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Article

Spatiotemporal Evolution and Influencing Factors of Urban Industry in Modern China (1840–1949): A Case Study of Nanjing

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Abstract: In modern China, industrialization has formed a critical foundation for the transition to modernization. However, the spatiotemporal evolution patterns and driving mechanisms of urban industrial development in Nanjing from 1840 to 1949 remain unclear. Based on textual historical sources, this study examined the spatiotemporal patterns of urban industrial development in Nanjing from 1840 to 1949 by using spatial analysis methods, GeoDetector, regression models and industrial structure indices. The results reveal the following: (1) The overall spatial distribution pattern of the industry in modern Nanjing exhibited a "one main, one secondary" dual-center "ladle-shaped" arrangement. Over time, industry has expanded from the urban center toward the east and north. (2) The modernization level of different industries was uneven, exhibiting a "center-periphery" spatial pattern. (3) At the micro level, transportation and population density were the primary influencing factors for industrial location, whereas at the macro level, government intervention mainly affected the industrialization pattern. (4) The industrial development pattern in modern Nanjing, in alignment with the "pole-axis" spatial system, serves as a microcosm of China's urban modernization transition. This study represents the application of GIS methods in the humanities and provides valuable insights for urban planning and development.

Keywords: modern China; industrial location; spatiotemporal evolution; textual data; GIS

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1. Introduction

Industry is the foundation of urban development, and the development of urban industry influences the spatial structure of cities [1]. In the early stages of industrial development, the establishment, relocation, and disappearance of modern factories have left traces on the urban spatial form, witnessing the development and evolution of industrial civilization within cities [2] and reflecting the journey of urban modernization [3].

Modernization, as defined by O'Connell [4], refers to the transformation of human society from traditional agricultural communities into modern industrial societies characterized by the use of machine technology, rational and secular attitudes and highly differentiated social structures. This transition is revolutionary and involves transforming rural agrarian cultures into urban industrial cultures, as described by Huntington [5]. Within the modernization process, industrialization emerges as a crucial sub-process [6]. This sub-process is marked by a fundamental shift in the economic landscape, transitioning from a predominant focus on agriculture to a greater emphasis on manufacturing. This shift catalyzes social and economic changes and serves as a foundation for modernization. Kendall [7] documented the idea that urbanization is closely intertwined with modernization and the rapid industrialization process. This process of industrialization attracts people to migrate to cities, leading to urbanization or urban sprawl. The development of modern industry has played a pivotal role in shaping urban patterns. It has attracted a considerable influx of people to cities, fostering urban expansion and facilitating the construction of modern infrastructure. Understanding the rise and progression of modern industry is essential for gaining insight into the historical, political, and societal transformations that have occurred during this period. Studying the evolution of modern industry is crucial for a deeper understanding of the formation of contemporary society.

The modern era, spanning from 1840 to 1949, marked a period of transformation in China from being a traditional society to a modern society. During this period, China gradually shifted from a feudal society to a semi-colonial and semi-feudal society. This period was profoundly impacted by foreign imperialist aggression and the imposition of unequal treaties. It was characterized by political turmoil, frequent revolutions, and a substantial degree of foreign influence [8]. The emergence of modern industry in Chinese cities occurred within a tumultuous social context. It initially developed passively but eventually became a proactive endeavor for survival and revival [9,10]. Throughout the modern era, industrialization had a profound impact on accelerating urbanization in China, thereby propelling the social transformation of Chinese cities. Accordingly, the study on urban industrialization in China holds historical significance and provides valuable insights into this transformative period. Nanjing has historically been a political center and the capital of six dynasties [11,12]. Renowned as one of the great cities in the pre-industrial world, it boasts 6000 years of civilization and 2500 years of urban history. Nanjing is also one of the first cities in China to adopt modern urban planning [13]. In 1919, The International Development of China was formulated, proposing the planning of two industrial areas on both the north and south banks of the Yangtze River. In 1929, the Capital Plan (shoudujihua) was formulated, specifically aimed at modernizing Nanjing. Additionally, modern industrial survey materials such as the Chinese Economic Records (Nanjing) [14] have been preserved, providing a robust foundation for this study's database. Consequently, Nanjing serves as an ideal case study for understanding the typical pattern of industrial and historical evolution in modern China. Selecting Nanjing as a key research case allows for a comprehensive examination of how Chinese cities fared during the modernization era.

