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EDITED BY
Qingsong He,
Huazhong University of Science and Technology, China

REVIEWED BY
Hui Zhang,
Guangzhou University, China
Qing Wan,
Wuhan Institute of Technology, China

*CORRESPONDENCE
Xiang Luo,
philiplaw@163.com
Guodong Lin,
1054370341@qq.com

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Impact of relocation and reconstruction policies on the upgrading of urban industrial structure in old industrial districts

Qixing Lin[1], Xiang Luo[2]*, Guodong Lin[2]*, Tiantian Yang[2] and Wenjie Su[3]

[1]School of Architecture and Urban Planning, Huazhong University of Science and Technology, Wuhan, China, [2]School of Public Administration, Central China Normal University, Wuhan, China, [3]School of Public Administration, South -Central Min Zu University, Wuhan, China

Old industrial bases (municipal districts) play a decisive role in the process of China's economic development. This study focuses on the upgrading of urban industrial structure. Based on the panel data of 120 old industrial bases (municipal districts) in China from 2010 to 2018, a double difference model was established to empirically analyze the impact of pilot relocation and reconstruction policies on the upgrading of urban industrial structure in old industrial districts. The results demonstrate that 1) The pilot relocation and reconstruction policies play a significant role in promoting the upgrading of urban industrial structure in old industrial districts; 2) Upgrading of urban industrial structure is significantly affected by the urban economic development level, urban population density, land marketization level, industrial enterprise agglomeration degree and infrastructure construction; 3) The impact of relocation and reconstruction policies on the upgrading of urban industrial structure in old industrial districts exhibits certain regional heterogeneity. Finally, some targeted suggestions are proposed for future formulation of effective policies for the relocation and reconstruction of old industrial areas and optimal allocation of urban industrial structure.

KEYWORDS

relocation and reconstruction of old industrial districts, industrial structure upgrading, double difference, regional heterogeneity 1.Introduction, policy pilot

1 Introduction

Old industrial bases (municipal districts) are centralized industrial areas (cities) with relatively complete industrial categories established with national investment during the planned economy period, which are mostly distributed in northeast, central and western China. With the transformation of China's economic development from "high-speed growth" to "high-quality growth", the old industrial bases (municipal districts) are confronted with a series of problems, such as backward industrial production capacity, unbalanced configuration of industrial structure, extensive land use and serious environmental pollution (Dong et al., 2022; Li et al., 2022). Among these

problems, unbalanced configuration of industrial structure has largely hindered the high-quality development of regional economy (Du et al.,2021; Gu et al.,2022). According to the statistical bulletin, the proportion of China's primary, secondary and tertiary industry in GDP was 7.3, 39.4 and 53.3% in 2021, respectively. Compared with that in developed countries, the industrial structure configuration in China is still relatively unbalanced. In order to achieve economic "structural growth", it is necessary to accelerate the substitution of old driving force with new driving force, as well as improve infrastructural construction, land use efficiency and urban ecological environment. In 2014, the General Office of the State Council issued Guiding Opinions on Promoting the Relocation and Reconstruction for Old Industrial Districts in Urban Areas (GBF [2014] No. 9). The document identified 21 old industrial bases (municipal districts) such as Beijing, Hebei, Shanxi, Inner Mongolia, Liaoning and Jiangsu, which lays a solid foundation for the upgrading of industrial structure in these areas.

In recent years, Chinese government has accelerated the implementation of urban renewal activities, focusing on the transformation of old industrial bases (factories), and promoting the upgrading of industrial structure. In this context, it is of great practical and theoretical significance for old industrial bases (municipal districts) to fully utilize the relocation and reconstruction policies. At present, research on relocation and reconstruction mechanism in old industrial districts has attracted extensive attention of scholars and achieved fruitful results, but many major issues remain to be further explored. Generally, the existing research has the following problems. First, it is mainly focused on the importance (Zhang G. et al., 2021; Zhou et al., 2021), existing problems (Liu et al., 2019; Hu et al., 2019; Hu et al., 2022), impact mechanism (LAI et al., 2021; Chen and Lin, 2021) and innovation paths (Lin and Zhou, 2021) of the relocation and reconstruction of old industrial districts, while the relationship between the relocation and reconstruction policies and industrial structure upgrading has been largely ignored. In addition, little is known about the changes during the policy implementation and regional heterogeneity of the impact. In terms of research methods, previous research is mainly qualitative research or logical deduction with little quantitative analysis through the empirical model. Finally, in terms of the spatial scale, previous studies mostly took a city or a region as an example (Yang et al., 2017; Li et al., 2021; Pu and Zhang, 2022), while there has been no research on the impact of pilot relocation and reconstruction policies for old industrial districts on the upgrading of industrial structure based on a large number of old industrial bases (municipal districts).

