutant in all cities; and UE_{ij}^s was the standardized value of the indicator.

Secondly, due to the large difference between the emission of pollutants and the proportion of pollutants in each city, the adjustment coefficient was used to approximately reflect the difference in characteristics of pollutants. The formula of adjustment coefficient was as follows:

$$W_j = UE / \overline{UE_{ij}} \quad (5)$$

where $\overline{UE_{ij}}$ denoted the average level of emissions per unit output value of pollutants of category j among cities in each year.

Finally, we calculated the intensity of environmental regulation ($ER1_i$) of city i . The larger the value was, the higher the degree of urban pollution emissions and the weaker the intensity of environmental regulation. In order to facilitate the study, the intensity indicator

of environmental regulation we used was: $ER_{i,t} = (-1) \times ER1_{i,t}$. After the conversion, the larger the indicator, the stronger the government's environmental regulation intensity.

$$ER1_i = \frac{1}{3} \sum_{j=1}^3 W_j UE_{ij}^s \quad (6)$$

3.2.3. Control Variables

With reference to existing research, this paper controlled other variables that may affect the industrial structure and social employment level of cities. The control variables involved are shown below. Economic development level (*PERGDP*): a good economic growth environment is an important guarantee for enterprises to organize production and accommodate labor force, and also will directly affect inter-industry replacement and structural upgrading. Financial autonomy (*FREE*): the extent to which the local government's financial revenue meets its financial expenditure can affect the ability of local government to intervene in industrial transformation. Medical and health level (*MEDICAL*): through the level of urban public service supply, it is possible to measure the city's investment situation in health human capital. Retail level (*RETAIL*): residents' consumption power can reflect the market size of a city, and then measure the impact of urban social demands on industrial structure. Science and education level (*SE*): the situation of college students at school reflects the quality and quantity of the city's direct reserve employees, while the level of human capital accumulation restricts the production efficiency of the city. Capital factor market support (*CAPITAL*): a large amount of capital demand for the transformation and upgrading of industrial structure, and the deposit scale of urban financial industry can increase the availability of capital elements. Economic policy uncertainty (*EPU*): the macroeconomic environment will have a profound impact on the economic entities in it (we used the monthly data of China's economic policy uncertainty index constructed by Baker et al. [55] to calculate the annual index). Investment in fixed assets (*FIX*): an important driving force for economic development, which can drive the agglomeration of various factors in production and operation, while industrial agglomeration affects structural transformation. Wage level (*WAGE*): a balancer that adjusts labor supply and demand, and affects the level of employment in a region [56]. Enterprise development situation (*FIRM*): the production scale and profitability of industrial enterprises affect their ability to provide employment opportunities for society. Openness degree (*OPEN*): when the degree of openness is relatively high, the improvement of transportation accessibility will further attract foreign direct investment and bring more employment opportunities. Financial development level (*FINANCE*): the stronger lending capacity of regional financial institutions can ease the financing constraints of enterprises and provide financial support for entrepreneurs, thereby affecting the level of social employment. Detailed definitions of main study variables are given in Table 1.

Table 1. Definitions of main study variables.

Type	Variable	Symbol	Calculation Method	
Explained variables	Upgrading of industrial structure	AIS	Industrial structure advancement calculated through Formula (1) and (2) by Fu (2010)'s method	
	Employment density	ED	The total number of the city's employed population at the end of the year divided by the area of administrative region of the city	
Explanatory variable	HSR opening	HSR	Equals 1 if the prefecture-level city has opened an HSR in the observation year, and 0 otherwise	
Action mechanism variable	Environmental regulation	ER	The urban pollutant emission intensity calculated by Formulas (4)–(6) was multiplied by negative 1	
Control variables	Economic development level	PERGDP	The natural logarithm of urban per capita GDP (RMB)	
	Industrial structure level and social employment level (units in brackets)	Medical and health level	MEDICAL	The natural logarithm of the number of beds (one) in urban hospitals and health institutions
		Science and education level	SE	The proportion of the number of students in colleges and universities (one) in the total population (one)
		Economic policy uncertainty	EPU	The arithmetic mean of the monthly data of the economic policy uncertainty index by Baker et al. (2016)'s research
	Only at industrial structure level (units in brackets)	Financial autonomy	FREE	The city's public finance revenue (RMB 10,000) divided by its public finance expenditure (RMB 10,000)
		Retail level	RETAIL	The proportion of total retail sales of social consumer goods (RMB 10,000) in urban GDP (RMB 10,000)
		Capital factor market support	CAPITAL	The natural logarithm of the city's per capita year-end deposit balance (RMB)
	Only at social employment level (units in brackets)	Investment in fixed assets	FIX	Fixed asset investment (RMB 10,000) as a percentage of urban GDP (RMB 10,000)
		Wage level	WAGE	The natural logarithm of the average wage (RMB) of on-the-job employees in the city
		Enterprise development situation	FIRM	Gross industrial output value above designated size (RMB 10,000) divided by urban GDP (RMB 10,000)
Openness degree		OPEN	The natural logarithm of the amount of foreign capital (USD 10,000) actually used by the city in the year	
	Financial development level	FINANCE	Balance of deposits of financial institutions (RMB 10,000) at the end of the year divided by urban GDP (RMB 10,000)	

3.3. Research Methods

3.3.1. Baseline Model

An HSR opening can be used as a quasi-natural experiment, that is, the implementation of policy will affect some regions, while other regions are not affected by the policy or have no obvious effect. DID method is helpful to evaluate the effect of a policy measure before and after implementation and effectively alleviate the problem of omitted variable bias [57]. For reducing the influence of the differences of some omitted variables, due to individual characteristics and time changes on the empirical results, this study took into account the fixed effect of the city (*City*) and the fixed effect of the year (*Year*) by drawing on the method of Beck et al. [57]. Among them, *City* reflected the individual heterogeneity characteristics that can affect high-quality urban development (e.g., controlling the urban characteristic factors that do not change over time), and *Year* reflected the time effect that affects high-quality urban development (e.g., controlling macroeconomic or political shocks in the time dimension). Meanwhile, due to the different opening times of an HSR in different cities, we constructed two multi-period DID models that can consider the inconsistency of policy implementation time points to estimate the impact of an HSR opening on high-quality urban development. The benchmark model is set as follows:

$$AIS_{i,t} = \alpha_0 + \alpha_1 HSR_{i,t} + \sum_{\alpha_j} Controls_{i,t} + \sum City + \sum Year + \varepsilon_{i,t} \quad (7)$$

$$ED_{i,t} = \beta_0 + \beta_1 HSR_{i,t} + \sum_{\beta_j} Controls_{i,t} + \sum City + \sum Year + \varepsilon_{i,t} \quad (8)$$

where *i* and *t* denoted city and year, respectively. $AIS_{i,t}$ and $ED_{i,t}$ represented industrial structure upgrading and social employment level, respectively. $Controls_{i,t}$ represented a set of control variables. $\varepsilon_{i,t}$ denoted the random error term.