Focusing on Nanjing, this study employs textual historical materials and geographic information system (GIS) quantitative analysis to (1) examine the spatiotemporal evolution of urban industry development during 1840–1949 in Nanjing; (2) identify the modernization level and distribution patterns from the perspectives of industrial sectors; and (3) explore the influencing factors from micro and macro perspectives and discover specific evolutionary patterns of industrialization in modern Nanjing.

The remainder of this paper is organized as follows: Section 2 provides a literature review on industrial location and studies of modern industry. Section 3 introduces the study area, data sources, and methods. Section 4 presents the results of the spatiotemporal analysis and the industrial sector analysis. Section 5 discusses the factors influencing industrial layout, patterns of industrialization, and the "Pole-axis" spatial system. The final section of the paper summarizes the conclusions, offers recommendations, and outlines directions for future research.

2. Literature Review

Research on urban industrial locations has been a key topic of research in economic geography. Weber first systematically discussed industrial location theory in 1909 [15]. The mid-20th century marked the zenith of the development of location theory, leading to the emergence of location decision practices. Subsequently, topics including behavioral geography of enterprises [16], structuralism [17], new regionalism [18], and qualitative research [19] gained prominence. In the 21st century, western industrial geography has seen a shift toward exploring topics such as industrial zones [20,21], industrial clusters [22,23], and globalization [24]. In China, research on industrial location initially followed the former Soviet Union's tradition. Following economic reforms and opening up, research has been substantially influenced by Western industrial geography [25]. This evolution has transformed the focus from practical applications to a balanced emphasis on theory and practice. Current research on industrial geography predominantly involves industrial location [26,27], industrial agglomeration [28–30], regional collaborative development [31], and globalization [32,33]. Industrial location and its transformations continue to influence regional development [34] and remain a prominent subject in Chinese industrial geography.

Significant advancements have been achieved in the field of modern industrial studies. Historical analyses of modern industry often concentrate on the era's contextual backdrop [35], delve into specific case studies [36], and address labor-related issues [37]. A notable example is the investigation into China's first modern industrial cartel, which offers profound insights into the intricate dynamics between corporate governance and elite roles during the early stages of China's industrialization [36]. David Pong's research highlights that between 1860 and 1912, private enterprises in China exhibited more advanced labor organization practices compared to their state-owned counterparts [37]. Previous studies have shown that various factors such as markets, technology, and government interventions have played distinct roles in the development of modern industry. Scholars have analyzed the factors influencing the establishment of the paper industry in Argentina between 1880 and 1940 [38]. Other research has examined the industrialization attempts in the Chinese wool industry from 1880 to 1937, uncovering a consistency between industry structure and consumer demand [39]. Galloway investigated the modernization of the sugar industry in Southeast Asia from 1880 to 1940, finding that modernization rendered the industry's development reliant on advances in scientific research [40]. Further studies have compared the different roles that government agencies and commercial organizations played in the development of the steel industries in Spain and Italy [41]. Moreover, there have already been a series of research achievements regarding the modern industry of Nanjing. For instance, Liu et al. conducted a detailed analysis of the characteristics of Nanjing's industrial development from 1927 to 1937 [42], highlighting key developmental trends during this period. Wu explored the intrinsic connections between the Self-Strengthening Movement, the Jinling Manufacturing Bureau, and the process of modern industrialization in Nanjing [43]. Furthermore, some scholars have systematically studied Nanjing's industrial heritage [44,45], enriching our understanding of the city's historical and cultural industrial contexts. These studies have significantly advanced our understanding of the modern industrial development of Nanjing.