The marginal contributions of this study can be summarized as follows. 1) Theoretical value. The year of 2022 is the time to check the effect of the relocation and reconstruction policies for old industrial districts. It remains undetermined whether the implementation of these policies promotes the upgrading of urban industrial structure, what are the influencing factors, and whether the impact has any heterogeneity in different regions. Here, based on the panel data of 120 old industrial bases (municipal districts) in China from 2010 to 2018, and the national pilot relocation and reconstruction policies for old industrial bases issued by the central government in 2014, this study builds a double difference model to answer the above questions, which may help to further enrich the relevant theory and practice in the relocation and reconstruction of old industrial districts. 2) Practical value. An in-depth analysis on the effect of the relocation and reconstruction policies for old industrial districts can help solve the problems in the process of relocation and reconstruction, as well as provide important reference for improving the relocation and reconstruction policies in the future.

The rest of this paper is arranged as follows. First, policy practices are combed and the relevant literature is reviewed, including theoretical research on the relocation and reconstruction of old industrial districts and the impact on industrial structure upgrading. Secondly, the research design is elaborated, such as research methods, data sources and variable selection, followed by empirical results, robustness test results and regional heterogeneity analysis. Finally, brief conclusions and policy recommendations are proposed.

2 Policy practice and literature review

2.1 Policy practice

In 2011, the General Office of the State Council issued the Special Plan for Adjustment and Transformation of Old Industrial Bases in China (2011–2020), signifying that China's old industrial bases have entered the stage of comprehensive rectification. In March 2014, the General Office of the State Council issued the Guiding Opinions on Promoting the Relocation and Reconstruction of Old Industrial Districts in Urban Areas; Subsequently, the National Development and Reform Commission established the National Pilot List for the Relocation and Reconstruction of Old Industrial Districts in Urban Areas, pointing out the direction for the reconstruction and reuse of old factory areas and buildings. Since 21 pilot cities were established by the National Development and Reform Commission, local governments have actively carried out the relocation and transformation based on the resource allocation of each city, forming the following typical models. 1) Active planning and urban transformation to reduce dependence on resource-based industries. Taking the Zigong mode as an example, Zigong makes full use of traditional advantages of chemical fluid machinery, restructures the supporting facilities of the industrial chain, and develops a large number of new

kinetic energy industries, such as energy-saving and environment-friendly equipment, aviation and gas turbines, and new materials. 2) Promotion of the upgrading through integration, development through opening up, and enhancement through transformation. Taking the Xuzhou model for example, the Xuzhou municipal government issued the "Made in China 2025 Xuzhou Practice Plan" to build a "smart manufacturing" and powerful city in 2016, creating a new system of modern industrial industries and advancing the development of manufacturing industry clusters by relying on "6 + 6″ and "255″ development models. Advanced manufacturing industries such as solar photovoltaic, industrial machinery, new medicine and 3D printing have been vigorously developed. 3) Industrial heritage conservation development, service industry-driven development, investment and financing market-oriented operation, such as the Shijingshan model. By taking the Beijing winter Olympics as a development opportunity, the Shijingshan District in Beijing developed and reused the inefficient, idle and obsolete industrial plants to create distinctive national demonstration bases of sports industry, such as the winter sports training base of the national team, air trails and rock climbing bases, while retained the landscape of old industrial zones of Shougang. The focus of regional industrial development has been shifted to five high-end service industries, including modern finance, scientific and technological services, cultural creativity, business services, tourism and leisure. 4) Shiyan model, which enhances the transformation and upgrading of traditionally advantageous industries and extension of industrial chains, and cultivates advantageous emerging industries. With focus on the development of main automobile industries and cultivation of emerging industries, it strengthens the transformation and upgrading of traditionally advantageous industries, extends the automobile industry chain, promotes the transformation of industrial mountain cities to landscape garden cities, and expands and develops industries such as hydropower development, agricultural product processing and biomedicine. Three new automobile industrial parks and seven professional parks have been built, attracting 50 enterprises in the urban area to move to new industrial parks for development. 5) Implementation of the urban transformation strategy in three dimensions, including industry, people's livelihood and ecological environment. For example, the Shizuishan model focuses on the implementation of urban transformation and development strategy, starting with the cultivation and development of continuous leading industries, transformation and upgrading of traditional industrial chains, and development of circular economy and other aspects, so as to win people's trust and promote social harmony and stability by improving people's livelihood, and improve urban living environment by improving the ecological environment. This model lays much emphasis on new materials, equipment manufacturing, calcium carbide chemical industry, metallurgy, new energy, biomedicine and other special industries, as well as vigorously develops modern logistics, cultural tourism, e-commerce and other fast-growing service industries.

