

Article

Industrial Land Change in Chinese Silk Road Cities and Its Influence on Environments

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Abstract: The “Belt and Road” has developed from a Chinese initiative to an international consensus, and Silk Road cities are becoming a strategic step for its high-quality development. From the perspective of industrialization, the “Belt and Road” can be regarded as a “spillover” effect of the industrialization process in China. With the spatial shift of Chinese industries along the “Belt and Road” and their clustering in Silk Road cities, the development and change of industrial land in Silk Road cities has become a new area of concern for governments and scholars. In this paper, the driving mechanism of industrial land change in 129 cities along the Silk Road in China is empirically studied by the GeoDetector method. The findings include: first, the development and changes of industrial land in Silk Road cities are significantly spatially heterogeneous, and the “Belt and Road” reshapes the town system and economic geography along the route by virtue of the differentiated configuration and changes of industrial land, changing the social, political, landscape and spatial relations in cities on the line. Second, the driving forces of industrial land change in Silk Road cities under the influence of the “Belt and Road Initiative” are increasingly diversified and differentiated, with significant two-factor enhancement and non-linear enhancement interaction between two driving factors, and growing complexity of the driving mechanisms, requiring policy makers to design policies based on key factors, comprehensive factors and their interaction. Third, the environmental effect of industrial land change is highly complex. The industrial land quantity has a direct impact on the ecological state parameter and plays a decisive role in the quality of the ecological environment and its changes in Silk Road cities. However, changes in the industrial land affect the ecological state change indirectly, mainly interacting with it through the coupling of pollutant and carbon dioxide emissions, energy use, ecological planning and landscape design and policy interventions. Finally, this study provides a new framework and method for Silk Road scholars to analyze the spatial and temporal evolution characteristics of land use and coverage in cities along the “Belt and Road” and their influence mechanisms, and provides a basis for the government to make decisions on industrial land supply and layout planning and spatial governance policy design, which is of great theoretical significance and practical value.



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1. Introduction

1.1. Background

Chinese President Xi Jinping successively proposed to work together towards building the “Silk Road Economic Belt” and the “21st-Century Maritime Silk Road” (hereinafter referred to as the “Belt and Road Initiative”) in 2013 during his visits to Central Asia and Southeast Asia, which received great attention from the international community [1–4]. The “Belt and Road” has undergone a huge transition from a Chinese initiative to an international consensus, and is becoming a platform for more and more countries and political leaders around the world to explore a new model of global economic governance. The “Belt and Road” initiative aims to optimize the division of labor in industrial chains

and the spatial layout of industrial clusters, and to improve the comprehensive industrial competitiveness of countries and cities along the route [5]. The industrialization process is essentially about modernization, and the productive capacity and knowledge accumulation behind the industry are key to the long-term economic development performance of a country. The countries and cities along the “Belt and Road” are still in the process of industrialization in general, but at very different stages [6]. From the perspective of industrialization, the proposal of the “Belt and Road” initiative can be regarded as a greater “spillover” effect that is being produced by China, pursuing a peaceful ascendancy, in the process of industrialization. In other words, by means of industrial capacity cooperation with the regions along the “Belt and Road”, China promotes the industrial upgrading, economic development and further industrialization of the countries and cities along the route, which is of great significance to the advancement of global industrialization [7].

The Vision and Proposed Actions Outlined on Jointly Building Silk Road Economic Belt and 21st-Century Maritime Silk Road released by the Chinese government in 2015 proposed to build the “Belt and Road” “relying on core cities along the route”. UNESCO (United Nations Educational, Scientific and Cultural Organization) introduced the concept of cities along the Silk Road in 2015 from a historical perspective, mainly referring to the major trade and trading hubs on the ancient Silk Road [8]. Tu Qiyu, in 2016, proposed the concept of Silk Road Cities, which are mainly hub cities located in countries and regions along the “Belt and Road” that have a strategic position and influence on the economy, society, culture and foreign economic exchanges of the host countries and regions. In the new era, Silk Road cities, with the function of “cohesion” and “outreach”, have become a strategic starting point and an important spatial support for the construction of the “Belt and Road”. Industrial land is a key production factor and an important spatial carrier in the process of industrialization and urban development, and its input scale, usage, development intensity and spatial layout affect the industrialization process as well as the allocation and utilization efficiency of urban land resources. The impact of industrial land change on the environment and ecology is a global issue and has raised a wide range of concerns from a variety of stakeholders in the era of industrialization and urbanization. The implementation of the “Belt and Road Initiative” has brought a complex impact to the use of energy and resources, ecological construction and environmental protection along the route, and the expansion of capacity cooperation and industrial land has exerted a significant impact on environmental and ecological sustainability. Under the “Belt and Road Initiative”, China has witnessed further speed up in industrial space transfer and capacity cooperation. The study of industrial land use changes in Silk Road cities and their driving mechanisms, and further analysis of the interaction between changes in industrial land and the environment, will help reveal the profound impact of the “Belt and Road Initiative” on the spatial economy and landscape patterns along the route.

1.2. Literature Review

As the “Belt and Road Initiative” has attracted increasing attention and achieved great construction achievements, academic research on the “Belt and Road” is also heating up rapidly. In recent years, the research on resources and environments in cities along the “Belt and Road” has been increasing, and has become an emerging area of interest in geography, planning, resources and environmental science. By reviewing the papers involved, we find the following three features and shortcomings in the existing studies in this area.

First, from the perspective of the research scale, there are abundant research results achieved at the national and regional levels at the macroscale, but the research at the meso- and microscale, such as cities and industrial parks, is in the ascendant and its development still has a long way to go. Research papers at the macroscale account for the largest proportion, mainly focusing on the synergistic effect of sustainable development goals between China and those countries along the “Belt and Road” as well as the strategy for the countries along the route to join the “Belt and Road Initiative” [9], including Kuwait [10], Pakistan [11,12], Myanmar [13], Kenya [14], Singapore [15], Italy [16], Russia [17,18],

Europe [19–22] and the European Union [23–25]. However, meso- and microscale research at the level of cities and industrial parks has just emerged, with theoretical summaries and academic research lagging behind practical work. Current exploratory studies include research on the network and urban system of the cities along the “Belt and Road” [26,27], the analysis of the factors influencing urban development [28], and the comparative study on the development strategies of China–Belarus Great Stone Industrial Park [29] and Longjiang Industrial Park [30], as well as industrial parks inside and outside China [31].

Second, from the perspective of the research field, the “Belt and Road Initiative” ranges over a wide field, but there are still few studies on land use and cover changes, especially on land use and its changes for industrial, logistic, residential and other specific purposes in urban areas. There are many research papers regarding the impact of the “Belt and Road Initiative” on economic development [32–34], energy cooperation [35–37], overseas investment and Mergers and Acquisitions (M&A) [38–40], cooperation on production capacity [41,42], cross-border supply chain [43,44] and value chain [45,46] cooperation, international trade [47–51], educational cooperation [52,53], normative influence [54], and urbanization [55–58], and there are also many research papers regarding vegetation [59], lakes [60], PM_{2.5} [61], natural disasters [62,63], and ecosystem services valuation [64,65] changes and their driving factors along the “Belt and Road”. It can be said that the research on the “Belt and Road” has been deeply considered in almost all disciplines except basic science [66]. Research on land use and cover changes [67,68], landscape changes [69,70], and factors influencing environment and resources use [71,72] under the “Belt and Road Initiative” has attracted the attention of some scholars, but there is still a gap in the research on land use changes and their driving factors for a particular type of urban land use, except for arable land [73].

Third, from the perspective of ecological and environmental effects, there are a wealth of studies on green development and energy conservation and emission reduction in countries along the “Belt and Road”, but there are fewer analyzing the environmental effects of land use, especially industrial land changes. Studies on green development include research concerning the impact of “Belt and Road” green logistics [74] and green finance [75,76] development, and green energy investment [77] on environmental quality, as well as the evaluation of green development level [78,79]. Studies on energy conservation and emission reduction involve the impact of energy consumption and economic growth [80], international trade [81–83], renewable energy use [84], direct Chinese foreign investment [85,86], agricultural development [87,88], manufacturing exports [89], power investment [90,91], and transportation [92,93] on carbon emission and energy conservation in the countries along the “Belt and Road”, as well as the contributions made by countries along the “Belt and Road” to global carbon emission reduction [94], the spatial pattern of carbon emission [95], and the estimation of energy conservation and emission reduction potential [96]. However, there are few studies on spatial environmental protection along the “Belt and Road”. Only Aung [97], Coenen [98], and Fang [99] have now conducted exploratory studies on environmental quality assessment, environmental governance, and the environmental footprints of countries along the “Belt and Road”.

1.3. Aim and Question

Promoting the transfer of the industries in China from the east to the west and their concentration in Silk Road cities, so as to solve the problem of overcapacity and drive international cooperation on production capacity is the core element of the “Belt and Road Initiative” [100,101]. Under the new situation, the contradiction between industrial land development and arable land protection is becoming increasingly prominent with the rapid expansion of industrial land scale in Silk Road cities. This study aims to explore the following questions: What is the difference in industrial land scale in the Silk Road cities? What are the dynamic evolution characteristics of industrial land changes under the “Belt and Road Initiative”? What are their driving forces? What are the impacts on environment and ecology? It will be of great theoretical and practical significance to answer the above

questions for understanding the spatial distribution of industrial land and its scale change trend in Silk Road cities, promoting the efficient supply of industrial land and its effective distribution among different cities, and accelerating the industrialization and urbanization as well as modernization process in the regions along the “Belt and Road”. Therefore, this paper empirically investigates the characteristics of industrial land changes and their driving forces in Chinese Silk Road cities from 2014 to 2018 based on GeoDetector and GIS analysis method, taking 129 cities along the China section of the “Belt and Road” as examples. The study provides a basis for policy makers and decision makers in Silk Road cities to understand the complexity of industrial land dynamics and to establish industrial land allocation and spatial distribution patterns to match the high-quality development of the “Belt and Road”.

2. Research Design

2.1. Study Area: China

The “Belt and Road” consists of an overseas section and a section in China, and in this paper Silk Road cities along the Chinese section are the study region. Since the “Belt and Road” construction is open and inclusive and welcomes the active participation of all countries, international and regional organizations in the world, the number of countries and regions in the overseas section has been in continuous expansion, and thus the dynamic changes in the number of Silk Road cities make it difficult to acquire accurate data and analyze the spatial and temporal evolution across regions. In contrast, the spatial scope is stable and there are statistics of the same standards available in the China section. *The Vision and Proposed Actions Outlined on Jointly Building Silk Road Economic Belt and 21st-Century Maritime Silk Road* proposes to “give full play to the comparative advantages of all regions in China”, clearly defines 18 key provinces (autonomous regions and municipalities directly under the Central Government) to jointly promote the construction of the “Belt and Road” [102], and puts forward requirements for Beijing, Shanghai, Hefei, Hong Kong, Macao and Taiwan to participate in the construction of the “Belt and Road”. With the exception of Taiwan (China), whose administrative division differs from that of the Chinese mainland, there are 162 Silk Road cities at the prefecture level and above in the China section. Hainan and Tibet were not included in the study area of the key provinces due to the lack of urban data. Additionally, in view of data comparability, relative spatial continuity, and data integrity, all Silk Road cities in the provinces involved were excluded from the study, so were Turpan, Hami, Qiqihar, Heihe, Pu’er, Qingyuan, Heyuan, Chaozhou, Meizhou, and Huizhou in the key provinces, and finally the study area of this paper consisted of 129 cities in 14 key provinces (see Figure 1 and Table A1).