With the advancement of technology, an increasing number of quantitative methods are being used in industrial pattern research, such as clustering [46,47], factor analysis [48,49], and econometric models [50,51], among others. Notably, geographic information system (GIS) techniques have found widespread application in modern Chinese industrial studies. For instance, the application of GIS methods has uncovered the spatial patterns of Shenyang's industrial heritage and its characteristics deeply influenced by foreign elements [52]. Henriot has conducted an in-depth study of the spatial patterns and transformations in modern Shanghai's industry using GIS methods [53]. Similarly, Liu et al. have used GIS methods to analyze the spatiotemporal evolution of modern urban industry in China from a macroscopic perspective [54]. Yao has also explored the evolution of the industrial pattern in modern and contemporary Fuzhou using GIS technology [55]. These studies demonstrate GIS's capacity to provide detailed insights into the evolution of modern industry from a spatial perspective, affirming its critical utility in urban and industrial research. However, there are still some deficiencies in the current research. Firstly, the data used in modern industrial research are mainly derived from historical records, archives, and local gazetteers. These sources are often sparse and unstructured [56,57], leading to gaps in the industrial geographic database. Secondly, due to the difficulty in obtaining data, modern industrial research often relies on qualitative analysis and lacks comprehensive studies that integrate both quantitative and qualitative approaches. This makes it challenging to fully grasp the complex relationship between industrial development and urbanization. Thirdly, existing research tends to focus on specific industrial sectors [58,59], lacking a comprehensive analysis of the entire industrial system. Additionally, research often concentrates on specific historical periods and lacks a complete time series analysis [39], limiting our ability to understand the longitudinal development of urban industry.

To address these limitations, our research establishes a historical geographic database through the analysis of historical literature and the spatial quantification of industrial data to explore the industrial development of modern Nanjing. This study examines the spatiotemporal distribution patterns and evolution of modern industry, discussing the degree of modernization exhibited by different types of industries, with the aim of systematically presenting the evolution and development of Nanjing's industrial geographic layout during its transition era. This research not only represents a practical application of GIS methods in the humanities and social sciences but also contributes to a comprehensive understanding of the historical value of modern urban industrial heritage, providing valuable insights and lessons for contemporary urban planning and development.

3. Materials and Methods

3.1. Study Area

In most studies of modern Nanjing, the study area is typically confined within the Ming City Wall of Nanjing. However, this approach results in the omission of the key factories associated with modern industry along the Yangtze River. To ensure a more comprehensive analysis, we examined historical map data, particularly the map of Jiangning Prefectural City (1898) (Figure A1) and the new survey map of the provincial city Jinling by the Army Academy (1909) (Figure A2). These maps allowed us to determine the urban spatial extent of modern Nanjing. Finally, the study area encompassed the central urban area of modern Nanjing, specifically including the area within the Ming City Wall of Nanjing and the Xiaguan area outside the city wall (Figure 1).