2.2 Literature review

To solve the problems of unreasonable industrial structure and environmental pollution caused by the development of traditional industries, the development and reuse of inefficient, idle and obsolete industrial land not in line with economic development have become important issues for many countries to improve the comprehensive competitiveness of cities (Sosnovskikh., 2017; Ahmad et al., 2021). Despite of some differences in the exploration and practice in the relocation and reconstruction of old industrial districts in various countries, the essence of the development and reuse of industrial districts is to improve the regional urban land resource utilization efficiency, industrial structure optimization, infrastructure improvement and urban environment restoration. During the changing process of industrial structure in a country, the resource allocation theory believes that industrial land policy can utilize the differences in information advantage to guide the endowment of resource elements to industries with higher productivity and development rate, so as to improve the use efficiency of industrial land resources. Luo et al. (2022) revealed that effective institutional supply can realize the optimal allocation of urban land resources based on the life cycle management of industrial land. According to the urban renewal theory, urban renewal is a process of "metabolism" from the inside out of the city. The formulation of a series of policies can guide the spatial layout and reconstruction of industrial structure in old urban areas. Obviously, decision-makers have the responsibility to determine the most effective way to promote economic development and transform industrial structure. Upadhyay (2015) believes that developing countries are faced with greater risks of market failure in the process of industrial structure transformation. In general, in the process of urban industrial structure transformation, there are some common problems such as inconsistent policies, low implementation efficiency, insufficient technical support and rent-seeking and corruption, as well as problems such as long transformation time and high cost, which inevitably lead to greater risks and uncertainties of the transformation. Therefore, in the process of relocation and reconstruction of old industrial districts, decision-makers believe that the government should be able to effectively identify and avoid the redevelopment risk of inefficient urban land use through a series of strategic layout such as policy design, implementation and follow-up measures (Verma and Haimanti, 2022; Samford.,2022).

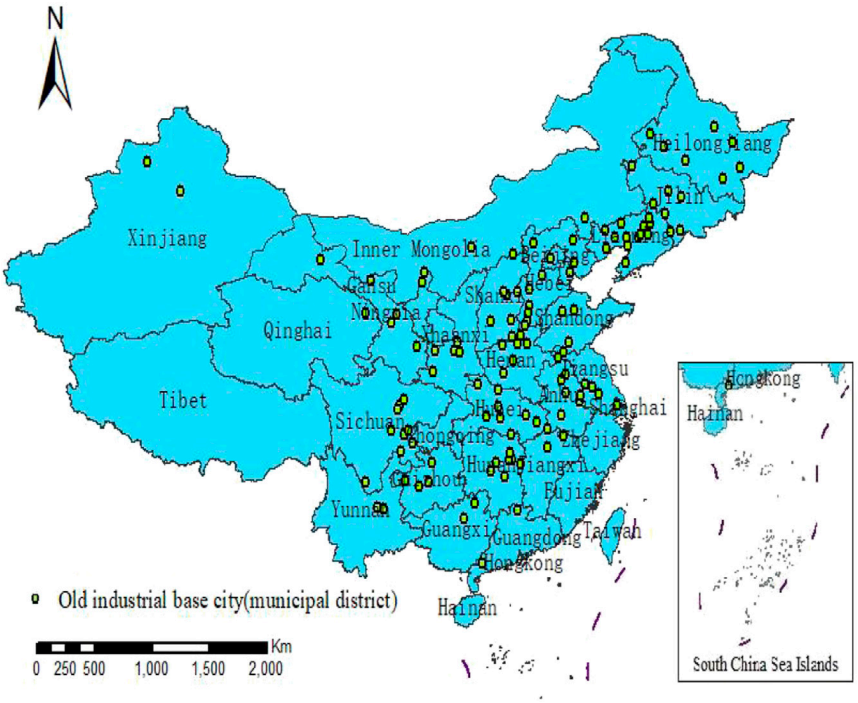

FIGURE 1
Distribution map of 120 old industrial base cities (municipal districts).

In the complex and dense urban environment in China, there are significant differences in the layout, structure and composition of old industrial districts. Rapid industrialization has prompted China to enter the "post industrialization" era. The complex history, scale and spatial layout of degraded old industrial districts have caused a series of social, economic and environmental problems (Wang et al., 2022; Zhang et al., 2022). Pan et al. (2017) proposed that China's industrial districts are currently faced with problems such as scarcity of space for industrial structure upgrading and low efficiency of industrial space utilization. In order to alleviate the degradation and irrationality of urban industrial structure, some scholars suggest that planners should take different reconstruction conditions into account when formulating reconstruction policies and regulations in different regions (Lai et al., 2021). Zhan (2019) demonstrated that environmental regulation has an obvious spatial effect and lagging effect on the upgrading of urban industrial structure. Geng (2021) proposed that the government should make better use of market-oriented policies and "creative destruction" mechanism to promote the upgrading of industrial structure. Some studies also indicated that some measures such as strengthening infrastructure construction, technological innovation, financial subsidies and resource allocation could also help to refine the urban industrial structure to some extent (Jiang et al.,. 2020; Su et al., 2021; Yu and Wang, 2021).

3 Research design and data source

3.1 Variable selection

This study uses the panel data of 120 old industrial bases (municipal districts) from 2010 to 2018 before and after the policy promulgation for empirical research. Among them, 21 cities including Beijing, Chongqing, Taiyuan, Dalian, Harbin, Hefei, Nanchang, Jinan, Wuhan, Guiyang, Xi'an, Lanzhou, Zigong, Maoming, Zhuzhou, Luoyang, Xuzhou, Jilin, Tieling, Baotou and Zhangjiakou are classified into the treatment group, and the remaining 99 cities are defined as the control group. The specific geographical distribution is shown in Figure 1.