A number of empirical studies on the development of Silk Road cities in the China section have emerged in recent years, including the evaluation of the performance of Chinese ports along the “Belt and Road” [103] and the study of the differences in their urban financial development [104], and the study of multicity sustainable regional urban growth simulation along the route [105]. As only a very small portion of Silk Road cities (generally no more than 50) are used as research samples in the existing papers, and the study area covers less than 30% of Silk Road cities in China, the accuracy and practicality of the research findings need to be further tested. Compared with the existing studies, the study area in this paper covers 80% of Silk Road cities in China, further improving the precision and application value of the study.

Additionally, from the perspective of industrial land area and its changes, the study area holds an important position in all Silk Road cities and cities in China, which is highly representative (see Table 1). In 2018, the industrial land in the study area accounted for more than 65% of that in Silk Road cities, and 21.80% of the urban construction land in the study area. The growth of industrial land in the study area from 2014 to 2018 accounted for 83% of that in Silk Road cities, and 26.05% of the urban construction land in the study area. The comparative analysis in Table 1 shows that the study area is very representative of Silk Road cities and even cities in China. The industrial land is a major engine driving the

urban spatial expansion of Silk Road cities, and thus it has become an important indicator for studying land use changes in Silk Road cities.

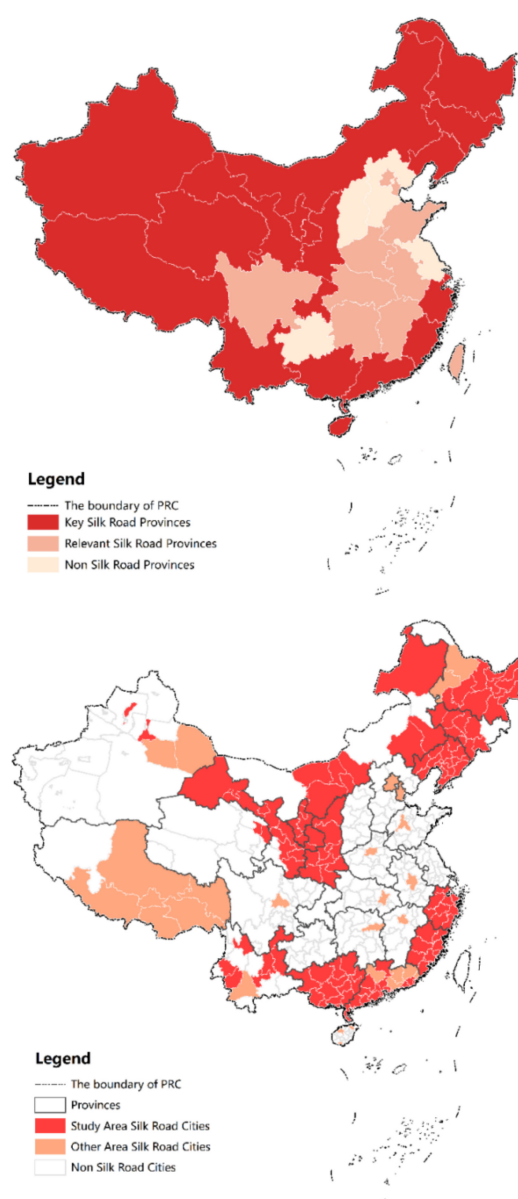


Figure 1. Study area.

Table 1. Descriptive analysis of the study area.

Index		2014	2018	Change
Value of industrial land area (Km ²)	Study Area	3413.33	4112.91	699.58
	Silk Road Cities	5464.39	6310.11	845.72
	China	8635.91	9654.64	1018.73
Proportion of industrial land area (%)	Study Area/China	39.52	42.60	68.67
	Study Area/Silk Road Cities	62.46	65.18	82.72
	Silk Road Cities/China	63.28	65.36	83.02
Proportion of industrial land in urban construction land (%)	Study Area	21.10	21.80	26.05
	Silk Road Cities	20.54	21.13	25.98
	China	20.63	20.45	19.00

2.2. Research Methods

GeoDetector, created by Professor Wang Jinfeng in 2010 and developed through continuous refinement, is an emerging statistical method to detect spatial heterogeneity and reveal its influencing factors [106]. With the characteristics of clear principle, defined meaning, broad application conditions and nonlinear mechanism, this method has been widely used in many natural sciences and humanities disciplines including geography, sociology, economics, ecology, environmental science, landscape science, planning science and even medicine [107]. There have been papers based on the GeoDetector method at present in the field of land use and cover research [108–111] to explain the spatial divergence and spatial–temporal evolution characteristics of land use and their driving factors. GeoDetector offers 4 functions—factor detector, interaction detector, ecological detector, and risk detector (<http://www.geodetector.cn>, accessed on 10 March 2021)—and in this paper the first three are used to study the influencing factor forces, and their interaction effects on industrial land changes in Silk Road cities.

Let the independent variable be X_i and the dependent variable be Y_i , the q value acquired from the differentiation and factor detection can be used to measure the heterogeneity of Y_i and to what extent X_i explains the heterogeneity of Y_i . The q value is in a range of $[0, 1]$, under the condition of passing the significance test, a larger value indicates that Y_i has a more obvious heterogeneity and X_i has a stronger power to explain it. Generally speaking, 0.01 is taken as the standard for the significance test under strict conditions, 0.05 under general conditions, and 0.1 under easing conditions. Interaction detection helps identify the interaction between different driving factors X_i ; that is, whether the driving factors X_1 and X_2 will increase or decrease the explanatory power of the dependent variable Y_i when they are involved in the interaction, or whether the influence of these factors on Y_i is independent of each other. According to the relationship between q_{12} , q_1 , and q_2 under the interaction of the two driving factors, the evaluation results include nonlinear weakening ($q_{12} < \min(q_1, q_2)$), single-factor non-linear weakening ($\min(q_1, q_2) < q_{12} < \max(q_1, q_2)$), dual-factor linear enhancement ($q_{12} > \max(q_1, q_2)$), independence ($q_{12} = q_1 + q_2$), and non-linear enhancement ($q_{12} > (q_1 + q_2)$) [112,113] (see Table 2).

Table 2. Interaction between Explanatory Variables (X_i and X_j).

Graphical Representation	Description	Interaction
	$q(X_i \cap X_j) < \min(q(X_i), q(X_j))$	Weaken, nonlinear
	$\min(q(X_i), q(X_j)) < q(X_i \cap X_j) < \max(q(X_i), q(X_j))$	Weaken, uni-
	$q(X_i \cap X_j) > \max(q(X_i), q(X_j))$	Enhance, bi-
	$q(X_i \cap X_j) = q(X_i) + q(X_j)$	Independent
	$q(X_i \cap X_j) > q(X_i) + q(X_j)$	Enhance, nonlinear

Legend: ● $\min(q(X_i), q(X_j))$; ● $\max(q(X_i), q(X_j))$; ● $q(X_i) + q(X_j)$; ▼ $q(X_i \cap X_j)$.

2.3. Index Selection

Inventory and increment are critical parameters for evaluating the current characteristics and changing trends of industrial land development in Silk Road cities. In this paper, three indicators of industrial land area in 2014, industrial land area in 2018, and the change amount of industrial land area from 2014 to 2018 are used as dependent variables, and 20 indicators are used as independent variables from 8 driving factors of population, facilities, cost, investment, innovation, openness, coordination, and greenness, by referring to the research ideas of Wu [114], Zhao [115] and Liu [116], to explore the mechanism driving industrial land changes in Silk Road cities (see Table 3). The independent variables of Y_1 and Y_2 are the data of the 20 indicators in 2014 and 2018, and Y_3 is closely related to the changing scope and the base period duration of the 20 indicators, denoted by change-1 and

change-2, respectively. The former represents the amount of change in the independent variable from 2014–2018 and the latter represents the independent variable in 2014.

Table 3. Model variable description.

Variable	Index	Code	Type
Dependent variable Y_i	Industry land area in 2014	Y_1	Inventory
	Industry land area in 2018	Y_2	Inventory
	Industry land area change from 2014 to 2018	Y_3	Increment
Independent variable X_i	Floating population	X_1	Population driving force
	Resident population	X_2	
	Road network density	X_3	
	Road area ratio	X_4	
	Water supply pipeline density	X_5	Industry driving force
	Drainage pipeline density	X_6	
	Land area for public facilities	X_7	
	Average wage of employees	X_8	Cost driving force
	Fixed asset investment in urban municipal public facilities	X_9	Investment driving force
	Loans from financial institutions	X_{10}	
	City public budget expenditure	X_{11}	
	City science and technology expenditure	X_{12}	Innovation driving force
	Foreign direct investment	X_{13}	Open driving force
	Import	X_{14}	
	Export	X_{15}	
	Land area for logistics and warehousing	X_{16}	Coordination driving force
	Added value of tertiary industry	X_{17}	
	Industrial wastewater discharge	X_{18}	
	Industrial sulfur dioxide emission	X_{19}	Green driving force
	Industrial NOx emission	X_{20}	
	Electricity consumption for industry	X_{21}	
	Natural gas consumption	X_{22}	
	Green coverage area	X_{23}	
	Carbon dioxide emission	X_{24}	

2.4. Research Steps

Referring to the research method of Zhao [117], the research framework in this paper consists of 3 phases, and the implementation process includes 4 main steps and 9 key points (see Figure 2). The first phase is “Ask Question”, presenting the study objectives and questions based on the research background and literature analysis. The second phase is “Analyze Question”, aiming to analyze and construct the indicator system, collect, process and analyze the data according to the selected research methods and research areas. The last phase is “Solve Question”, summarizing the main findings in this paper, and presents the final conclusions with the help of external verification discussions. The main research steps are as follows:

The first step is “Raw Data and Preprocessing”. ① Develop a complete raw data table based on the data released by the involved statistical websites; ② discrete the continuous data of the independent variables using Python, and divide the 129 Silk Road cities into

10 categories (3–12) by natural breaks to eliminate artificial influence. If none of the 10 schemes meet the requirements, for example, there is only one city in a given category, the 11th data discretization will be performed with the mean value as the criterion.

The second step is “Data Processing”. ③ Calculate the coefficient of variation of the dependent variable using Excel; ④ import the raw data of the dependent variable and the discretized data of the independent variable into GeoDetector to calculate the analysis results.

The third step is “Data Review”. Make a preferred choice among the alternatives in ②; ⑤ use the significance test as a criterion to determine the credibility of the results; and ⑥ select the one with the highest q-value as the final solution when the same or higher level of significance is met. In this paper, 0.05 is taken as the criterion for significance test, or 0.1 in special cases, for an exploratory study under loose constraints.

The fourth step is the result analysis and discussion. ⑦ Determine the explanatory power of the independent variables by ranking them according to the q value; ⑧ analyze the interaction effects of the driving factors; ⑨ calculate the mean value of q for the independent variables that have passed the significance test, calculate the strength of the 8 driving factors, and analyze ecological and environmental effects to further reveal the driving mechanisms and policy implications of industrial land changes in Silk Road cities.