$HSR_{i,t}$ was the core explanatory variable of this study, namely an HSR opening: during the sample period, if the prefecture-level city has opened an HSR, it belonged to the experimental group (treat = 1); if the prefecture-level city has not opened an HSR, it belonged to the control group (treat = 0). If the city has opened an HSR in the observation year, the value of post was 1, otherwise it was 0. $HSR_{i,t}$ was the interaction item between treat and post. That is, when the prefecture-level city has opened an HSR in the observation year, the value of $HSR_{i,t}$ was assigned to 1; otherwise, it was assigned to 0. What we were interested in were the regression coefficients α_1 and β_1 , because they captured the impact of the opening of an HSR on the high-quality development of cities.

3.3.2. The Moderating Role of Environmental Regulation Intensity

In order to verify whether environmental regulation is the action mechanism for an HSR opening to affect the high-quality development of cities, this paper constructed a regression model (9) and a model (10). Compared with model (7) and model (8), the new linear regression models added a variable to measure the intensity of environmental regulation and its interaction term with the HSR opening variable. Meanwhile, all control variables remained unchanged.

$$AIS_{i,t} = \alpha_0 + \alpha_1 HSR_{i,t} + \alpha_2 ER_{i,t} + \alpha_3 HSR_{i,t} \times ER_{i,t} + \sum_{\alpha_j} Controls_{i,t} + \sum City + \sum Year + \varepsilon_{i,t} \quad (9)$$

$$ED_{i,t} = \beta_0 + \beta_1 HSR_{i,t} + \beta_2 ER_{i,t} + \beta_3 HSR_{i,t} \times ER_{i,t} + \sum_{\beta_j} Controls_{i,t} + \sum City + \sum Year + \varepsilon_{i,t} \quad (10)$$

If α_3 was negative and statistically significant, it indicated that the relatively strong environmental regulation weakened the effect of an HSR opening in promoting the transformation and upgrading of industrial structure. If β_3 was positive and statistically significant,

it showed that the relatively strong environmental regulation was more conducive to exert the role of an HSR opening in improving the level of social employment.

4. Empirical Results and Analysis

4.1. Summary Statistics

Panel A in Table 2 provides the descriptive statistical results of main variables. As we can see, the mean values of *AIS* and *ER* were 6.408 and -0.237 , respectively, and the standard deviations were 0.345 and 1.139, respectively. This showed that there were great differences among cities in the degree of industrial structure advancement. At the same time, the intensity of government environmental regulation also varied greatly among different cities. This provided the basis for our research. The mean value of *ED* was 0.006, and the standard deviation was 0.013. In addition, there were also great differences among sample cities in terms of economic development level (*PERGDP*), medical and health level (*MEDICAL*), enterprise development situation (*FIRM*), openness degree (*OPEN*) and financial development level (*FINANCE*). During the sample period, the degree of uncertainty in China's economic policies exhibited relatively large fluctuations. Further, this study performed the variance inflation factor (VIF) test of multicollinearity. Panel B and Panel C in Table 2 reported the VIF test results of the main variables at the industry level and employment level, respectively. It revealed that at the level of industrial structure and social employment, the maximum values of VIF among the variables are 5.520 and 4.130, respectively, both of which are far less than the critical value of 10. Therefore, in the data samples of this study, there is no obvious multicollinearity problem between all variables, which can be included in the regression model.

Table 2. Descriptive statistics and multicollinearity test.

Panel A. Descriptive Statistics of the Main Variables						
Variable	N	Mean	Std. Dev.	Min	Median	Max
AIS	2711	6.408	0.345	5.517	6.377	7.600
ED	2711	0.006	0.013	0.000	0.003	0.230
HSR	2711	0.367	0.482	0.000	0.000	1.000
ER	2711	-0.237	1.139	-32.324	-0.064	0.000
PERGDP	2711	10.389	0.683	4.595	10.370	13.056
FREE	2711	0.494	0.233	0.053	0.460	1.545
RETAIL	2711	0.354	0.097	0.026	0.347	0.826
SE	2711	0.018	0.024	0.000	0.009	0.131
FIX	2711	0.717	0.272	0.087	0.687	2.197
CAPITAL	2711	2.297	0.076	1.991	2.297	2.535
MEDICAL	2711	9.494	0.722	7.154	9.481	12.086
EPU	2711	141.037	20.676	91.598	150.630	165.743
WAGE	2711	10.477	0.387	9.161	10.518	11.718
FIRM	2711	1.439	0.667	0.126	1.364	17.647
OPEN	2711	10.006	1.736	3.135	10.013	14.947
FINANCE	2711	1.264	0.580	0.368	1.111	4.935

Panel B. VIF Test of Variables-Industrial Structure Level										
Variable	PERGDP	CAPITAL	FREE	SE	MEDICAL	RETAIL	HSR	FIX	EPU	Mean VIF
VIF	5.520	5.010	2.720	1.650	1.590	1.560	1.410	1.180	1.150	2.420
1/VIF	0.181	0.200	0.367	0.607	0.628	0.643	0.709	0.847	0.868	

Panel C. VIF Test of Variables-Social Employment Level										
Variable	PERGDP	WAGE	SE	OPEN	FINANCE	MEDICAL	FIRM	HSR	EPU	Mean VIF
VIF	4.130	3.360	2.470	2.310	2.210	1.880	1.440	1.390	1.150	2.260
1/VIF	0.242	0.298	0.405	0.432	0.453	0.531	0.694	0.720	0.867	