3.1.1 Explained variables

On the basis of existing research, the upgrading and rationalization of industrial structure are taken as proxy variables to measure the upgrading of urban industrial

TABLE 1 Policy practices of relocation and reconstruction of old industrial bases (municipal districts).

Number	Region	Time	Model	Practice focus
1	Zigong	2014	Active planning and urban transformation to reduce dependence on resource-based industries	Vigorous development of non-salt industries such as energy-saving and environment-friendly equipment, aviation and gas turbines and new materials
2	Xuzhou	2011	Promotion of upgrading through integration, development through opening up, and upgrading through transformation	Promoting the development of new industries such as service outsourcing and e-commerce logistics
3	Shijingshan	2008	Conservation and development of industrial heritage, service industry-driven development, investment and financing market-oriented operation	Transferring the focus of industrial development to the five high-end service industries of modern finance, scientific and technological services, cultural creativity, business services, tourism and leisure
4	Shiyan	2014	Intensifying the transformation and upgrading of traditional advantageous industries and the extension of industrial chains, and cultivating emerging industries with advantages	Expanding and developing industries such as automobiles, hydropower development, agricultural products processing, and biomedicine
5	Shizuishan	2013	Implementation of urban transformation strategy in three dimensions: industry, people's livelihood and ecological environment	Development of new materials, equipment manufacturing, calcium carbide chemical industry, metallurgy, new energy, biomedicine and other characteristic industries, as well as modern logistics, cultural tourism, e-commerce and other fast-growing service industries

TABLE 2 Meaning, measurement and data source of main variables.

Variable	Name	Measurement	Data resource	Index selection basis
Explained variable	Advanced industrial structure	1 ≤ ais≤3	China Yearbook for Regional Economy	You(2022)
	Rational structure of production	0 ≤ theil≤1		
Core variable	Pilot cities of relocation and reconstruction of old industrial districts	Dummy variable (0,1)	National Development and Reform Commission website	Self-building database
Control Variable	Urban economic development level	Per capita GDP (yuan)	China City Yearbook	Zhu (2019)
	Urban population density	Total permanent population of the city/area of the municipal district (person/km2)	China Yearbook for Regional Economy	Su (2022)
	Industrial agglomeration degree	Total number of industrial enterprises/urban construction land area (number/km2)	China City Yearbook	Zhang H. et al. (2021)
	Land marketization	Bidding, auction and listing area of municipal primary market/total land area transferred (%)	China Yearbook for Regional Economy	Lu (2020)
	Infrastructure construction level	Per capita road area (m2)	China City Yearbook	Chen et al. (2022)

structure. Advanced industrial structure (AIS) mainly reflects the connotation of industrial structure upgrading. As shown in Equation 1, n represents the primary, secondary and tertiary industry, respectively, and yn represents the proportion of output value of the *n*th industry in the total output value; the rationalization of industrial structure (Theil) mainly reflects the "input-output" coupling relationship. Li refers to the total output value of all industries in an old industrial base (municipal district), and L represents the number of employees of all industries in an old industrial base (municipal district); Yi refers to the total output value of all industries in an old industrial base (municipal district). The data were derived from China Statistical Yearbook for Regional Economy.

$$ais = \sum_{n=1}^{3} y_n^{\star} n \left(1 \le ais \le 3\right) \tag{1}$$

$$theil = \sum_{i=1}^{m} \left(\frac{Y_i}{Y}\right) \ln\left(\frac{Y_i}{Y} \Big/ \frac{Y}{L}\right) \tag{2}$$

Note: advanced industrial structure (AIS) is a positive indicator; the closer it is to 3, the more advanced; and the rationalization of industrial structure (Theil) is a negative indicator; the smaller it is, the more reasonable it is.

TABLE 3 Descriptive statistical results of main variables.

Variable	Obs	Mean	Std. Dev	Min	Max
Advanced industrial structure	1,080	2.304	0.151	1.933	2.907
Rationalization of industry structure	1,080	0.254	0.159	0.012	0.846
Pilot cities for relocation and reconstruction of old industrial districts	1,080	0.097	0.296	0	1
Urban economic development level (take logarithm)	1,080	10.711	0.5	9.127	11.942
Urban population density	1,080	0.605	15.918	0.003	523.222
Industrial enterprises agglomeration degree	1,080	7.835	5.368	0.42	42.992
Land marketization	1,080	14.538	5.452	1.37	44.892
Infrastructure construction level	1,080	0.894	0.169	0.138	1.694

3.1.2 Core explanatory variables

A cluster of pilot cities for the relocation and reconstruction in old industrial districts are defined as the experimental group. The pilot city is set as 1 and the non-pilot city is set as 0. The interactive term generated by multiplying two dummy variables is the core explanatory variable (did) of this study. The data were derived from the website of National Development and Reform Commission.

3.1.3 Control variables

This study selects the following indicators as control variables to measure the upgrading of urban industrial structure (as shown in Table 2). The urban economic development level is represented by per capita GDP; the urban population density is expressed by the total urban permanent population/area of the municipal district; the industrial agglomeration degree is measured by the total number of industrial enterprises/urban construction land area; the land marketization level is measured by the total number of industrial enterprises/urban construction land area; the per capita road area is used to represent the infrastructure construction level. The data were from China Urban Yearbook and China Statistical Yearbook for Regional Economy.