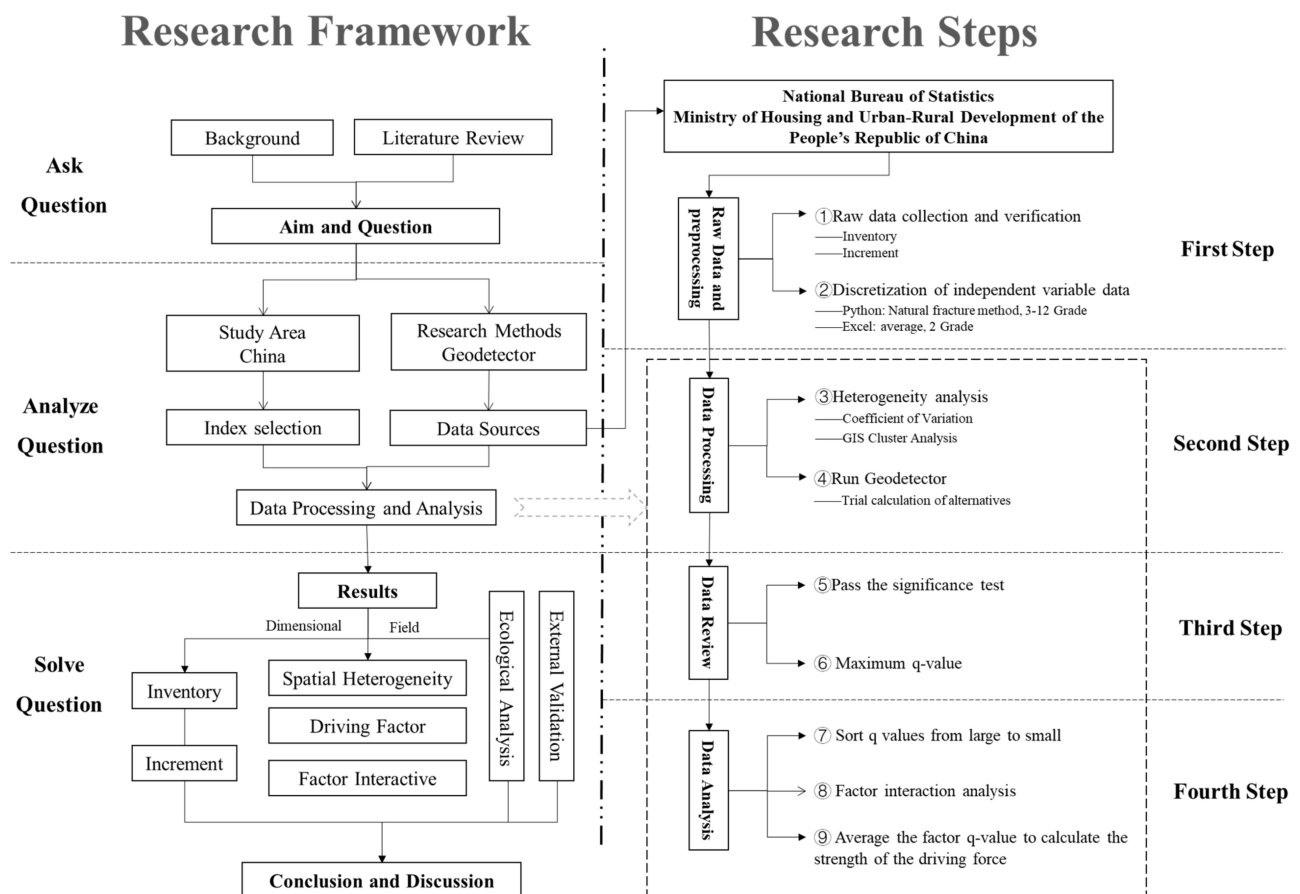


Figure 2. Research framework and steps.

2.5. Data Sources

The data mainly come from *China Urban Construction Statistical Yearbook* and *China City Statistical Yearbook*, and individual missing data come from statistical yearbooks, statistical bulletins, government work reports of provinces and cities. Although the “Belt and Road Initiative” was proposed in 2013, land use change is lagging behind, so the base period is set to 2014 in this study. It should be noted that the data years for carbon

dioxide emission are 2014 and 2017, because the data for 2018 is not yet available. The industrial land mentioned in this article is consistent with the *Urban Land Classification and Planning and Construction Land Standard* (GB50137–2011). Industrial land refers to land used for production workshops, warehouses and auxiliary facilities of industrial and mining enterprises, including land used for special railways, wharfs and auxiliary roads, parking lots, etc., excluding land used for open-pit mines. Generally, most industrial land is distributed in industrial parks, which are divided into three categories.

3. Results

3.1. Heterogeneity Analysis

Table 4 shows the results of spatial heterogeneity analysis of industrial land in Silk Road cities.

Table 4. Analysis of spatial heterogeneity of industrial land and its change.

Index	2014	2018	Change
Max	349.68	398.44	75.57
Min	0.16	0.16	−42.69
Max–Min	349.52	398.28	118.26
Max/Min	2185.5	2490.25	–
Average	26.47	30.63	4.16
Standard Deviation	47.54	51.44	13.54
Coefficient of Variation (CV)	1.80	1.68	3.25

3.1.1. Inventory

The differences in development stages, resource endowments and location conditions lead to significant heterogeneity in the area of industrial land and its changes in Chinese Silk Road cities. In 2018, the city with the largest industrial land area was Dongguan (398.44 km²), and the city with the smallest industrial land area was Longnan (0.16 km²), with a difference of about 2500 times. Additionally, the variation coefficient of urban industrial land area along the Silk Road is 1.68, much greater than 0.36, showing high heterogeneity [118]. The largest and smallest cities in terms of industrial land area were the same in 2014, but the coefficient of variation was greater (1.80) and the spatial heterogeneity was more significant. Based on the spatial clustering analysis of score digits in GIS, it was found that the distribution pattern of industrial land in the Silk Road cities varied significantly in some regions. In the southwest it mainly changed from High to Low, such as cities in Guangxi and Guangdong; in the northeast it mainly changed from Low to High, such as coastal cities in Liaoning and border cities in Jilin; in the southeast the changes are complicated, with different forms such as “High→Low”, “Medium→Low” and “Low→Medium” appearing at the same time in Zhejiang and Fujian (see Figure 3).

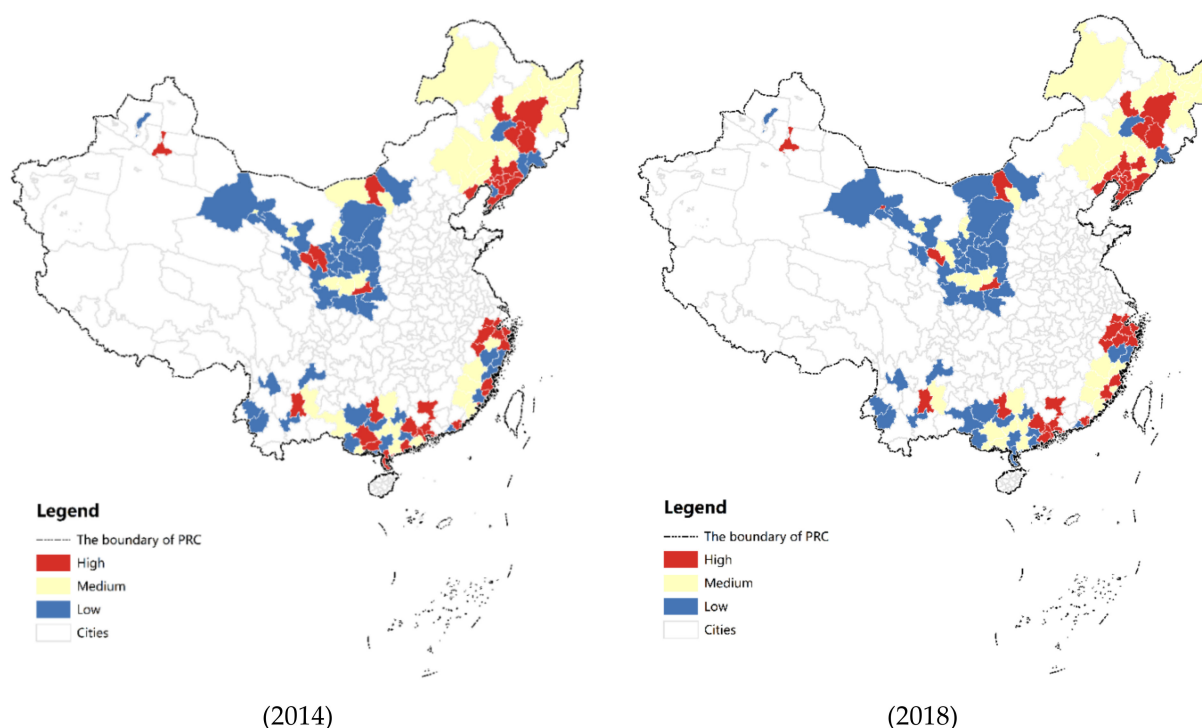


Figure 3. Cluster analysis of industrial land in Silk Road cities (2014 and 2018).

3.1.2. Increment

Very high spatial heterogeneity was found in the change of industrial land use in Chinese Silk Road cities during 2014–2018. Specifically, Zhuhai had the largest industrial land area expansion (75.57 km²) and Shenzhen had the largest industrial land area contraction (−42.69 km²), with a variation coefficient of up to 3.25, indicating high heterogeneity. In the past five years, 69.77% of the cities have achieved positive growth in industrial land, and the cities with positive growth are concentrated in contiguous areas; 11.63% have stayed the same, scattered in distribution and mostly in the northwest and northeast; 18.60% have experienced negative growth, mainly the core cities in the Yangtze River Delta and the Pearl River Delta, facing pressure from the policy of reduced development; while the rest are border cities in the northeast and marginalized cities in the northwest with insufficient development momentum (see Figure 4).

These changes show that the transformation of the economic growth pattern in eastern China, the economic revitalization of the northeast China and the development of the west regions are in full force, both domestic industrial transfer and production capacity cooperation among international communities are making steady progress, and the northeast and western regions that have been long marginalized are embracing great opportunities for development under the guidance of the “Belt and Road Initiatives”. Specifically, in 2016, the central government promulgated and implemented the *Several Opinions on the Comprehensive Revitalization of the Northeast Region and Other Old Industrial Bases and the Thirteenth Five-Year Plan for Northeast Revitalization*, requiring the northeast region to be actively integrated into and participate in the “Belt and Road Initiatives” to promote industrial upgrading, international production capacity and equipment manufacturing cooperation, and build an important window for opening up to the north and a central hub for cooperation in northeast Asia. Globally, the northeast region has accelerated the promotion of China–Mongolia–Russia economic corridor construction, run China–Mongolia–Russia international container transport freight trains on a regular basis, and built border industrial parks and China–Russia international cooperation demonstration zones in recent years; domestically, by virtue of preferential policies, the northeast region has increased investment in steel, petrochemicals, machinery, machine tools, automobiles and other

high-tech manufacturing industries For the western region, besides the great efforts made by the state and provinces or cities to expand the industrial capacity distribution and offer more favorable policies in their “13th Five-Year Plan”, the central government has also specially issued the *Guidance on Promoting the Development of the Western Region to Form a New Pattern in the New Era*, requiring key support for the construction of international corridors and industrial bases in Xinjiang, Chongqing, Sichuan, Shaanxi, Gansu, Guizhou, Qinghai, Inner Mongolia and other regions to accelerate the pace of industrial transfer from the east to the west and enhance the level of globalization and industrialization in the western region, guided by common construction of “Belt and Road”. As a package of policies are implemented, a large number of projects are planned, and a series of actions are taken, there will inevitably be a huge demand for the transformation of industrial land stock and the development of additional industrial land, resulting in a “positive growth” of industrial land in the northeast and western regions.