4.2. Baseline Regression Results

4.2.1. HSR and High-Quality Development of Cities

The benchmark regression results of model (7) and model (8) are shown in Table 3, which reveals the impact of the opening of an HSR on the industrial structure transformation and social employment level of cities. In column (1), the coefficient of variable HSR was 0.0103, which was significantly positive at the 5% level. The result showed that the construction of an HSR has significantly promoted the dynamic transformation of regional industrial structure from low-level to high-level and was helpful to realize the advanced process of urban industrial structure. Meanwhile, in column (2), the coefficient of variable HSR was 0.0026, which was positive and significant at the 1% level. It illustrated that the construction of an HSR has significantly improved the level of social employment in HSR-opening cities, and then widened the employment gap between cities with an HSR and cities without an HSR. Consequently, the opening of an HSR will be beneficial to promoting the high-quality development of cities. Both our hypothesis 1 and our hypothesis 3 were verified. For control variables, the higher retail level (*RETAIL*), science and education level (*SE*), capital market support level (*CAPITAL*) and medical and health level (*MEDICAL*) can promote the transformation and upgrading of urban industrial structure, while the higher degree of economic development (*PERGDP*), openness degree (*OPEN*) and financial development (*FINANCE*) can encourage the improvement of urban social employment.

Table 3. Baseline regression results.

Variable	(1)	Variable	(2)
	AIS		ED
HSR	0.0103 ** (2.29)	HSR	0.0026 *** (5.79)
PERGDP	−0.0028 (−0.31)	PERGDP	0.0068 *** (4.46)
FREE	0.0293 (1.59)	WAGE	0.0023 (1.33)
RETAIL	0.1186 *** (3.58)	FIRM	0.0005 (1.19)
FIX	−0.0146 * (−1.68)	OPEN	0.0011 *** (7.48)
SE	0.7697 *** (2.64)	FINANCE	0.0068 *** (7.05)
CAPITAL	0.7260 *** (6.14)	SE	−0.0581 * (−1.85)
MEDICAL	0.0422 *** (3.42)	MEDICAL	0.0004 (1.10)
EPU	0.0017 *** (5.96)	EPU	−0.0002 *** (−6.45)
Year FE	YES	Year FE	YES
City FE	YES	City FE	YES
Constant	4.9921 *** (19.37)	Constant	−0.0872 *** (−6.19)
Observations	2711	Observations	2711
Adj R ²	0.971	Adj R ²	0.329

Note: The t-statistics are in parentheses. ***, ** and * represent the significance level of 1%, 5% and 10%, respectively.

4.2.2. The Moderating Role of Environmental Regulation Intensity

In order to verify whether the driving effect of an HSR opening on the high-quality development of cities would be affected by the environmental regulation policies of local governments in the cities where HSR were opened, we used model (9) and model (10) for regression analysis. Table 4 reveals the test results of the action mechanism, namely, the environmental regulation intensity of local governments. The results showed that

at the level of industrial structure transformation and upgrading, the coefficient of the interaction term $ER \times HSR$ was significantly negative (-0.0106) at the level of 1%. It indicated that when the intensity of environmental regulation of cities was relatively weak, the positive influence of an HSR opening on the transformation and upgrading of cities' industrial structure were more significant. This result confirmed our hypothesis 2. One explanation for this was that the higher level of environmental regulation was not conducive to an HSR opening to play the roles of boosting technological innovation and improving the efficiency of factor allocation. In other words, the effect of industrial structure upgrading of an HSR was subject to the constraints of the environmental regulation policies of local governments. Nevertheless, at the level of social employment, the coefficient of the interaction term $ER \times HSR$ was significantly positive (0.0010) at the 5% level. It suggested that the improvement of the local government's environmental regulation level would bring more labor force demand, and strengthen the positive impact of an HSR opening on the social employment level of cities, thereby enhancing the quality of urban economic and social development. This result confirmed our hypothesis 4.

Table 4. Moderating effect of environmental regulation intensity.

Variable	(1)	Variable	(2)
	AIS		ED
HSR	0.0073 (1.60)	HSR	0.0027 *** (5.90)
ER	-0.0001 (-0.07)	ER	-0.0001 (-0.69)
HSR \times ER	-0.0106 *** (-4.74)	HSR \times ER	0.0010 ** (2.08)
PERGDP	0.0017 (0.19)	PERGDP	0.0068 *** (4.45)
FREE	0.0258 (1.42)	WAGE	0.0023 (1.33)
RETAIL	0.1059 *** (3.22)	FIRM	0.0005 (1.18)
FIX	-0.0186 ** (-2.15)	OPEN	0.0011 *** (7.50)
SE	0.7790 *** (2.69)	FINANCE	0.0068 *** (7.05)
CAPITAL	0.7215 *** (6.14)	SE	-0.0584 * (-1.86)
MEDICAL	0.0436 *** (3.56)	MEDICAL	0.0004 (1.03)
EPU	0.0017 *** (5.86)	EPU	-0.0002 *** (-6.45)
Year FE	YES	Year FE	YES
City FE	YES	City FE	YES
Constant	4.9523 *** (19.34)	Constant	-0.0868 *** (-6.18)
Observations	2711	Observations	2711
Adj R ²	0.971	Adj R ²	0.329

Note: The t-statistics are in parentheses. ***, ** and * represent the significance level of 1%, 5% and 10%, respectively.

4.3. Robustness Checks and Endogeneity Mitigation

4.3.1. Alternative Measurement for High-Quality Development of Cities

In order to ensure the robustness of our empirical results, we replaced the proxy variables of the high-quality development of cities. Firstly, following the research of Lin et al. [28], we utilized the ratio of the output value of tertiary industry to the output

value of secondary industry (*RIS*) to measure the transformation and upgrading of urban industrial structure. The specific calculation formula was as follows:

$$RIS_{i,t} = Y_{3,i} / Y_{2,i} \quad (11)$$

where $Y_{3,i}$ and $Y_{2,i}$ denoted the output value of the tertiary industry and the secondary industry of city i , respectively.