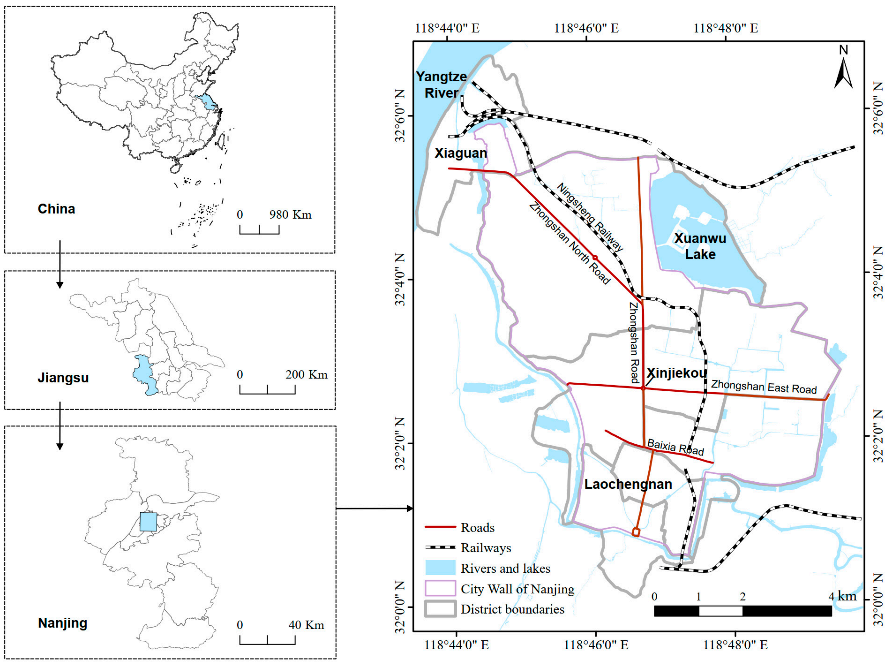

Figure 1. Location of the study area.

3.2. Data Sources

Our study used multisource data as detailed in Table 1, including the base map, industrial geographic data, product value, employee data, population, and DEM. The base map originates from a Nanjing aerial survey topographic map (Figure A3). This map was photographed between 1932 and 1937 and drawn between 1932 and 1942, with a scale of 1:10,000. It was vectorized, control points were selected, and georeferencing was performed to produce the base map. The geographical features in the base map include administrative divisions, roads, railways, water systems, city walls, etc. Industrial geographic data from the modern era (1840–1949) were extracted from various documents, archives, local chronicles, and other sources (Table A1). Using the base map, we determined the locations of factories and consulted a comprehensive gazetteer to ensure data consistency and accuracy. According to industrial types, we correlated the product value and the employee data with industrial data. Based on the administrative divisions in the base map, we incorporated population data into the dataset. A total of 1192 records of modern Nanjing's industrial data, each with its geographical location, were collected. The data yielded from these inquiries represents a comprehensive sample of Nanjing's modern industry.

Table 1. Date sources.

Data	Source
Base map	1:10,000 aerial survey topographic map (1932–1937)
Factory data	Documents, archives, and local chronicles
Product value	Chinese Economic Records (Nanjing)
Employee	Chinese Economic Records (Nanjing)
Population	1936 Nanjing City Population Statistics Report
DEM	ALOS 12.5 m DEM (2015)

3.3. Modern Industry Types and Development Phasing

3.3.1. Industry Types

The classification of industry types was primarily based on the characteristics and categorization of the industrial sector structure outlined in the 1930s Report of the China Industrial Survey [60]. This survey, organized by the China Institute of Economic Statistics, stands as the first and only nationwide industrial survey in modern Chinese history. Then, according to the Chinese Economic Records (Nanjing) [14], the main industry sectors (Table 2) were finally selected throughout the study period, considering the characteristics of industrial development in modern Nanjing.

Table 2. Industry types in modern Nanjing.

Industry Types	Subcategories
Timber	Woodworking
Furniture	/
Machinery and metal	Machine, scales, hardware
Soil and stone	Cement, briquette
Construction materials	Brick and tile, construction
Hydroelectricity	Power, waterwork, electric light
Chemistry	Electroplating, candle soap
Textile	Satin, Nanjing brocade, flannelette, silk
Apparel	cloth
Leather and rubber	Tannery
Food and beverage	Flour, rice, winery, ice making
Paper printing	Printing
Ornamental instrument	Arts and crafts
Others	/

3.3.2. Development Phasing

Firstly, regarding the theoretical foundation, we consulted the historical economic literature on the periodization of modern industrial development in China [61–64]. These periods illustrate the transition from handicraft to mechanized production, along with the impact of economic policies and social conditions across different historical periods on industrial development [65,66]. Secondly, from the perspective of empirical research, we examined case studies on the development of modern industry in China [54,55,67–69], identifying a series of common developmental patterns and turning points. The industrial development of Nanjing not only exhibits commonalities with the national historical periodization but also possesses its unique characteristics [70,71]. Based on the theoretical foundation and empirical research, it is ultimately divided into five periods (Table 3).