Figure 4. Cluster analysis of industrial land change in Silk Road cities (2014–2018).

3.2. Factor Analysis

Tables 5 and 6 show the results of the factor detection and the results of the driving factor analysis.

Table 5. Analysis of factor detector.

Index	2014 (Y ₁)		2018 (Y ₂)		Change-1 (Y ₃)		Change-2 (Y ₃)	
	q Statistic	p Value	q Statistic	p Value	q Statistic	p Value	q Statistic	p Value
X ₁	0.72	0.000	0.69	0.000	0.47	0.000	0.10	0.096
X ₂	0.47	0.000	0.46	0.000	0.08	0.150	0.09	0.059
X ₃	0.12	0.061	0.34	0.024	0.08	0.030	0.16	0.051
X ₄	0.12	0.232	0.33	0.005	0.04	0.024	0.13	0.154
X ₅	0.03	0.155	0.11	0.258	0.04	0.225	0.13	0.075
X ₆	0.07	0.050	0.07	0.165	0.03	0.192	0.04	0.106
X ₇	0.57	0.000	0.58	0.000	0.09	0.002	0.26	0.026
X ₈	0.10	0.006	0.16	0.013	0.03	0.571	0.07	0.201
X ₉	0.35	0.008	0.30	0.000	0.04	0.171	0.17	0.201
X ₁₀	0.51	0.000	0.59	0.000	0.13	0.002	0.19	0.046
X ₁₁	0.62	0.000	0.57	0.000	0.23	0.000	0.27	0.000
X ₁₂	0.60	0.000	0.50	0.000	0.16	0.013	0.35	0.003
X ₁₃	0.66	0.000	0.48	0.000	0.00	0.999	0.17	0.010
X ₁₄	0.07	0.240	0.75	0.000	0.04	0.044	0.08	0.098
X ₁₅	0.03	0.405	0.68	0.000	0.12	0.013	0.08	0.179
X ₁₆	0.68	0.000	0.62	0.000	0.04	0.047	0.11	0.010
X ₁₇	0.57	0.000	0.44	0.000	0.03	0.067	0.17	0.006
X ₁₈	0.36	0.000	0.48	0.000	0.01	0.253	0.05	0.092
X ₁₉	0.06	0.053	0.10	0.026	0.02	0.133	0.13	0.040
X ₂₀	0.08	0.010	0.14	0.007	0.11	0.059	0.19	0.027
X ₂₁	0.67	0.000	0.40	0.000	0.04	0.115	0.21	0.000
X ₂₂	0.45	0.000	0.46	0.000	0.00	0.633	0.07	0.102
X ₂₃	0.62	0.000	0.62	0.000	0.05	0.066	0.35	0.000
X ₂₄	0.36	0.000	0.31	0.002	0.06	0.449	0.17	0.088

Table 6. Analysis of driving force.

Driving Force	0.05 Significance Level				0.1 Significance Level			
	2014	2018	Change-1	Change-2	2014	2018	Change-1	Change-2
Population	0.59	0.57	0.47	–	0.59	0.57	0.47	0.09
Industry	0.32	0.42	0.07	0.21	0.25	0.42	0.07	0.18
Cost	0.10	0.16	–	–	0.10	0.16	–	–
Investment	0.50	0.48	0.18	0.23	0.50	0.48	0.18	0.23
Innovation	0.60	0.50	0.16	0.35	0.60	0.50	0.16	0.35
Open	0.66	0.64	0.08	0.17	0.66	0.64	0.08	0.12
Coordination	0.62	0.53	0.04	0.14	0.62	0.53	0.03	0.14
Green	0.37	0.36	–	0.22	0.37	0.36	0.08	0.17
Average	0.47	0.46	0.17	0.22	0.46	0.46	0.15	0.18

3.2.1. Inventory

In 2014, X₄, X₅, X₁₄, X₁₅ failed to pass the significance test, and X₃ could only pass a loose significance test at the 10% level, while the rest of the factors passed the significance tests at 5% or more stringent levels. At the 5% level of significance, the driving factors

were ranked as $X_1 > X_{16} > X_{21} > X_{13} > X_{23} > X_{11} > X_{12} > X_7 > X_{17} > X_{10} > X_2 > X_{22} > X_{24} > X_{18} > X_9 > X_8 > X_{20} > X_6 > X_{19}$ in intensity, and the driving forces were ranked as Open > Coordination > Innovation > Population > Investment > Green > Industry > Cost in intensity. The mean of the factor forces was 0.45, with 12 exceeding the value. The mean of the driving forces was 0.47, with 5 exceeding the value.

In 2018, X_5 , X_6 failed to pass the significance test, while the rest of the factors passed the significance tests at 5% or more stringent levels. At the 5% level of significance, the driving factors were ranked as $X_{14} > X_1 > X_{15} > X_{16} > X_{23} > X_{10} > X_7 > X_{11} > X_{12} > X_{18} > X_{13} > X_{22} > X_2 > X_{17} > X_{21} > X_3 > X_4 > X_{24} > X_9 > X_8 > X_{20} > X_{19}$ in intensity, and the driving forces were ranked as Open > Population > Coordination > Innovation > Investment > Industry > Green > Cost in intensity. The mean of the factor forces was 0.46, with 13 exceeding the value. The mean of the driving forces was 0.46, with 5 exceeding the value.

3.2.2. Increment

From the perspective of Change-1, X_2 , X_5 , X_6 , X_8 , X_9 , X_{13} , X_{18} , X_{19} , X_{21} , X_{22} , X_{24} failed to pass the significance test, and X_{17} , X_{20} , X_{23} only passed a loose significance test at the 10% level, while the rest factors passed the significance tests at 5% or more stringent levels. At the 5% level of significance, the driving factors were ranked as $X_1 > X_{11} > X_{12} > X_{10} > X_{15} > X_7 > X_3 > X_4 > X_{14} > X_{16}$ in intensity, and the driving forces were ranked as Population > Investment > Innovation > Open > Industry > Coordination > Cost > Green in intensity. The mean value of the factor force was 0.14, with 3 factors exceeding the mean. The mean of the factor forces was 0.14, with 3 exceeding the value. The mean of the driving forces was 0.17, with 2 exceeding the value.

From the perspective of Change-2, X_4 , X_6 , X_8 , X_9 , X_{15} failed to pass the significance test, and X_1 , X_2 , X_3 , X_5 , X_{14} , X_{18} , X_{22} , X_{24} only passed a loose significance test at the 10% level, while the rest factors passed the significance tests at 5% or more stringent levels. At the 5% level of significance, the driving factors were ranked as $X_{12} > X_{11} > X_7 > X_{10} > X_{20} > X_{13} > X_{17} > X_3 > X_{19} > X_{16}$ in intensity, and the driving forces were ranked as Innovation > Investment > Green > Industry > Open > Coordination > Population > Cost in intensity. The mean of the factor forces was 0.21, with 5 exceeding the value. The mean of the driving forces was 0.22, with 3 exceeding the value.

3.3. Interaction Analysis

3.3.1. Inventory

The driving factors were all enhanced with each other, including “Enhance, bi” and “Enhance, nonlinear”, and there was no independent or diminishing relationship (Figures 5 and 6). There were 40 and 54 “Enhance, nonlinear” factor pairs in 2014 and 2018, accounting for 23.39% and 23.38%, respectively. In 2014, the interaction influence of $X_1 \cap X_2$, $X_1 \cap X_7$, $X_2 \cap X_7$, $X_2 \cap X_{12}$, $X_2 \cap X_{13}$, $X_2 \cap X_{16}$, $X_2 \cap X_{17}$, $X_2 \cap X_{23}$, $X_6 \cap X_{16}$, $X_6 \cap X_{21}$, $X_6 \cap X_{23}$, $X_7 \cap X_9$, $X_7 \cap X_{12}$, $X_7 \cap X_{18}$, $X_7 \cap X_{19}$, $X_7 \cap X_{21}$, $X_7 \cap X_{23}$, $X_7 \cap X_{24}$, $X_9 \cap X_{13}$, $X_9 \cap X_{16}$, $X_9 \cap X_{23}$, $X_{10} \cap X_{16}$, $X_{12} \cap X_{13}$, $X_{12} \cap X_{16}$, $X_{12} \cap X_{23}$, $X_{13} \cap X_{16}$, $X_{13} \cap X_{18}$, $X_{13} \cap X_{21}$, $X_{13} \cap X_{23}$, $X_{13} \cap X_{24}$, $X_{16} \cap X_{17}$, $X_{16} \cap X_{18}$, $X_{16} \cap X_{21}$, $X_{16} \cap X_{23}$, $X_{16} \cap X_{24}$, $X_{18} \cap X_{23}$, $X_{19} \cap X_{23}$, $X_{21} \cap X_{23}$, $X_{22} \cap X_{23}$, $X_{23} \cap X_{24}$ was greater 0.9, and in particular, and especially that of $X_2 \cap X_7$, $X_2 \cap X_{23}$, $X_7 \cap X_9$, $X_{21} \cap X_{23}$ was up to 0.97. In 2018, the interaction influence of $X_1 \cap X_2$, $X_1 \cap X_4$, $X_1 \cap X_7$, $X_1 \cap X_{16}$, $X_1 \cap X_{23}$, $X_1 \cap X_{24}$, $X_2 \cap X_3$, $X_2 \cap X_4$, $X_2 \cap X_7$, $X_2 \cap X_{14}$, $X_2 \cap X_{16}$, $X_2 \cap X_{21}$, $X_2 \cap X_{22}$, $X_2 \cap X_{23}$, $X_2 \cap X_{24}$, $X_3 \cap X_{13}$, $X_3 \cap X_{18}$, $X_3 \cap X_{23}$, $X_4 \cap X_{13}$, $X_4 \cap X_{18}$, $X_4 \cap X_{21}$, $X_4 \cap X_{22}$, $X_4 \cap X_{23}$, $X_4 \cap X_{24}$, $X_7 \cap X_{13}$, $X_7 \cap X_{18}$, $X_7 \cap X_{21}$, $X_7 \cap X_{23}$, $X_7 \cap X_{24}$, $X_8 \cap X_{23}$, $X_{10} \cap X_{13}$, $X_{10} \cap X_{21}$, $X_{10} \cap X_{22}$, $X_{11} \cap X_{21}$, $X_{11} \cap X_{22}$, $X_{12} \cap X_{16}$, $X_{12} \cap X_{23}$, $X_{13} \cap X_{16}$, $X_{13} \cap X_{22}$, $X_{13} \cap X_{23}$, $X_{13} \cap X_{24}$, $X_{14} \cap X_{16}$, $X_{14} \cap X_{22}$, $X_{14} \cap X_{23}$, $X_{15} \cap X_{16}$, $X_{15} \cap X_{23}$, $X_{16} \cap X_{18}$, $X_{16} \cap X_{21}$, $X_{16} \cap X_{22}$, $X_{16} \cap X_{23}$, $X_{16} \cap X_{24}$, $X_{17} \cap X_{23}$, $X_{18} \cap X_{23}$, $X_{18} \cap X_{24}$, $X_{21} \cap X_{23}$, $X_{21} \cap X_{24}$, $X_{22} \cap X_{23}$, $X_{22} \cap X_{24}$ was greater 0.9, and especially that of $X_4 \cap X_{18}$ was up to 0.97.