Afterwards, referring to the thinking of Wang et al. [8], we selected the unemployment rate condition of cities (*UNEMPLOYMENT*) to represent the level of social employment. The specific calculation formula was as follows:

$$UNEMPLOYMENT_{i,t} = UNEM_{i,t} / (UNEM_{i,t} + EP_{i,t}) \quad (12)$$

where $EP_{i,t}$ represented the total number of employed population in city i at the end of period t and $UNEM_{i,t}$ denoted the number of urban registered unemployed persons in city i in period t .

The detailed regression results are given in Table 5. In column (1) and column (3), the coefficients of HSR were significantly positive and negative, respectively. This reflected that the opening of an HSR had significantly promoted the transformation and upgrading of urban industrial structure and reduced the level of urban unemployment, thus promoting the high-quality development of cities. Meanwhile, the intensity of environmental regulation played a significant moderating role in this relationship, and its influence direction was consistent with the baseline test. Consequently, after we chose alternative measures for high-quality city development, the research conclusions remained unchanged and were robust.

4.3.2. DID Test after PSM

The utilization of DID method needs to consider that if there is no HSR policy, there will be no systematic differences in the changing trend of high-quality development over time between HSR-opening cities and non-opening cities. PSM can solve sample selection bias effectively and then reduce DID estimation bias, but it is unable to avoid the inherent problems induced by missing variables. While DID can better solve inherent problems and obtain policy treatment effect, it fails to effectively solve sample deviation problems. Hence, this study further adopted a combined PSM-DID method to evaluate the incremental effect of an HSR opening more accurately. In this way, the endogenous problems caused by unobservable time factors and sample selection bias can be eliminated simultaneously. Specifically, drawing on the research of Zhao et al. [5], Chang et al. [18] and Liang et al. [27], by matching sample cities with the most similar characteristics to the treatment group as the control group, we controlled some confounding factors that interfered with an HSR opening, making the results more comparable. Firstly, we took the prefecture-level cities with an HSR opening and without an HSR opening as the treatment group and the control group, respectively, and then adopted 1:1 nearest neighbor matching without return [27]. At the industrial structure level, we selected *PERGDP*, *FREE*, *FIX*, *MEDICAL*, *RETAIL*, *SE*, *CAPITAL* and *EPU* as matching covariates. At the social employment level, we selected *PERGDP*, *WAGE*, *FIRM*, *MEDICAL*, *OPEN*, *SE*, *FINANCE* and *EPU* as matching covariates. Secondly, we checked the validity of the model. One was to conduct the balancing test of matching variables. From the perspective of industrial structure and social employment, Tables 6 and 7, respectively, report the t-test results of the significance of the differences between the mean values of each covariate in the treatment group and the control group before and after matching. It can be seen that after matching, there was no significant difference in the mean values of most covariates between the treatment group and the control group, proving the use of the PSM-DID method was reasonable.

Table 5. Alternative measurement for high-quality development of cities.

Variable	(1)	(2)	Variable	(3)	(4)
	RIS	RIS		UNEMPLOYMENT	UNEMPLOYMENT
HSR	0.0132 * (1.71)	0.0055 (0.64)	HSR	−0.0003 *** (−3.76)	−0.0003 *** (−3.97)
ER		0.0181 (1.49)	ER		0.0000 (1.26)
HSR × ER		−0.0430 ** (−2.10)	HSR × ER		−0.0001 ** (−2.10)
PERGDP	0.0179 (0.78)	0.0173 (0.75)	PERGDP	−0.0011 *** (−4.76)	−0.0011 *** (−4.74)
FREE	−0.1431 *** (−4.22)	−0.1427 *** (−4.21)	WAGE	0.0008 * (1.89)	0.0008 * (1.89)
RETAIL	0.0283 (0.39)	0.0243 (0.34)	FIRM	−0.0002 ** (−2.07)	−0.0002 ** (−2.05)
FIX	−0.0346 ** (−2.34)	−0.0375 ** (−2.53)	OPEN	−0.0001 * (−1.96)	−0.0001 ** (−2.00)
SE	−0.4299 (−0.77)	−0.3929 (−0.70)	FINANCE	−0.0010 *** (−8.39)	−0.0010 *** (−8.39)
CAPITAL	−0.3978 * (−1.80)	−0.4019 * (−1.82)	SE	0.0196 *** (6.53)	0.0196 *** (6.54)
MEDICAL	−0.0729 *** (−3.45)	−0.0703 *** (−3.33)	MEDICAL	−0.0000 (−0.23)	−0.0000 (−0.19)
EPU	0.0017 *** (3.27)	0.0018 *** (3.32)	EPU	−0.0000 (−0.06)	−0.0000 (−0.08)
Year FE	YES	YES	Year FE	YES	YES
City FE	YES	YES	City FE	YES	YES
Constant	1.5172 *** (3.31)	1.5100 *** (3.29)	Constant	1.0020 *** (443.60)	1.0020 *** (442.94)
Observations	2711	2711	Observations	2711	2711
Adj R ²	0.778	0.778	Adj R ²	0.171	0.171

Note: The t-statistics are in parentheses. ***, ** and * represent the significance level of 1%, 5% and 10%, respectively.

Table 6. Balancing test results of matching variables (industrial structure level).