3.2 Descriptive statistical analysis

The National Development and Reform Commission set up 21 pilot cities for the relocation and reconstruction among old industrial bases (municipal districts) of China in 2014. The processing group in the benchmark regression of this study include these 21 cites for robustness test. Finally, the panel data of 120 old industrial bases (municipal districts) from 2010 to 2018 were selected for the empirical analysis. The outliers of each variable were identified and eliminated, and the missing value interpolation method was filled in the missing data. The descriptive statistical analysis results of the processed variables are shown in Table 3.

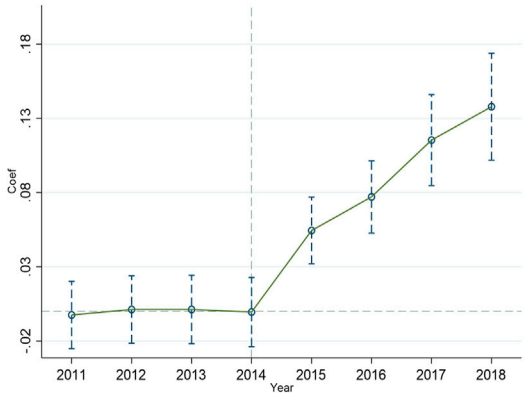

FIGURE 2
Parallel trend test of advanced industrial structure.

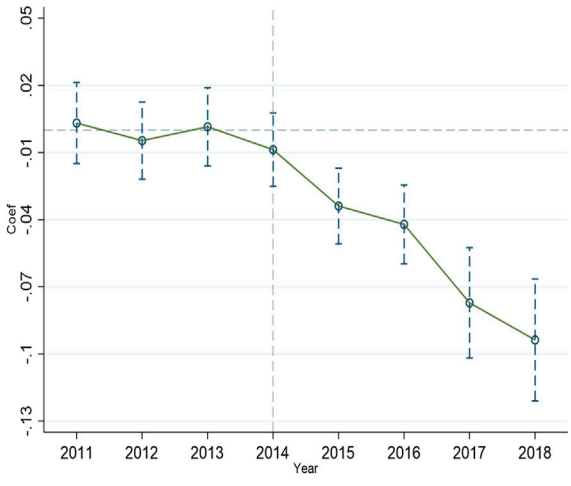

FIGURE 3
Parallel trend test of industrial structure rationalization.

TABLE 4 Impacts of pilot relocation and reconstruction policies of old industrial districts on the upgrading of urban industrial structure.

Variable	(1)	(2)	(3)	(4)
	Ais	ais	Theil	Theil
Policy Effect (did)	0.067***	0.067***	−0.043***(0.011)	−0.042***
	(0.013)	(0.013)		(0.01)
Lngdp		−0.077***		0.047
		(0.023)		(0.038)
pop		0.0002***		0.00005***
		(0.00001)		(0.00002)
Agg		0.0003		0.002**
		(0.0006)		(0.0008)
Inf		0.0001		0.003*
		(0.001)		(0.001)
landmr		0.029**		−0.01 (0.022)
		(0.015)		
Individual Fixation Effect	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes
R2	0.245	0.778	0.129	0.164
obs	1,080	1,080	1,080	1,080

Note: * is significant at the 10% level, * * is significant at the 5% level, * * * is significant at the 1% level, and the figures in brackets are standard errors.

4 Empirical study results and analysis

4.1 Parallel trend test

Parallel trend test is the basic premise for double difference evaluation, which means that the upgrading of industrial structure in the control group and the experimental group should be maintained in a stable situation before the implementation of pilot policies of relocation and reconstruction in old industrial districts. The results are shown in Figure 2 and Figure 3. Before the implementation of the pilot policies, the regression coefficient is not significant, indicating that the gap between the treatment group and the control group is not obvious. Given the impact of the relocation and reconstruction policy standards of old industrial areas, the advanced urban industrial structure was remarkably influenced, and the power of promotion continued to grow. The pilot policy has a lagging impact on the rationalization of urban industrial structure. Therefore, the industrial structure upgrading model established in this study passes the parallel trend test.

4.2 Basic regression results

This study adopts basic regression for the selected variables and the results are shown in Table 4. Model 1) and model 3) are not added with control variables; and model 2) and model 4) are added with all variables. According to model 1) and model 3), the pilot relocation and reconstruction policies for old industrial districts play a significantly positive role in promoting the upgrading and rationalization of urban industrial structure at the significance level of 0.01. The implementation of pilot policies can effectively promote the upgrading of urban industrial structure, accelerate the flow and allocation of various production factors among industries, and thus curb the imbalance of urban industrial structure.