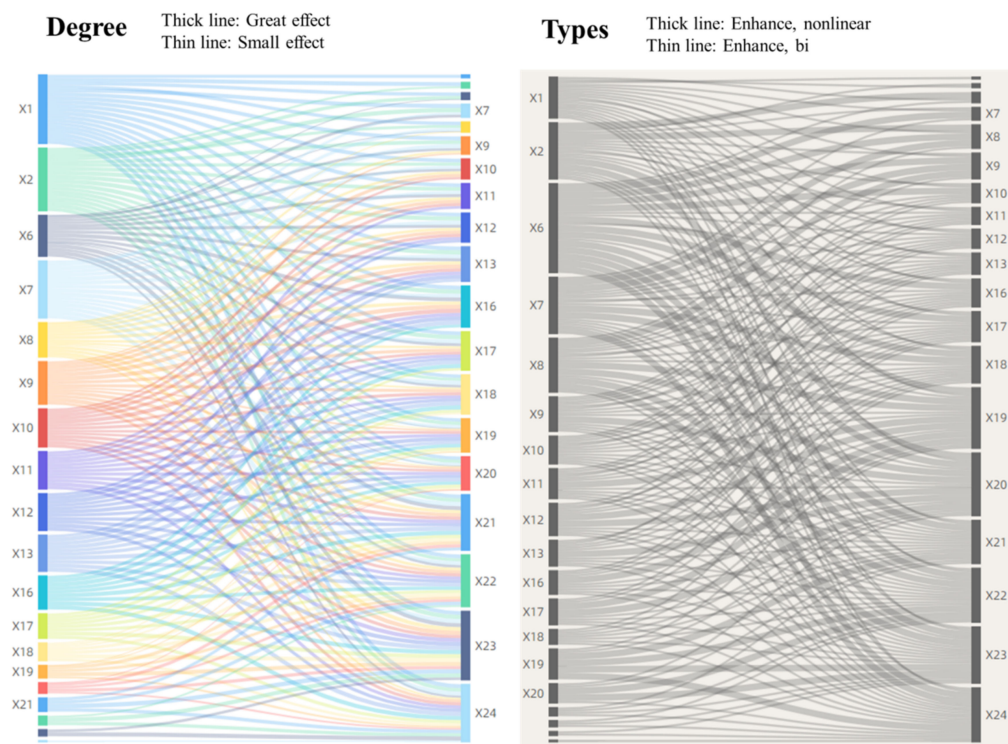


Figure 5. Analysis of interaction detector in 2014.

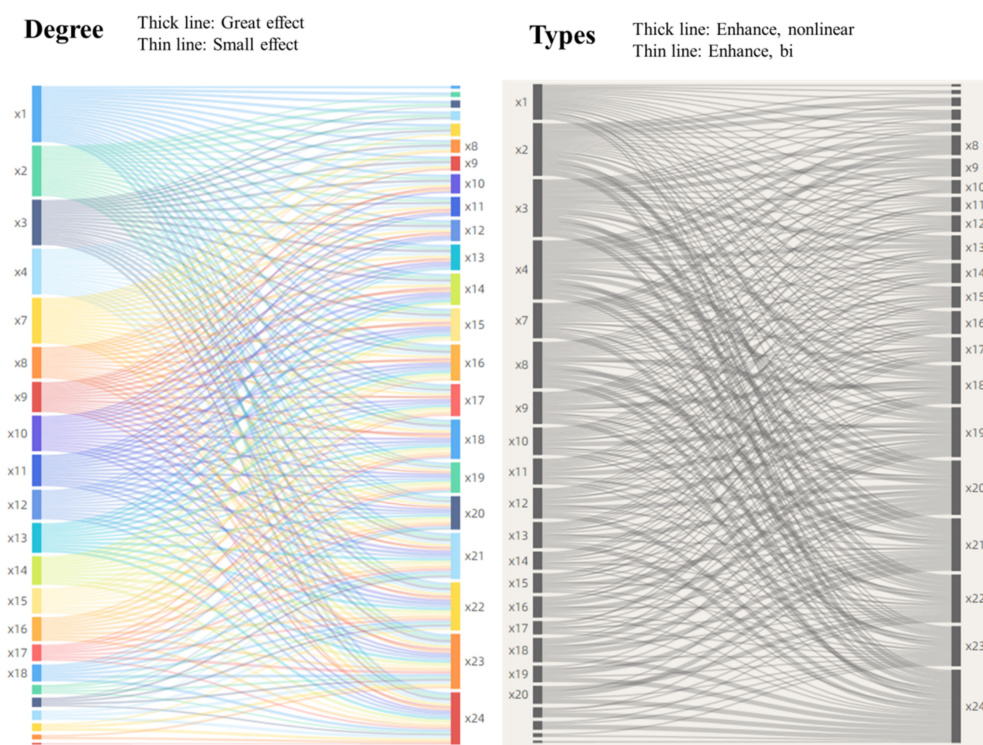


Figure 6. Analysis of interaction detector in 2018.

3.3.2. Increment

The driving factors were also both enhanced with each other, including “Enhance, bi” and “Enhance, nonlinear” (Figures 7 and 8). There were 26 and 53 “Enhance, nonlinear” factor pairs from both change-1 and change-2 perspectives, accounting for 57.78% and 80.30%, respectively. From the perspective of change-1, the interaction influence

of $X_1 \cap X_3$, $X_1 \cap X_4$, $X_1 \cap X_{10}$, $X_1 \cap X_{11}$, $X_1 \cap X_{15}$ was greater than 0.6, and especially that of $X_1 \cap X_{11}$ was up to 0.65. From the perspective of change-2, the interaction impact of $X_3 \cap X_7$, $X_3 \cap X_{11}$, $X_3 \cap X_{12}$, $X_3 \cap X_{13}$, $X_3 \cap X_{20}$, $X_3 \cap X_{21}$, $X_3 \cap X_{23}$, $X_7 \cap X_{10}$, $X_7 \cap X_{11}$, $X_7 \cap X_{12}$, $X_7 \cap X_{20}$, $X_7 \cap X_{21}$, $X_7 \cap X_{23}$, $X_{10} \cap X_{12}$, $X_{10} \cap X_{20}$, $X_{11} \cap X_{20}$, $X_{12} \cap X_{19}$, $X_{12} \cap X_{20}$, $X_{12} \cap X_{21}$, $X_{12} \cap X_{23}$, $X_{13} \cap X_{20}$, $X_{16} \cap X_{20}$, $X_{19} \cap X_{21}$, $X_{19} \cap X_{23}$, $X_{20} \cap X_{21}$, $X_{20} \cap X_{23}$, $X_{21} \cap X_{23}$ was greater than 0.6, and especially that of $X_3 \cap X_{21}$, $X_{21} \cap X_{23}$ was greater 0.8.

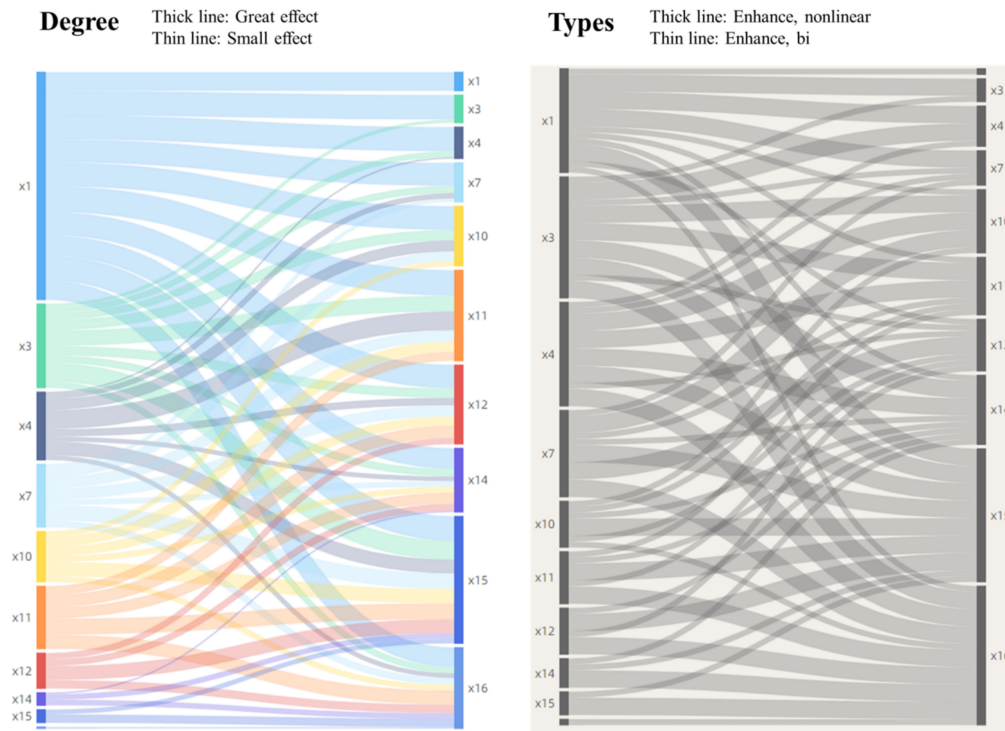


Figure 7. Analysis of interaction detector for change-1.

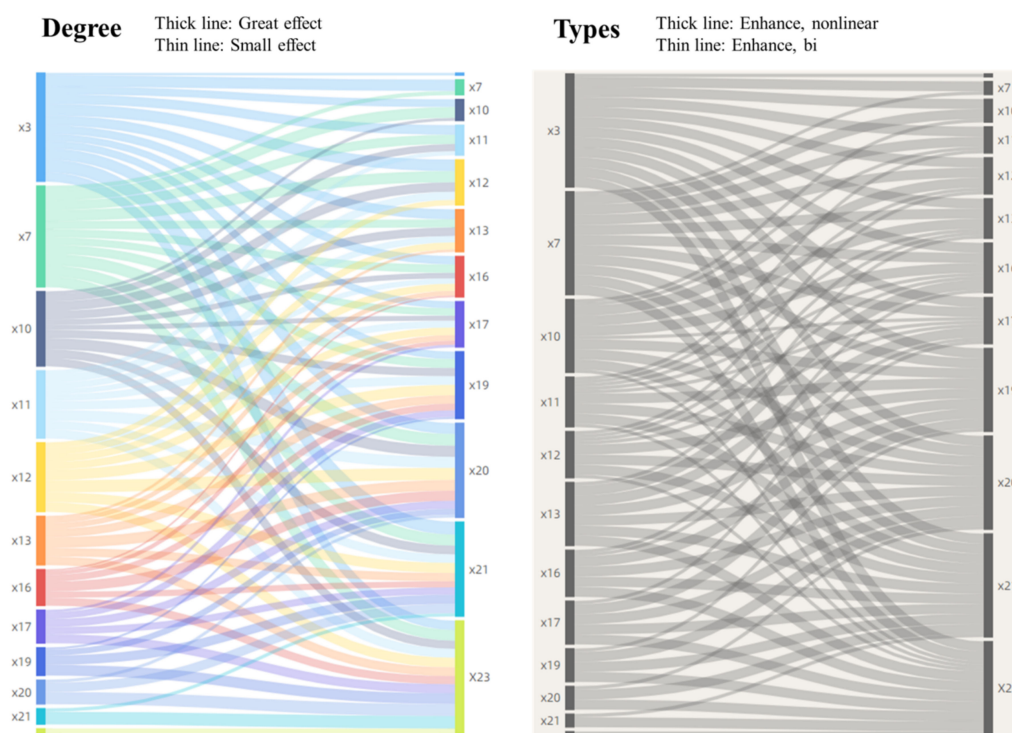


Figure 8. Analysis of interaction detector for change-2.