Variable	Sample	Mean Value		Bias%	Difference (T-Value)
		Treatment Group	Control Group		
PERGDP	Pre-matching	10.430	10.250	25.60	5.61 ***
	Post-matching	10.210	10.230	−3.00	−0.54
FREE	Pre-matching	0.522	0.394	58.50	12.16 ***
	Post-matching	0.384	0.390	−3.00	−0.60
RETAIL	Pre-matching	0.365	0.314	52.10	11.56 ***
	Post-matching	0.317	0.317	0.10	0.01
FIX	Pre-matching	0.705	0.757	−17.90	−4.15 ***
	Post-matching	0.783	0.762	7.20	1.18
SE	Pre-matching	0.021	0.008	71.10	12.57 ***
	Post-matching	0.006	0.008	−5.70	−3.19 ***
CAPITAL	Pre-matching	2.301	2.279	29.90	6.25 ***
	Post-matching	2.272	2.278	−8.60	−1.64
MEDICAL	Pre-matching	9.623	9.034	91.40	18.69 ***
	Post-matching	8.995	9.052	−8.80	−1.84 *
EPU	Pre-matching	141.000	141.100	−0.40	−0.08
	Post-matching	141.400	141.100	1.20	0.21

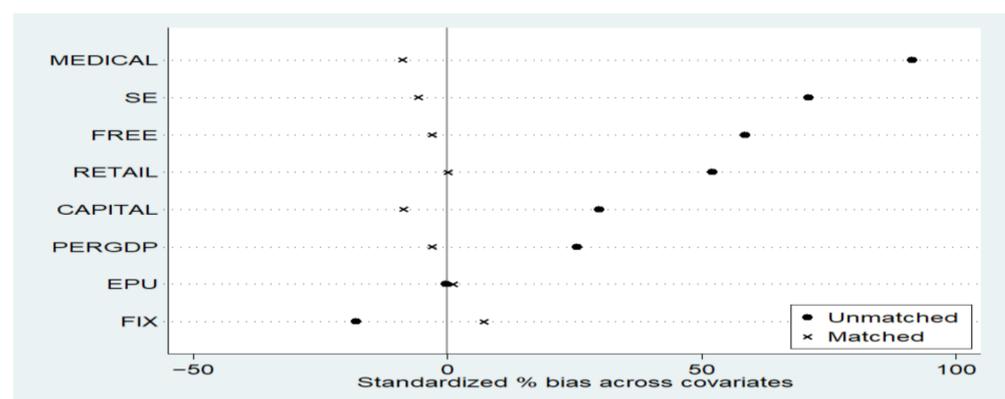
Note: *** and * represent the significance level of 1% and 10%, respectively.

Table 7. Balancing test results of matching variables (social employment level).

Variable	Sample	Mean Value		Bias%	Difference (T-Value)
		Treatment Group	Control Group		
PERGDP	Pre-matching	10.430	10.290	20.80	4.19 ***
	Post-matching	10.280	10.280	0.80	0.14
WAGE	Pre-matching	10.490	10.430	16.50	3.29 ***
	Post-matching	10.440	10.430	3.10	0.51
FIRM	Pre-matching	1.458	1.418	4.80	1.18
	Post-matching	1.414	1.414	−0.10	−0.01
OPEN	Pre-matching	10.300	8.941	81.00	16.53 ***
	Post-matching	8.960	8.991	−1.80	−0.31
FINANCE	Pre-matching	1.308	1.095	42.40	7.39 ***
	Post-matching	1.037	1.095	−11.40	−2.56 **
SE	Pre-matching	0.021	0.008	71.50	11.64 ***
	Post-matching	0.006	0.008	−6.90	−3.49 ***
MEDICAL	Pre-matching	9.635	9.078	88.90	16.76 ***
	Post-matching	8.989	9.098	−17.30	−3.41 ***
EPU	Pre-matching	140.700	140.600	0.40	0.08
	Post-matching	140.700	140.600	0.20	0.02

Note: *** and ** represent the significance level of 1% and 5%, respectively.

Next, by comparing the standardized deviations of related covariates before and after matching, we examined the effect of matching between treatment group and control groups. As can be seen from Figures 1 and 2, after matching, regardless of the aspect of industrial structure or social employment, the standardized deviations of covariates between the treatment group and the control group were closer to 0%. Therefore, the total sample bias was significantly reduced. It indicated that after the selected sample underwent PSM, the differences in relevant covariates between the treatment group and the control group were significantly decreased, and the distribution of sample observations was more balanced, which effectively eliminated endogenous concerns caused by sample selection bias and further demonstrated the feasibility of the PSM-DID method.

**Figure 1.** Covariates balancing test distribution (industrial structure level).

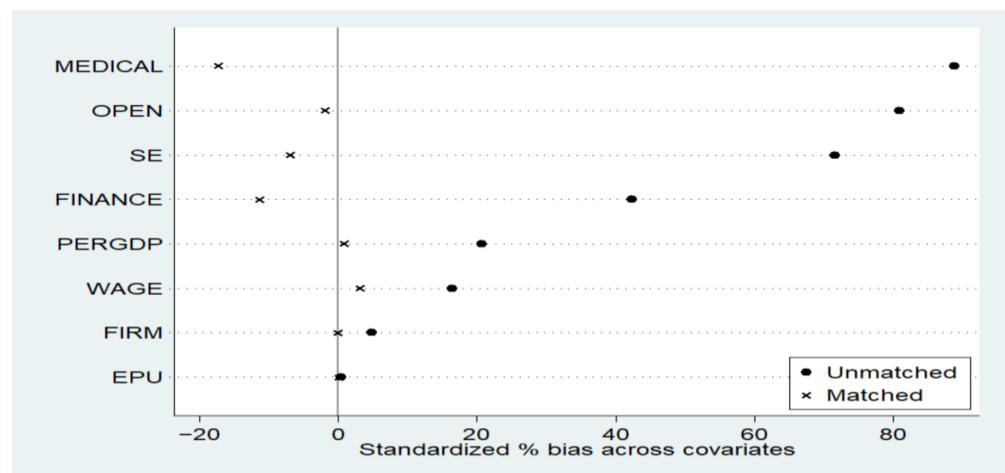


Figure 2. Covariates balancing test distribution (social employment level).

The PSM-DID test results in Table 8 present that the coefficients of *HSR* in column (1) and column (2) were both positive, passing the 5% level of significance test. Consequently, the opening of an HSR still significantly promoted the high-quality development of cities. The regression results were not significantly different from the previous DID results, which further supported the previous empirical conclusions.

Table 8. Endogeneity mitigation: PSM + DID.