As shown in model 2), urban economic development level has negative impacts on the upgrading of urban industrial structure at a significance of 0.01. Areas with a relatively high level of economic development will actively carry out pilot projects for the relocation and transformation of old industrial areas, but blindly pursuing the advanced industrial structure will bring about a “structural slowdown” of economic growth. Urban population density and land marketization have positive impacts on the upgrading of urban industrial structure at a significance of 0.01. The relocation and reconstruction policies play important roles in accelerating local economic development and promotion of government officials. Therefore, regions with high economic development levels and better conditions tend to more actively carry out the pilot work of relocation and reconstruction of old industrial areas. Urban population density can reflect the housing demand in urban areas to certain extent. Therefore, provinces with higher urban population densities tend to have greater housing demand. In order to relieve the housing imbalance between supply and demand caused by increasing population, the local government develops and reuses the inefficient, idle and

obsolete industrial land for residential land to meet the growing housing demand. Land marketization reflects the utilization efficiency of urban land resources to certain extent. Under the background of the reconstruction of China's tax sharing system, the local government with higher land marketization degrees behaves better in land function transformation. Revitalization of the inefficient, idle and obsolete industrial land can not only improve land use efficiency and reshape urban land use structure, but also facilitate the healthy and sustainable development of cities.

As descripted in model 4), the urban population density still has a positive impact on the rationalization of urban industrial structure, which is significant at the level of 0.01, indicating that a higher urban population density is more likely to encourage the government to adjust the urban industrial structure to some extent. The degree of industrial enterprise agglomeration also has a positive effect on the rationalization of urban industrial structure at a significance level of 0.05. This may be due to the role of economy in reducing enterprise production cost caused by industrial enterprise agglomeration. From a dynamic point of view, the agglomeration of industrial enterprises is conducive to the improvement of innovation ability and production efficiency of enterprises, thus boosting urban economic development. The infrastructure construction level has a positive impact on the rationalization of industrial structure, which is significant at the level of 0.1. On the one hand, the improvement of infrastructure construction can promote the flow of production factors in various industrial sectors, improve production efficiency, enhance the optimal allocation of industrial structure, and has a strong structural dividend effect. On the other hand, it can alleviate the potential mismatch of market space and reduce the transportation cost. As a result, enterprises tend to have more funds for innovative activities, forming an excellent competition mode, so as to achieve greater diversification and rationalization of urban industries.

4.3 Dynamic marginal effect test

The implementation of relocation and reconstruction policies for old industrial districts is a dynamic and lasting process. With the in-depth implementation of the policies, their impact on the advance and rationalization of urban industrial structure will gradually appear. Therefore, it is necessary to further test the dynamic marginal effect. The year of 2014 is an important node for the implementation of the relocation and reconstruction policies of old industrial districts. Therefore, the time dummy variables from 2014 to 2018 are set as 1 and those of the rest years are set as 0. By introducing time dummy variables respectively into model 2) and model 4), the following equations can be obtained:

$$ais_{i,t} = \beta_0 + \beta_1 y14 \times post_{i,t} + \beta_2 y15 \times post_{i,t} + \beta_3 y16 \times post_{i,t} + \beta_4 y17 \times post_{i,t} + \beta_5 y18 \times post_{i,t} + \sum x_{i,t} + \varepsilon_{i,t} + \mu + \eta \quad (3)$$

$$theil_{i,t} = \beta_0 + \beta_1 y14 \times post_{i,t} + \beta_2 y15 \times post_{i,t} + \beta_3 y16 \times post_{i,t} + \beta_4 y17 \times post_{i,t} + \beta_5 y18 \times post_{i,t} + \sum x_{i,t} + \varepsilon_{i,t} + \mu + \eta \quad (4)$$

The test results are shown in Table 5. Model 5) and model 7) are not added with control variables. The coefficients of multiplication term from 2014 to 2018 become increasingly significant, whether it be the upgrading of urban industrial structure or the rationalization of industrial structure, demonstrating that the implementation of the relocation and reconstruction policies for old industrial districts can effectively promote the upgrading and rationalization of urban industrial structure. In addition, the implementation of these policies has a certain lag, as revealed by the regression results after the addition of control variables into model 6) and model 8).

4.4 Robustness test

In view of the possible non-randomness in the implementation of old industrial districts relocation and reconstruction policies, which violates the principle of random experiments, this study adopts the PSM-DID method to correct the selection error of samples, and selects propensity matching methods such as nearest neighbor matching, kernel matching and radius matching for the matching. The pilot cities with sample investigation period were used as the control group for regression, and the results are shown in Table 6. The difference between the average value of the treatment group and control group is significant at the level of 0.01, indicating high balance and robustness.

4.5 Placebo test

In order to avoid limitation by unobserved factors, this study conducts random sampling of all data the control group and treatment group for a total of 500 times, and carries out basic regression on the samples randomly selected each time. The results are shown in Figure 4 and Figure 5. The average estimated coefficient of industrial structure upgrading and industrial structure rationalization is 0.000, which is not significantly different from the actual estimated coefficients of 0.067 and −0.042, respectively. Therefore, it can be concluded that the unobserved urban characteristics have no impact on empirical test results, and thus the relocation and reconstruction policies for old industrial districts can significantly improve the upgrading and rationalization of urban industrial structure.

TABLE 5 Dynamic effects of the relocation and reconstruction policies for old industrial districts on the upgrading and rationalization of industrial structure.