4. Discussion

4.1. Significant Differences in the Composition of Stock and Incremental Drivers and Their Influence Intensity

There are many factors influencing the industrial land stock in Silk Road cities, and the intensity of the force varies significantly, and the development of industrial land in Silk Road cities under the influence of the “Belt and Road Initiative” is characterized by diversified driving forces and complex driving mechanisms. Based on the ranking results and mean values, the factors are classified into three categories in this paper (see Figure 9). The first category contains key factors, i.e., the top three factors, which have the greatest impact on the industrial land stock in Silk Road cities. The second category contains important factors, i.e., the factors above the mean, which have a non-negligible impact on the industrial land stock in Silk Road cities. The third category contains general factors, i.e., the factors below the mean, which have an impact on the industrial land stock in Silk Road cities but are largely negligible. Additionally, according to the comparative analysis of driving factors in 2014 and 2018, floating population, resident population, land area for public facilities, loans from financial institutions, city public budget expenditure, city science and technology expenditure, foreign direct investment, land area for logistics and warehousing, added value of tertiary industry, green coverage area, natural gas consumption and industrial wastewater discharge are long-term and influential factors (Table 4), which lends support to the findings of Lee [119], Tian [120] and Lall et al. [121] that factors such as transportation investment, trade and FDI are determinants of the spatiotemporal evolution of Silk Road cities. In general, Open, Population, Coordination, Innovation and Investment are major driving forces determining the size of urban industrial land stock in Silk Road cities, while Industry, Green, and Cost are less influential.

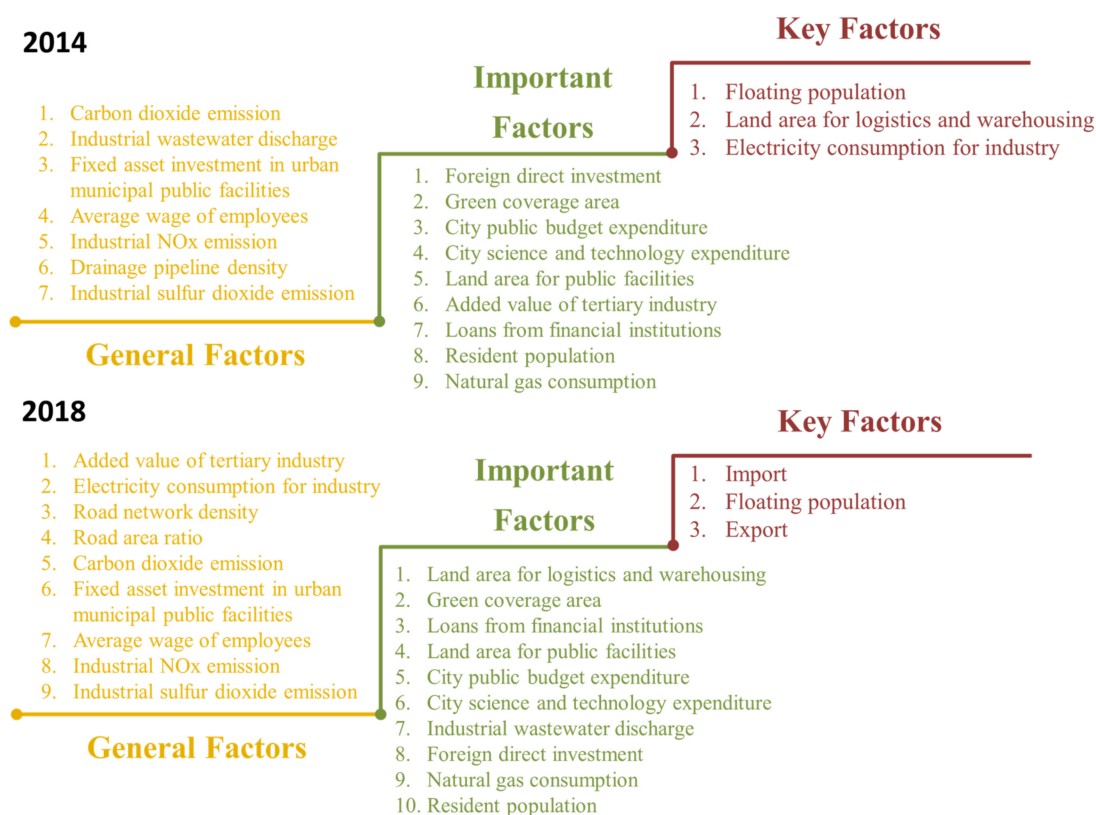


Figure 9. Classification of driving factors for Inventory.

It should be noted that the impact of the population driving force is becoming increasingly complex, with the absolute force going down, but the relative force going up. The absolute force decreased slightly from 2014 to 2018, changing from 0.60 to 0.58. However,

the force in the same period was surging rather than falling, from the fourth to the second place. One possible explanation is that with China's industrial upgrading, the demand for population in the eastern region is decreasing as the level of industrial automation and intelligence is increasing; in contrast, the demand for population is increasing as the industries in the east, especially labor-intensive businesses, are moved to the west and northeast. This phenomenon agrees with the changing dynamics of industrial land use found in Section 3.1.1. In addition, the trend of migrant worker mobility in China also provides material evidence. According to the *Monitoring Survey Report on Migrant Workers*, the number of migrants employed workers in the eastern region fell by 1.2% in 2018, while it rose by 4.2% in the western region.

The number of industrial land development driving factors in Silk Road cities was larger in 2018 than in 2014, increased from 19 to 22, indicating a growing diversity in driving forces. In particular, Import and Export were transformed from non-driving factors to key driving factors, while Road network density and Road area ratio were transformed from non-driving factors to important driving factors. In conclusion, with the increase in the number of driving factors and the concentration of forces, there are interaction effects of double factor enhancement and non-linear enhancement among the factors, reflecting that the driving forces of industrial land development in Silk Road cities under the "Belt and Road Initiative" are increasingly diversified and the driving mechanisms are increasingly complex.

There are few factors influencing the increment of industrial land in Silk Road cities with weak forces, but there is a significant difference in their intensity. Based on the ranking results, the factors are classified into three categories in this paper (see Figure 10). The first category contains key factors, i.e., the top three factors, which have the greatest impact on the industrial land changes in Silk Road cities. The second category contains important factors, i.e., the top 4–6 factors, which have a non-negligible impact on the industrial land changes in Silk Road cities. The third category contains general factors, i.e., other factors, which have an impact on the industrial land changes in Silk Road cities but are largely negligible. Additionally, according to the comparative analysis of driving factors from the perspective of change-1 and change-2, at the significance level of 0.05, Land area for public facilities, Loans from financial institutions, City public budget expenditure, City science and technology expenditure, Land area for logistics and warehousing have great influence; at the significance level of 0.1, the influences of Electricity consumption for industry, Carbon dioxide emission, Green coverage area, Road network density, Import, Added value of tertiary industry and Industrial NO_x emission cannot be ignored (see Table 4). These conclusions are in agreement with some of the findings of Park [122], Huang [123], Tong [124], Yang [125], Chen [126] et al. that FDI and international economic and trade cooperation, as the representation of unblocked trade, and infrastructure investment, as a basis for facility connectivity, have great influence on the spatial changes of Silk Road cities. In general, the change in the corresponding indicators of the driving factors Investment and Innovation and the base period stock have powerful influence on the change of industrial land in Silk Road cities, the driving force Population can only exert great influence relying on the change in corresponding indicators, and the driving force Industry can only exert great influence by virtue of the base period total of corresponding indicators, while other driving forces have less influence.

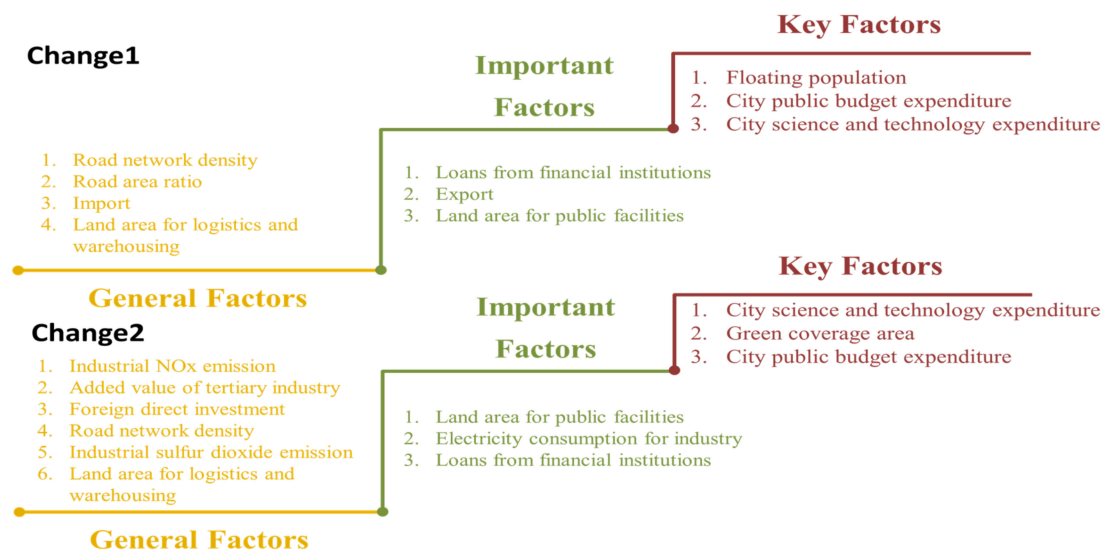


Figure 10. Classification of driving factors for Increment.

4.2. Use of Key and Integrated Factors and Their Interactions as a Basis Helps to Achieve Precise Policy Design

This study will be able to identify the influencing factors that drive both the stock and the increment of industrial land in Silk Road cities as integrated factors, and characterize the driving force intensity by summing the q-values. At the significance level of 0.05, the integrated factors are ranked as City public budget expenditure > City science and technology expenditure > Land area for public facilities > Land area for logistics and warehousing > Loans from financial institutions. Floating population, Added value of tertiary industry, Industrial NOx emissions, Green coverage area and other factors cannot be ignored under the loose condition of 0.1 [127,128] (see Figure 11). Similarly, at the significance level of 0.05, the integrated driving forces are ranked as Innovation > Open > Investment > Coordination > Industry. Population and Green also become important integrated driving forces under the loose condition of 0.1 (see Figure 12).