Variable	(1)	Variable	(2)
	AIS		ED
HSR	0.0164 ** (2.25)	HSR	0.0008 ** (2.43)
PERGDP	-0.0107 (-0.41)	PERGDP	0.0015 *** (4.27)
FREE	0.0941 ** (2.22)	WAGE	-0.0015 * (-1.85)
RETAIL	0.0217 (0.40)	FIRM	0.0009 * (1.87)
FIX	0.0141 (0.89)	OPEN	0.0005 *** (5.87)
SE	-0.9460 (-0.87)	FINANCE	0.0017 *** (5.07)
CAPITAL	0.9014 *** (3.06)	SE	0.0462 * (1.73)
MEDICAL	0.0434 ** (2.38)	MEDICAL	0.0002 (0.53)
EPU	0.0013 * (1.80)	EPU	-0.0000 (-1.20)
Year FE	YES	Year FE	YES
City FE	YES	City FE	YES
Constant	3.7227 *** (6.80)	Constant	-0.0045 (-0.70)
Observations	1176	Observations	988
Adj R ²	0.950	Adj R ²	0.251

Note: The t-statistics are in parentheses. ***, ** and * represent the significance level of 1%, 5% and 10%, respectively.

4.3.3. Exclusion of the Influence of Municipalities and Provincial Capitals

Although the opening of an HSR can be considered exogenous in empirical tests, in reality, the opening of HSR stations is closely related to regional economy, geographical location and other factors, especially those cities with high administrative level and large economic aggregate, the possibility of an HSR opening is also greater. Therefore, we

excluded the samples of municipalities and provincial capitals to reduce the endogenous problems caused by omitted variables and self-selection bias. We re-examined the influence of HSR on AIS and ED, as well as the action mechanism of these relationships, namely ER. The results are shown in Table 9. Regardless of the industrial structure level or the social employment level, the regression results were consistent with the above baseline results, verifying the robustness of our hypotheses.

Table 9. Endogeneity mitigation: excluding municipalities and provincial capitals.

Variable	(1)	(2)	Variable	(3)	(4)
	AIS	AIS		ED	ED
HSR	0.0220 *** (4.26)	0.0063 (1.27)	HSR	0.0021 *** (4.94)	0.0023 *** (5.03)
ER		−0.0250 * (−1.72)	ER		0.0000 (0.30)
HSR × ER		−0.0108 * (−1.72)	HSR × ER		0.0011 *** (2.82)
PERGDP	−0.0061 (−0.62)	−0.0098 *** (−5.26)	PERGDP	0.0072 *** (4.02)	0.0072 *** (4.00)
FREE	−0.0340 (−1.59)	0.0478 ** (2.17)	WAGE	−0.0040 ** (−2.44)	−0.0040 ** (−2.40)
RETAIL	0.3303 *** (9.68)	0.0638 (1.47)	FIRM	0.0007 (1.28)	0.0007 (1.25)
FIX	0.0020 (0.20)	−0.0189 ** (−2.06)	OPEN	0.0005 *** (3.88)	0.0005 *** (3.85)
SE	1.3400 *** (2.70)	0.1774 (0.30)	FINANCE	0.0086 *** (4.97)	0.0086 *** (4.98)
CAPITAL	1.0358 *** (9.64)	0.7606 *** (5.27)	SE	0.1249 *** (2.87)	0.1275 *** (2.94)
MEDICAL	0.0784 *** (5.80)	0.0643 *** (4.91)	MEDICAL	0.0012 *** (3.08)	0.0012 *** (2.98)
EPU	−0.0004 *** (−6.10)	0.0021 *** (5.91)	EPU	−0.0001 *** (−3.66)	−0.0001 *** (−3.67)
Year FE	YES	YES	Year FE	YES	YES
City FE	YES	YES	City FE	YES	YES
Constant	3.1937 *** (23.28)	3.9740 *** (14.03)	Constant	−0.0401 *** (−2.87)	−0.0396 *** (−2.85)
Observations	2402	2402	Observations	2402	2402
Adj R ²	0.950	0.958	Adj R ²	0.293	0.294

Note: The t-statistics are in parentheses. ***, ** and * represent the significance level of 1%, 5% and 10%, respectively.

4.4. Further Analyses

Resource-based cities are the type of cities where the mining and processing of natural resources, such as mineral and forests in the region, are the leading industries. Compared with non-resource-based cities, resource-based cities have the characteristics of a higher degree of dependence on resource industries, greater pollution emission intensity and a relatively high proportion of employment in the secondary industry. Therefore, it is worth further exploring whether there are differences in the impact of the opening of an HSR on the high-quality development of the two types of cities. We performed group-level regressions on resource-based city samples and non-resource-based city samples respectively. The results are presented in Table 10.

Table 10. Further test of the impact of resource endowment.

Variable	(1)	(2)	Variable	(3)	(4)
	AIS			ED	
	Non-Resource-Based Cities	Resource-Based Cities		Non-Resource-Based Cities	Resource-Based Cities
HSR	0.0101 * (1.85)	0.0105 (1.52)	HSR	0.0022 *** (3.97)	0.0013 *** (5.18)
PERGDP	−0.0181 (−0.94)	0.0119 (1.50)	PERGDP	0.0111 *** (3.78)	0.0006 * (1.73)
FREE	0.0194 (0.77)	0.0882 ** (2.39)	WAGE	0.0016 (0.51)	−0.0016 ** (−2.09)
RETAIL	0.1256 ** (2.32)	0.1642 *** (2.84)	FIRM	−0.0016 (−1.45)	0.0013 * (1.65)
FIX	−0.0027 (−0.14)	−0.0000 (−0.00)	OPEN	0.0017 *** (6.22)	0.0003 *** (4.20)
SE	−0.5047 (−0.87)	0.2833 (0.42)	FINANCE	0.0070 *** (6.83)	−0.0002 (−0.86)
CAPITAL	0.8614 *** (3.44)	0.7211 ** (2.51)	SE	−0.1224 *** (−2.89)	0.0791 *** (4.88)
MEDICAL	0.0106 (0.60)	0.0066 (0.36)	MEDICAL	−0.0002 (−0.39)	−0.0004 *** (−2.67)
EPU	0.0020 *** (3.60)	0.0012 * (1.95)	EPU	−0.0002 *** (−5.46)	0.0000 (0.24)
Year FE	YES	YES	Year FE	YES	YES
City FE	YES	YES	City FE	YES	YES
Constant	4.7789 *** (9.03)	4.3004 *** (8.06)	Constant	−0.1160 *** (−6.07)	0.0111 ** (2.06)
Observations	1642	1069	Observations	1642	1069
Adj R ²	0.974	0.953	Adj R ²	0.353	0.341

Note: The t-statistics are in parentheses. ***, ** and * represent the significance level of 1%, 5% and 10%, respectively.