Variable	(5)	(6)	(7)	(8)
	ais	ais	Theil	Theil
year_2014×treat	−0.003 (0.007)	−0.003	−0.007	−0.006
		(0.007)	(0.005)	(0.006)
year_2015×treat	0.048***	0.051***	−0.027**	−0.029***
	(0.013)	(0.014)	(0.011)	(0.01)
year_2016×treat	0.066***(0.015)	0.073***(0.015)	−0.031**	−0.035***
			(0.013)	(0.011)
year_2017×treat	0.104***	0.11**	−0.065***	−0.07***
	(0.019)	(0.02)	(0.015)	(0.015)
year_2018×treat	0.124***	0.131**(0.023)	−0.083***	−0.086***
	(0.022)		(0.016)	(0.016)
Control variable	No	Yes	No	Yes
Individual fixation effect	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes
R2	0.794	0.811	0.153	0.188
obs	1,080	1,080	1,080	1,080

Note: * is significant at the 10% level, * * is significant at the 5% level, * * * is significant at the 1% level.

TABLE 6 Robustness test results.

Variable	Nearest neighbor matching		Radius matching		Kernel matching	
	(9)	(10)	(11)	(12)	(13)	(14)
	ais	Theil	ais	Theil	ais	Theil
	0.07***	−0.043***	0.07***	−0.067***	0.061***	−0.052***
	(0.014)	(0.01)	(0.022)	(0.02)	(0.012)	(0.013)
Control Variable	Yes	Yes	Yes	Yes	Yes	Yes
Individual Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
R2	0.777	0.146	0.785	0.128	0.795	0.133
obs	1,062	1,062	918	918	981	981

Note: * is significant at the 10% level, * * is significant at the 5% level, * * * is significant at the 1% level. The figures in brackets are standard errors. In order to save the text space, the report of control variables is omitted, same as and the following table.

4.6 Regional heterogeneity analysis

To explore the impact of the relocation and reconstruction policies for old industrial districts on the upgrading of urban industrial structure in different regions, this study further classifies the observed values into eastern region, central region, northeast region and western region. The results show that the policies have different effects on the upgrading of urban industrial structure in different regions (Table 7).

From the perspective of urban industrial structure upgrading, these regions follow the order of western region > eastern region > central region. The western region and northeast region make significantly greater achievements than the eastern region and central region, which may be attributed to the following two reasons. On the one hand, there is a poor coordination between China's economic development and industrial structure upgrading. When the industrial structure deviates from the economic development level, those regions with lower economic development levels are more likely to have

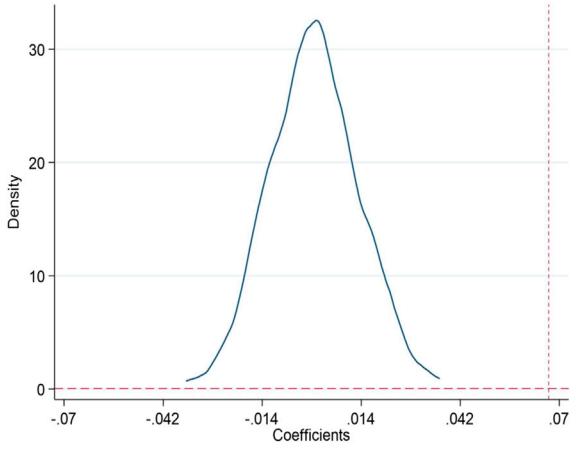

FIGURE 4
Placebo test of advanced industrial structure.

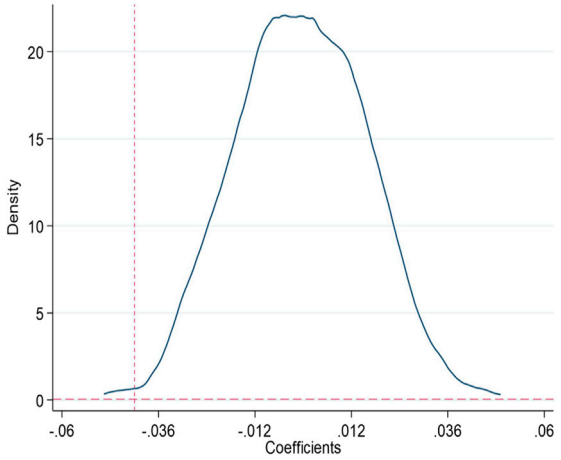

FIGURE 5
Placebo test of rationalization of industrial structure.

TABLE 7 Regional heterogeneity test.

Variable	Eastern region		Central region		Western region	
	(15)	(16)	(17)	(18)	(19)	(20)
	ais	Theil	ais	Theil	Ais	Theil
Policy effect	0.067*** (0.011)	−0.048*** (0.016	0.035*	−0.043**	0.105***	−0.03
			(0.018)	(0.018)	(0.037)	(0.018)
Control Variable	Yes	Yes	Yes	Yes	Yes	Yes
Individual fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
R2	0.776	0.252	0.879	0.138	0.756	0.262
obs	396	396	378	378	306	306

Note: * is significant at the 10% level, * * is significant at the 5% level, * * * is significant at the 1% level. The advanced industrial structure is a positive indicator, which is more significant when close to 3; The rationalization of industrial structure is a negative indicator, which is more significant when close to 0. The numbers in brackets are standard errors, and the report of control variables is omitted in order to save the text space.