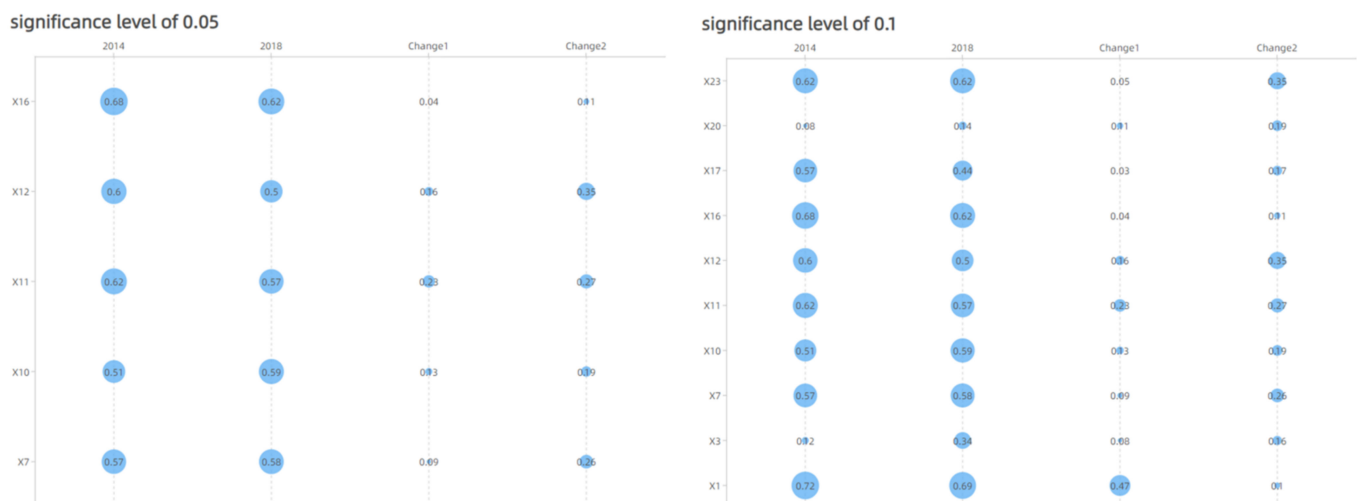


Figure 11. Comparative analysis of driving factors for Inventory and Increment.

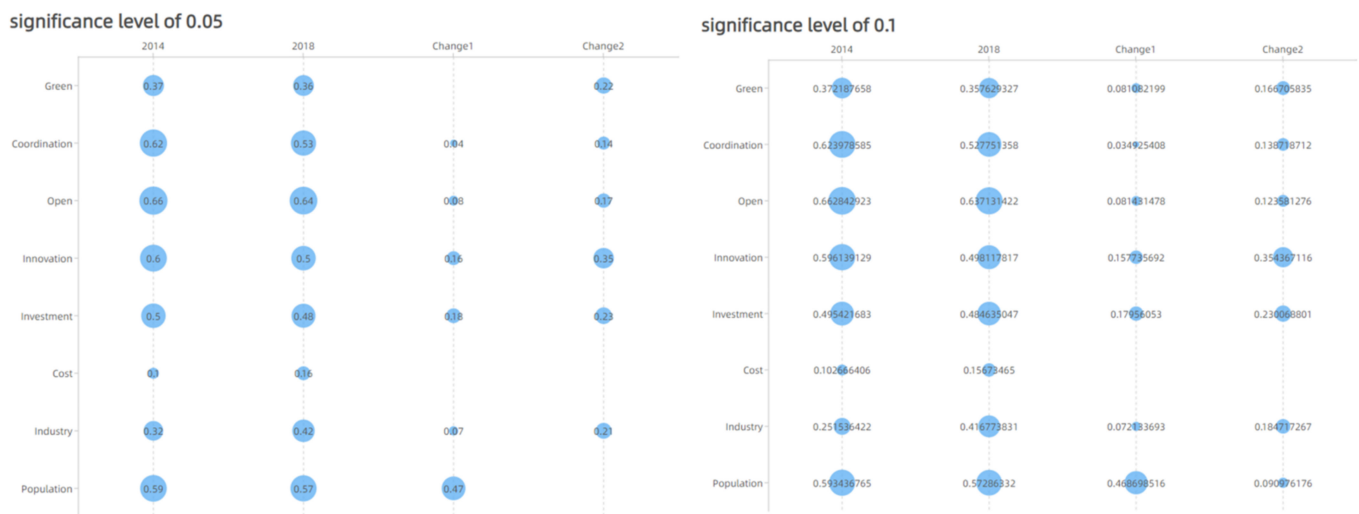


Figure 12. Classification of driving factors for Increment.

To sum up, Floating population, City public budget expenditure, City science and technology expenditure, Foreign direct investment, and Import and Export are key or integrated factors influencing industrial land and its changes in Silk Road cities [129,130], and Innovation, Open, and Investment are key or integrated driving forces [131,132], which should be given priority attention when developing industrial development plans and spatial governance policies in Silk Road cities (see Figure 13).

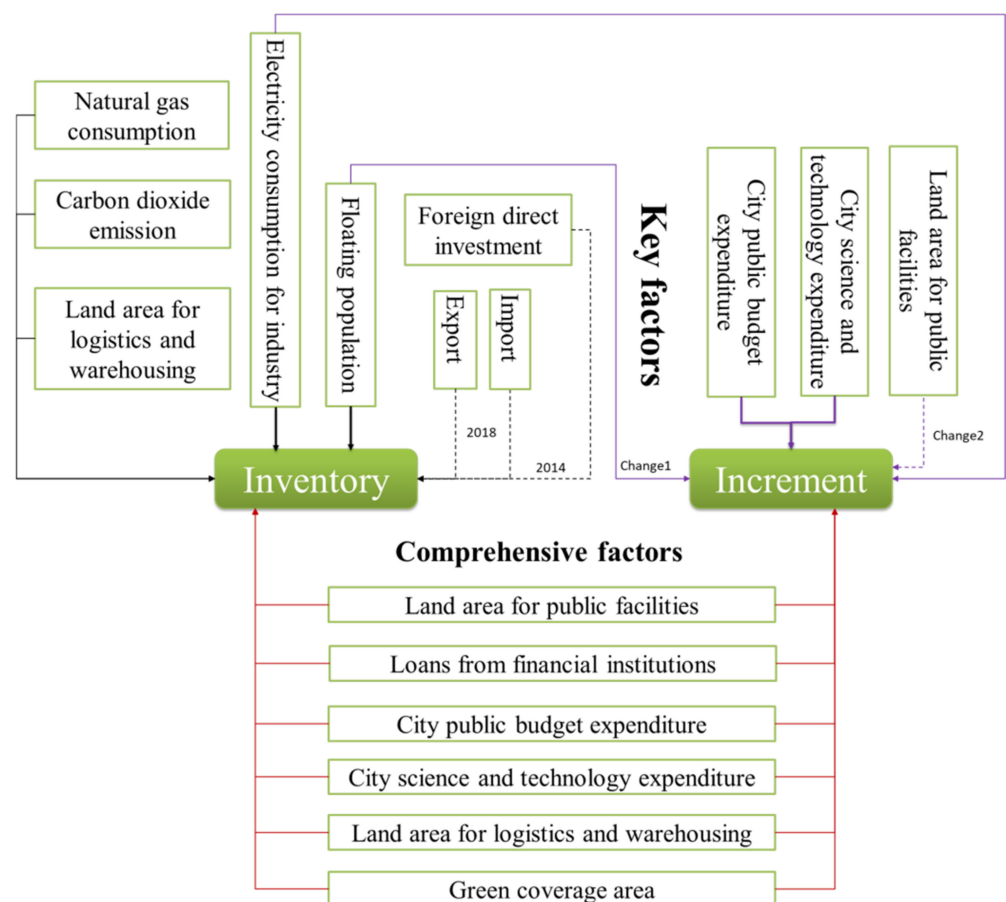


Figure 13. The influence mechanism of industrial land change in Silk Road cities.

It is important to note that the factors were enhanced with each other, and the synergistic driving force between two factors was generally doubled or multiplied even more than 10 times under the effect of non-linear enhancement and two-factor enhancement. For example, the force intensity of X_6 in 2014 was 0.07, and that of $X_6 \cap X_{16}$ was 0.91, an enhancement of 13 times. Therefore, it is important to accurately analyze the factor interactions and effects in policy design, and take advantage of them to further improve policy performance. It is with the help of these factors and their interaction that the “Belt and One Road” initiative promotes the reform of space production mechanisms and the development of the right structures in Chinese Silk Road cities [133–135].

4.3. Environmental Effects Caused by Changes in Industrial Land Are Highly Complicated

Industrial land is the land that sees the closest interaction between humans and nature, and the changes in the scale, type, form, structure, development intensity and other attributes of industrial land have a significant impact on the environment and climate change, and even the ecosystem functions and patterns [136]. The change of industrial land plays a decisive role in the quality of the ecological environment and its changes in Silk Road cities. The changes of environmental and ecological effects are mainly achieved through the coupling of pollutant and carbon dioxide emissions, energy utilization, landscape improvement and policy interventions. That is, in these ways, changes in industrial land have a dramatic impact on changes in urban land, air, water, cover, and other natural, ecological, and environmental changes, while environmental changes in turn act on changes in industrial land, thus exerting a constraining effect on new changes in industrial land (scale expansion, type conversion, morphological transformation, structural transformation, intensity enhancement and other evolutions).

First of all, a large amount of arable land, grassland, forest and other land has been developed and transformed into industrial parks, factories and their supporting facilities, bringing changes to the landscape pattern and the appearance of the land [137]. The expansion of industrial land comes along with the reduction in arable land, and the conversion between industrial land and arable land is considered to be unidirectional, that is, it is easy to convert arable land to industrial land, but it is very hard and even impossible to reverse the conversion. When land is used for industrial purposes, occupation and topsoil stripping lead to soil consolidation, structural damage, property alienation (e.g., salinization and sanding), functional degradation, and loss of capacity for agricultural production and plant growth [138]. In addition, special industrial development may also lead to land pollution, especially toxic and radioactive, corrosive, explosive and combustible high-risk industries, such as chemistry, chemical engineering, petroleum and mining. Toxic and harmful industrial products and their supporting items will be infiltrated into the soil during industrial development, and when the industrial land is converted to other uses (such as agricultural, residential, and service land) the “residual toxins” in the soil will slowly evaporate and be released for tens or even hundreds of years, resulting in serious ecological and environmental problems, leading to the final abandonment and discarding of the industrial land at the end of its service life. Therefore, for arable land converted into industrial land, real or potential contamination by harmful toxic or hazardous substances will prevent its reconversion and affect the redevelopment and reuse of the land itself.

In the redevelopment of industrial sites, China has announced the measures of classified renewal and zoning transformation. For previously developed land (PDL) with certain safety or environmental hazards, it is required to first assess the risks, then promote ecological and environmental restoration according to local conditions, and finally implement protective redevelopment. Such industrial land is in general converted into ecological land, parkland, land for transportation, land for firefighting facilities, and land for recreational and open space, but rarely converted into arable land in consideration of food security. For industrial land without safety or environmental hazards, enterprises should be encouraged to promote the transformation of industrial land into storage land,

land for scientific research, service land, residential land and land for mixed use, provided that they comply with the planning and safety standards. Urban industrial land is generally transformed into non-arable land, while rural industrial land and suburban industrial land are determined on a case-by-case basis, with a certain percentage of industrial land restored to arable land. Many policies and practical cases have emerged in this area, such as the implementation of the *Several Opinions on Supporting Industrial Transfer Industrial Park Land to Enhance the Quality and Efficiency of Land Use in Guangdong Province and the Guidance on Deepening Reform to Accelerate the “Three Old” Transformation for High-Quality Development*, besides the pilot project of integrated land use in the Shanghai Free Trade Zone allowing scattered landowners to change the original land use for joint redevelopment under the condition of joint participation, transforming the industrial plant of Jiangsu Changzhou Match-Well Electrical Products Co., Ltd. into Changzhou Tianning Cultural and Creative Industrial Park, and turning the old industrial area of Seg-Hitachi into a landmark urban complex integrating work, entertainment and life.