It is inferred that compared with resource-based cities, the promotion effect of the opening of an HSR on the transformation of industrial structure was more significant in the sub-sample of non-resource-based cities. Meanwhile, although the opening of an HSR had a significantly positive impact on the social employment level of the two types of cities, it had a greater impact coefficient on non-resource-based cities. The possible reason is that the secondary industry of resource-based cities relies too much on the primary product sector to obtain profits, resulting in a single industrial structure, poor innovation ability and technology absorptive capacity [58]. This restricts the development of industry diversification to a certain extent, and is not conducive to providing more employment opportunities for the society. On the contrary, by accelerating the free flow of various elements such as capital and labor among different industrial sectors, the opening of an HSR is conducive to cultivating an industrial system characterized by “simultaneous development of diversity” and “multi-polar support”, thereby promoting the sustainable economic development of non-resource-based cities.

At present, the construction of China’s HSR network presents the characteristics of being “relatively dense in the eastern coastal area and central area, while relatively sparse in the western area”. This state of non-equalization may lead to significant differences in the economic and social effects of the opening of an HSR between different regions. Therefore, according to the urban geographical location, this paper divided the sample cities into three regions: eastern cities, central cities and western cities. The regression results are presented in Table 11.

Table 11. Further test of the impact of geographical location.

Variable	(1)	(2)	(3)	Variable	(4)	(5)	(6)
	AIS				ED		
	Eastern Region	Central Region	Western Region		Eastern Region	Central Region	Western Region
HSR	0.0526 *** (5.44)	0.0222 *** (3.30)	0.0030 (0.36)	HSR	0.0021 ** (2.54)	−0.0001 (−0.35)	0.0003 (1.53)
PERGDP	0.0521 ** (2.42)	0.0690 ** (2.40)	0.0032 (0.25)	PERGDP	0.0143 *** (3.54)	−0.0006 * (−1.79)	0.0017 (1.54)
FREE	0.3706 *** (8.97)	−0.0436 (−1.40)	0.2082 *** (4.92)	WAGE	−0.0014 (−0.30)	−0.0008 (−0.98)	−0.0016 *** (−2.80)
RETAIL	0.4111 *** (5.55)	0.0530 (0.92)	0.1639 (1.32)	FIRM	−0.0008 (−0.55)	0.0028 *** (12.28)	−0.0000 (−0.47)
FIX	−0.1247 *** (−4.48)	0.0245 (1.55)	0.0268 (1.59)	OPEN	0.0015 *** (3.16)	−0.0002 ** (−1.97)	0.0001 *** (2.66)
SE	2.1526 *** (8.97)	0.0042 (0.01)	−0.6606 * (−1.81)	FINANCE	0.0123 *** (7.42)	−0.0006 ** (−2.36)	0.0005 (0.73)
CAPITAL	1.6830 *** (14.78)	0.6504 * (1.86)	0.2761 (1.00)	SE	−0.0999 * (−1.89)	0.1543 *** (15.71)	0.0410 *** (3.74)
MEDICAL	−0.0042 (−0.49)	0.0264 (1.40)	−0.0230 (−1.07)	MEDICAL	−0.0001 (−0.17)	0.0000 (0.02)	0.0007 (1.37)
EPU	−0.0006 (−1.05)	0.0000 (0.05)	0.0029 *** (4.05)	EPU	−0.0002 *** (−3.56)	0.0000 (1.42)	−0.0000 (−0.43)
Year FE	YES	YES	YES	Year FE	YES	YES	YES
City FE	YES	YES	YES	City FE	YES	YES	YES
Constant	1.8311 *** (8.28)	4.4904 *** (6.99)	6.1169 *** (10.60)	Constant	−0.1266 *** (−4.20)	0.0123 ** (2.24)	−0.0105 (−0.91)
Observations	991	967	753	Observations	991	967	753
Adj R ²	0.796	0.964	0.973	Adj R ²	0.387	0.627	0.847

Note: The t-statistics are in parentheses. ***, ** and * represent the significance level of 1%, 5% and 10%, respectively.

It can be found that the influence coefficient of the eastern region (0.0526) was larger than that of the central region (0.0222), although both are significantly positive. Consequently, the opening of an HSR had a greater role in promoting the transformation and upgrading of urban industrial structure in the eastern region, but the effect on cities in the western region was not significant. At the same time, compared with the central and western cities, the promotion effect of the opening of an HSR on the level of social employment was more significant in the sub-sample of cities in the eastern region. The reasons may be that the western region has the features of less construction of HSR lines, shorter HSR opening times, fewer operating numbers, less population distribution and relatively backward economy. Therefore, during the sample period, the opening of an HSR did not have an obvious impact on the accessibility of western cities along the route, which is temporarily manifested as a “corridor effect” [20]. In other words, the industrial upgrading effect and employment promotion effect of an HSR opening have not yet been reflected in western cities. Cities in the eastern region not only have advanced technology elements, larger market scale and a relatively perfect policy system, but also enjoy more HSR lines and more frequent train runs. Therefore, an HSR opening can produce a superposition effect, further strengthening the location advantage of eastern cities, improving transportation conditions and facilitating the flow and agglomeration of production factors. This further reduced transaction costs in the eastern region, prompting more high-end enterprises and high-quality talents to gather here. Consequently, the opening of an HSR has a higher impact on the transformation and upgrading of industrial structure and the improvement of social employment level in the eastern region than in the central and western regions.