"premature" upgrading of industrial structure (Guo and Liu, 2022). On the other hand, in recent years, the eastern and central regions have continuously deepened the reform on the system and mechanism and reshaped the competitiveness of industrial structure, providing "hematopoietic" function for old industrial bases (municipal districts), so as to enhance the upgrading of urban industrial structure.

From the perspective of rationalization of urban industrial structure, the overall order is central region > eastern region > western region. Compared with that in the eastern region, the pilot policies for the relocation and reconstruction of old industrial districts play a more obvious role in promoting the rationalization of industrial structure in the northeast and central regions, but not in the western region. There may be two reasons for the above phenomenon. On the one hand, these policies have a significant stimulating effect on cities with low economic development levels, and narrow the development gap in industrial structure between regions to some extent. On the other hand, under the influence of urban economic development level, urban population density, industrial enterprise agglomeration degree, infrastructure construction level and land marketization, these pilot policies have rather limited effects to bridge the differences in the upgrading of industrial structure between different regions. They only have such effect in the eastern region and central region, but cannot effectively solve the development problems caused by the unreasonable allocation of industrial structure in the central region and western region.

5 Conclusion and policy recommendations

5.1 Conclusion

This study takes 2010–2018 as the research period and 120 old industrial bases (municipal districts) in China as examples to empirically analyze the impact of the pilot relocation and reconstruction policies of old industrial districts on the upgrading of urban industrial structure based on the double difference model. The results demonstrate that: 1) The pilot relocation and reconstruction policies of old industrial districts play a significant role in promoting the upgrading of China's urban industrial structure; 2) Urban economic development level, urban population density, land marketization, agglomeration degree of industrial enterprises and infrastructure construction level have significant impacts on the upgrading and rationalization of urban industrial structure; 3) There is certain regional heterogeneity in the impact of these policies on the upgrading of urban industrial structure and the impact follows the order of western region > eastern region > central region. The overall order of the effect on the rationalization of industrial structure is central region > eastern region > western region.

5.2 Policy recommendations

First, the differential path of policies in pilot cities for the relocation and transformation of old industrial districts should be actively explored. In response to the relocation and reconstruction policies of old industrial districts, the local government is supposed to plan advantageous industries in conformity with local development according to the real conditions, determine the orientation of industrial development, and formulate relevant incentive and supporting policies. Besides, it is necessary to grasp the time node to refine the pilot policy plan. On the other hand, full consideration should be given to the coordination of the overall land use plan with regional development, industrial layout, and ecological environment construction, so as to balance the benefits of various parties such as the government, land owners with original property right and market subjects. On the other hand, the government should appropriately adjust special fund subsidies, tax incentives and financial services, enhance the confidence of original landowners, and reduce the cost of development and reuse of market subjects. Moreover, it is necessary to narrow the regional economic gap by promoting the strategic emerging industries to settle in economically backward areas for a more balanced spatial layout, so as to solve the problem of "last mile" in the upgrading of urban industrial structure.

Second, more attention should be paid to the promotion effect of relocation and transformation policies for old industrial districts on the upgrading of urban industrial structure. Most old industrial bases (municipal districts) focus on the development of traditional heavy industries. The relocation and transformation policies for old industrial districts are of great practical significance for the optimization of urban industrial structure. On the one hand, enterprises in old industrial bases (municipal districts) should make flexible use of undertaking transfer, chain extending and technological transformation to guide the division of labor and cooperation in regional development, so as to optimize the spatial layout and promote the coordinated development of regions. On the other hand, the old industrial bases (municipal districts) should focus on developing strategic emerging industries such as optoelectronic information, biological industry, energy conservation and environmental protection, new materials and high-end equipment manufacturing, and incubate new economic growth points.

Third, the successful experience of pilot cities in the relocation and transformation of old industrial districts should be popularized. Cities that have not carried out the pilot relocation and reconstruction of old industrial districts should fully mobilize regional resources to learn from the successful cases. On the one hand, the local government should dynamically adjust the relocation and reconstruction policies of old industrial districts, give full play to the joint efforts of the government, market and society, guide the traditional industries to move closer to emerging industries for the reasonable layout and unified supply, and ensure the strong development trend of urban industrial structure upgrading. On the other hand, according to characteristics of local resources, environment, economy and other aspects, land allocation should be coordinated for relocation and reconstruction of old industrial districts, green land, public infrastructure land and residential land. In addition, it is beneficial to optimize urban functional areas, improve the urban ecological environment, and reinforce the tenacity of urban development.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding authors.

Author contributions

Project administration, funding and review, XL; Conceptualization, methodology, formal analysis, writing-original draft preparation and visualization, GL; Data curation and software, QL; Validation, TY; Writing-editing, WS. All authors have read and agreed to the published version of the manuscript.

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