Secondly, the operation of factories leads to the rapid increase in urban energy consumption, including electricity, natural gas, oil and coal consumption for industry, changing the urban energy utilization system. Industry is the major energy consumer in Silk Road cities, and with the development of international capacity cooperation along the “Belt and Road”, there will be an increase in energy consumption [139]. Electrical power is the main source of energy for industry, and in terms of electricity consumption, for example, the share of industrial consumption of electrical energy in the Silk Road cities increased from 65% in 2014 to 69% in 2018, and the change in industrial consumption of electrical energy accounted for up to 73% of the change in urban electricity consumption. Therefore, industrial development has a significant positive driving effect on the energy consumption in Silk Road cities, and is gradually changing the urban energy utilization system and energy consumption structure.

Thirdly, industrial development has led to climate change and increasing environmental pollution, and has brought about a rapid increase in carbon dioxide emissions, industrial sulfur dioxide emissions, industrial NO_x emissions, industrial smoke (dust) emissions, industrial wastewater discharge, and industrial solid waste discharge, which has seriously affected the quality of the residential environment and the sustainable development of the natural ecological environment [140–142]. Climate and environmental quality are the most ecologically active factors and are major driving forces for the formation and evolution of ecology. Changes in industrial land use in Silk Road cities affect climate and environmental quality in the following ways: first, increased carbon dioxide emissions due to fossil energy use result in greenhouse effect; second, the conversion of arable land, forests and grasslands into industrial land leads to changes in the nature of the land substrate and land cover, resulting in changes in the thermal and water environments, and thus leading to the heat island effect, the destruction of water cycle and an impact on biodiversity; third, industrial development leads to increased emissions of air pollutants and decreased air quality. On the one hand, emissions of harmful substances such as sulfides, nitrogen compounds and particulate matter have increased; on the other hand, large amounts of arable land, grasslands, forests and wetlands have been converted into industrial land, leading to a weakening of their ability to purify the air and eventually an increase in air pollution.

In the end, for the healthy development of residents, land and ecology, the government has introduced policies and formulated spatial planning to intervene in the change of industrial land use. For example, energy conservation and emission reduction, environmental protection, ecological planning and landscape design have been incorporated into the mandatory policy system to counteract the change of industrial land. On the central government level, the Ministry of Environmental Protection, the Ministry of Foreign Affairs, the National Development and Reform Commission and the Ministry of Commerce have jointly issued the *Guidance on Promoting Green “Belt and Road” Construction*, requiring “the formulation and implementation of a series of ecological and environmental risk prevention policies and measures”; the General Office of the State Council has issued

the *Guidance on Scientific Greening*, requiring “a combination of artificial restoration and natural restoration, a reasonable layout of greening space, and the integrated protection and restoration of mountains, water, forests, fields, lakes, grasses and sands”, to lay a solid foundation for the construction of the green construction of “Belt and Road”. On the local level, the permanent basic farmland protection lines, ecological conservation redlines and urban development boundary lines should be defined in spatial planning to strictly control conversion of expropriated arable land into industrial land; the overall ecological planning and landscape design of the city should be strengthened during spatial planning, and the content and specific requirements of landscape greening design for industrial land and industrial parks should be clarified.

China has developed and implemented a series of special and comprehensive regulations on arable land protection. The Opinions on Establishing a Territorial Spatial Planning System and Supervising Its Implementation and the Urban and Rural Planning Law require that the spatial planning of provinces and cities must clearly delineate the red line for the protection of permanent primary farmland and increase farmland conservation. The Land Management Law gives further details and requires that for the transformation of arable land into construction land (including industrial land), it must be reported to the State Council for approval as long as the primary farmland is occupied; for arable land other than primary farmland, the occupation of an area over 35 hectares must also be reported to the State Council for approval. It also provides detailed regulations on the composition and amount of compensation expenses for the arable land expropriation. For example, the elements of the expenses include a land compensation fee, a resettlement subsidy and a compensation fee for ground attachment and seedlings, and the land compensation fee is six to ten times the average annual output value of the arable land for the three years before the land is expropriated. Raising the approval authority for arable land, especially primary farmland protection, to the central government and specifying the compensation fee for arable land occupation have increased the cost of converting arable land into construction land, so it is hard for arable land to be converted into industrial land without permission, and arable land is well protected

Besides, in line with the requirements of ecological civilization construction and “carbon neutral” development, the government has changed the regulations concerning arable land protection, energy conservation and emission reduction, and environmental protection as well as other related provisions into mandatory measures in the formulation of local policies. For example, in the 13th and 14th Five-Year Plans, a series of indicators such as arable land quantity, reduction in water consumption per unit of industrial value added, reduction in energy consumption and carbon dioxide emissions per unit of GDP, reduction in total emissions of major pollutants such as sulfur dioxide and nitrogen oxides, ratio of days with good air quality in cities, and forest coverage are set as binding. These binding indicators indicate what the government must do, showing the government’s commitment to the people. They are the targets that the government must achieve, complete or must comply with, and have become hard and key targets for the higher-level governments to assess those at a lower level. It should focus on spatial planning and public policies, with the help of monitoring, statistics, publication, assessment, reward and punishment for ecological- and environmental-effect-related indicators and their changes, to counteract the changes of industrial land, to restrain the development and evolution of industrial land, and to realize the mutual influence and effect between the industrial land change and the ecological environment change.

5. Conclusions

The allocation of land use and its changes are important policy tools for Chinese central and local governments to promote economic growth, industrial upgrading, and job creation, and industrial land has long played a key role in the process [143,144]. Cooperation on production capacity is a key element of the “Belt and Road Initiative”, and industrial land is its most important material support. The study of the driving mechanism of industrial

land change in Silk Road cities can explain how the “Belt and Road” reshapes the town system and economic geography along the route with the help of industries and their land use planning, and can even reveal, to a certain extent, how the “Belt and Road” policy is reshaping society, politics, landscape and spatial relations along the route, which is of great theoretical significance and practical value.

From a theoretical perspective, this study provides a framework and method for Silk Road scholars to analyze the spatial–temporal evolution characteristics of land use and coverage and their influence mechanisms in cities along the “Belt and Road”, and helps to seize and reveal the spatial rules of industrial land and its evolution. From a practical perspective, this study helps urban policy makers and decision makers to find a scientific and reasonable industrial land supply model and driving mechanism, provides theoretical support and a decision-making basis for industrial upgrading and layout optimization in the regions along the “Belt and Road”, and puts forward valuable suggestions for long-term industrial land supply planning, differentiated land allocation and spatial governance policy design for governments at all levels. The study methodology and the findings in this paper provide important references for countries along the “Belt and Road” to develop their own Silk Road cities, especially those in Southeast Asia, the Middle East and Africa in the rapid development stage of industrialization and urbanization, such as Vietnam, Thailand, the United Arab Emirates, Iran, Pakistan and Egypt.

In our study, some shortcomings and deficiencies are still observable. For instance, the supply of industrial land in China is greatly influenced by government policies and institutions [145,146], and factors such as the land transfer fee, land value increment tax, government management mechanisms and institutional reforms with great influence are not included in the analysis framework of this study due to the difficulty in data collection. Additionally, as a result of the lack of comparative analysis of non-Silk Road cities in the China segment against the control group of Silk Road cities in the overseas segment, we have only provided geographical conclusions about Chinese Silk Road cities, leading to insufficient awareness of Silk Road cities as a whole.

The “Belt and Road” initiative has already had a complex impact on industrial land changes in the rest of the world, and it is driving cities along the route to develop new industrial land or renovate old industrial land, as evidenced by the more than 100 international cooperative industrial parks that China has built with host countries. For example, the Suez Economic and Trade Cooperation Zone built by China and Egypt has completed the development of a 2 km² starting area and is now promoting the construction of a 6 km² expansion area. The development of this industrial land project has achieved huge economic and social benefits. As of the end of December 2020, the industrial project attracted 96 enterprises, with actual investment exceeding USD 1.25 billion, total sales exceeding USD 2.5 billion, tax payments of nearly USD 176 million, direct employment of about 4000 people, and industry-led employment of more than 36,000 people. We will continue to explore this promising new area. We have already traveled to Egypt, the UAE, Belarus and other countries to conduct field research, and we hope we can conduct a more standardized and comprehensive study on it in the future. In the end, we sincerely call for more researchers to join us, which will help provide more accurate knowledge for academic circles and for society.

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Appendix A

Table A1. The List of Silk Road Cities in China.

Type	Province	Silk Road Cities	
		Study Area	Other Study Area
Key Silk Road Provinces	Inner Mongolia	Hohhot, Baotou, Wuhai, Chifeng, Tongliao, Ordos, Hulunbeir, Bayannur, Ulanqab	
	Liaoning	Shenyang, Dalian, Anshan, Fushun, Benxi, Dandong, Jinzhou, Yingkou, Fuxin, Liaoyang, Panjin, Tieling, Chaoyang, Huludao	
	Jilin	Changchun, Jilin, Siping, Liaoyuan, Tonghua, Baishan, Songyuan, Baicheng	
	Heilongjiang	Harbin, Jixi, Hegang, Shuangyashan, Daqing, Yichun, Jiamusi, Qitaihe, Mudanjiang, Suihua	Qiqihar, Heihe
	Zhejiang	Hangzhou, Ningbo, Wenzhou, Jiaxing, Huzhou, Shaoxing, Jinhua, Quzhou, Zhoushan, Taizhou, Lishui	
	Fujian	Fuzhou, Xiamen, Putian, Sanming, Quanzhou, Zhangzhou, Nanping, Longyan, Ningde	
	Guangdong	Guangzhou, Shaoguan, Shenzhen, Zhuhai, Shantou, Foshan, Jiangmen, Zhanjiang, Maoming, Zhaoqing, Shanwei, Yangjiang, Dongguan, Zhongshan, Jieyang, Yunfu	Qingyuan, Heyuan, Chaozhou, Meizhou, Huizhou
	Guangxi	Nanning, Liuzhou, Guilin, Wuzhou, Beihai, Fangchenggang, Qinzhou, Guigang, Yulin, Baise, Hezhou, Hechi, Laibin, Chongzuo	
	Yunnan	Kunming, Qujing, Yuxi, Baoshan, Zhaotong, Lijiang, Lincang	Pu’er
	Shaanxi	Xi’an, Tongchuan, Baoji, Xianyang, Weinan, Yan’an, Hanzhong, Yulin, Ankang, Shangluo	
	Gansu	Lanzhou, Jiayuguan, Jinchang, Baiyin, Tianshui, Wuwei, Zhangye, Pingliang, Jiuquan, Qingyang, Dingxi, Longnan	
	Qinghai	Xining, Haidong	
	Ningxia	Yinchuan, Shizuishan, Wuzhong, Guyuan, Zhongwei	
	Xinjiang	Urumqi, Karamay	Turpan, Hami
	Tibet		Lhasa, Xigaze, Qamdo, Nyingchi, Shannan, Nagqu
	Shanghai		Shanghai
	Hainan		Haikou, Sanya, Sansha, Danzhou
	Chongqing		Chongqing

Table A1. Cont.

Type	Province	Silk Road Cities	
		Study Area	Other Study Area
Relevant Silk Road Provinces	Sichuan		Chengdu
	Henan		Zhengzhou
	Hubei		Wuhan
	Hunan		Changsha
	Jiangxi		Nanchang
	Anhui		Hefei
	Shandong		Jinan
	Beijing		Beijing
	Tianjin		Tianjin
	Hong Kong		Hong Kong
	Macao		Macao
	Taiwan		

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