5. Discussion

Based on the concept of economic and social sustainability, our research supports that the opening of an HSR is an important support for promoting the high-quality development sustainability of Chinese cities. Zhao et al. [5] believed that an HSR opening could raise the total factor productivity of enterprises, thus promoting listed enterprises' high-quality development. This study extends the impact of an HSR opening on the high-quality characteristics of development from the micro enterprise level to the macro economic and social level, providing different evidence by empirical test for the argument that an HSR itself is unlikely to have a transformative effect on the economy [23]. Specifically, the opening of an HSR has a positive effect on the transformation and upgrading of urban industrial structure. This is consistent with the finding about the positive impact of an HSR on China's industry development [14], but from a completely different perspective, namely industrial structure transformation. Meanwhile, the opening of an HSR is beneficial to increase the level of social employment of cities. Based on the context of HSR construction in developing countries, this conclusion supports the findings of Garcia-López et al. [19] and Sobieralski [22] on the employment promotion effect of transport infrastructure upgrading. The analysis of action mechanism shows that the impacts of an HSR opening on the high-quality development of urban industry and employment are affected by the local government's environmental regulation intensity, which present two different influences of inhibition and reinforcement, respectively. This study expands existing research on the direct industrial and employment effects of environmental regulation from the perspective of the interactive effect between national HSR policy and local environmental regulation strategy [7,24]. By selecting alternative high-quality development indicators, excluding samples of municipalities and provincial capitals and using the PSM-DID regression method, we further test the robustness of the research results. In addition, the opening of an HSR has a more significant impact on the high-quality development of cities in the eastern region with better economic development level and non-resource-based cities with fewer shackles in industrial transformation.

From the dual perspectives of economic transformation and people's social livelihoods, this study provides empirical evidence for the effectiveness of transportation infrastructure improvements. The results demonstrate that an HSR opening is an important factor for cities to achieve high-quality development and promote the sustainability of economy and society, expanding the research perspective of the economic consequences of an HSR opening. Meanwhile, by introducing an environmental regulation factor, this study explores whether the economic and social effects of an HSR opening are sustainable, and emphasizes that stronger environmental regulation is beneficial to an HSR's employment promotion effect, but it will also lead to the unsustainability of an HSR's industrial upgrading effect.

From a broader view, our conclusions on an HSR's industrial effect and employment effect in the context of China will help encourage more countries, especially emerging market countries facing greater economic and social sustainable development pressure, to incorporate HSR construction into their future spatial strategic planning. Meanwhile, the different results of the interactive effects of national HSR policy and local government's environmental regulation strategy also help to provide reference for other countries on how to give consideration to economic, societal and environmental sustainable development. Specifically, to achieve high-quality and sustainable city development, countries can start by upgrading their transportation infrastructure. However, the central government should pay attention to coordinating the allocation of factor resources among cities with different geographical locations and different resource endowments in the process of continuously promoting the construction of an HSR. In order to maximize the industrial upgrading effect and employment promotion effect of an HSR network on such cities, the central government shall issue relevant supporting policies to guide the appropriately flow of essential factors. Moreover, in order for cities to benefit more from HSR construction, it is necessary for local governments to formulate reasonable environmental regulation standards based on their own development priorities and specific goals in adjusting industrial structure and

expanding social employment, matching them with the national HSR policy, so as to give full play to the positive effect of an HSR on the high-quality and sustainable development of economy and society.

There are several research limitations. Firstly, we measure the high-quality development of cities from two levels, that is, industrial structure and social employment. Although these two indicators could represent the high quality of urban development to a large extent, they are, inevitably, unable to capture all the features of high-quality development. Further research could continue to explore new high-quality development indicators from the dual perspectives of economic transformation and people's social livelihoods. One possible direction is to construct proxy variables that can reflect the coupling (or deviation) degree of urban industrial structure and employment structure. Secondly, this study emphasizes the negative impact of environmental regulation, that is, the relatively strong environmental regulation will weaken the industrial upgrading effect of an HSR opening. Further research could try to reveal the threshold effect of environmental regulation, and explore at what intensity the regulation is above where this negative effect is shown, as well as how to achieve the coordination and mutual benefit of the two policies. Moreover, although many researchers have accepted and used the PSM-DID approach, some scholars have pointed out the possible limitations of PSM. Further research can deeply explore the validity of the PSM method or find more appropriate matching methods. Finally, limited by the availability of data, this paper focuses on the impact of the opening of an HSR on the high-quality development of prefecture-level cities. Future research may shift the research object to a more detailed micro-level at the municipal districts and county-level cities and investigate whether there is heterogeneity in the role of HSR construction in the high-quality development of cities at different levels as well as the role of environmental regulation on it.

6. Conclusions

In the current uncertain macroeconomic environment, the important role of transportation infrastructure construction in promoting China's sustainable economic and social development has attracted more and more attention. Taking an HSR opening as a quasi-natural experiment and choosing 280 prefecture-level cities in China from 2007 to 2019 as research samples, this paper makes an empirical study on the impact of transportation infrastructure improvement on high-quality development of cities and further explores the action mechanism of this relationship from the perspective of the intensity of local government's environmental regulation. The conclusions of this study are as follows:

- (1) The opening of an HSR will contribute to the high-quality development of Chinese cities by promoting the upgrading of industrial structure and increasing the level of social employment. On the one hand, the opening of an HSR can accelerate the flow and agglomeration of production factors such as technology, capital and manpower, and push forward urban technological innovation and resource integration, thus promoting the transformation and upgrading of urban industrial structure. On the other hand, the opening of an HSR can not only increase the demand for labor force within the cities, but also expand the supply of the labor force, thereby increasing the level of social employment.
- (2) Environmental regulation has a significant moderating effect on the relationship between the opening of an HSR and the high-quality development of cities. A high level of environmental regulation is not conducive to the opening of an HSR to play the role of promoting technological innovation and improving the efficiency of factor allocation, thus inhibiting the industrial upgrading effect of an HSR. However, the impact is the opposite for social employment. The enhanced environmental regulation level will provide more labor force demand. Therefore, the relatively strong environmental regulation can help the opening of an HSR to exert a positive influence on the level of social employment of cities.

- (3) The city's own location and industrial characteristics will restrict the effect of an HSR on its high-quality development. Compared with the central and western regions, the high-quality development of cities in the eastern region is more affected by the opening of an HSR. Compared with resource-based cities, the high-quality development of non-resource-based cities is more affected by the opening of an HSR. Therefore, an HSR opening has no significant positive effect on regional balanced development and the transformation of resource-based cities.

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