Table 3. Stages of Nanjing modern industrial development.

Period	Stage	Background
1840–1911	Emerging stage of modern industry	Self-Strengthening Movement, the late Qing Dynasty
1912–1926	Primary development stage of modern industry	Establishment of the Government of the Republic of China
1927–1937	Rapid development stage of modern industry	Nanjing decade
1938–1945	Stagnant development stage of modern industry	War of Resistance
1946–1949	Decline stage of modern industry	War of Liberation

The key historical nodes in Table 3 are described below. From 1840 to 1911, industrial development was significantly influenced by the Self-Strengthening Movement. The Revolution of 1911 erupted, and in early 1912, the Qing government was overthrown, establishing a democratic republic. In 1927, the Nanjing National Government was established. Moreover, 1927–1937 is recognized as the "Nanjing Decade", during which the economy developed positively. From 1938 to 1945, Nanjing was in the midst of war turmoil, suffering severe industrial damage. In 1946, the National Government returned to Nanjing, marking a brief period of peace before plunging into civil war again.

3.4. Methods

3.4.1. Point Pattern Analysis

The scale of modern industry varies greatly. Factories of different scales were graded and assigned corresponding weights to ensure the rationality and accuracy of the results. The size of the factory is reflected by capital quantity and the number of employees. Weights were considered in the subsequent point pattern analysis.

1. Kernel density estimation

Kernel density estimation is a nonparametric density statistical method based on the distribution characteristics of the object itself [72]. The kernel density value represents the degree of concentration of the study object distributed spatially [73]. Kernel density analysis helps calculate the distribution density of factories in modern Nanjing. The calculation formula is as follows:

$$\mathrm{f(x)} = \frac{1}{\mathrm{nh}}\sum_{\mathrm{i=1}}^{\mathrm{n}} \mathrm{k}\left(\frac{x - x_i}{\mathrm{h}}\right) \tag{1}$$

In the formula, h is the search radius, k() refers to the spatial weight function, $x - x_i$ denotes the distance from x to x_i, and n is the total number of samples.

2. Standard deviational ellipse

The standard deviation ellipse quantitatively analyzes the global centrality and directionality of geographical features. The direction of industrial distribution indicates the extent of distribution and directional characteristics of factories [74]. The azimuth reflects the main trend direction of the distribution. The standard deviation ellipse is calculated as follows:

$$\text{Center} : \overline{\mathrm{X}}_{\mathrm{w}} = \frac{\sum_{\mathrm{i=1}}^{\mathrm{n}} w_i x_i}{\sum_{\mathrm{i=1}}^{\mathrm{n}} w_i}; \overline{\mathrm{Y}}_{\mathrm{w}} = \frac{\sum_{\mathrm{i=1}}^{\mathrm{n}} w_i y_i}{\sum_{\mathrm{i=1}}^{\mathrm{n}} w_i} \tag{2}$$

$$\text{x standard deviation} : \sigma_x = \sqrt{\frac{\sum_{i=1}^{n}\left(w_i\widetilde{x}_i cos\theta - w_i\widetilde{y}_i sin\theta\right)^2}{\sum_{i=1}^{n} {w_i}^2}} \tag{3}$$

$$\text{y standard deviation}: \sigma_y = \sqrt{\frac{\sum_{i=1}^{n}\left(w_i \widetilde{x}_i sin\theta - w_i \widetilde{y}_i cos\theta\right)^2}{\sum_{i=1}^{n} w_i{}^2}} \quad (4)$$

$$\text{Oblateness}: S = (y - x)/y \quad (5)$$

In the formula, $(\overline{X}_w, \overline{Y}_w)$ denotes the spatial coordinates of the industry gravity center; w_i is the weight; θ represents the azimuth of the ellipse; $\widetilde{x}_i$ and $\widetilde{y}_i$ represent the coordinate deviations from the average center; and σ_x and σ_y represent the standard deviations along the x and y axes, respectively. The oblateness reflects the degree of concentration.

3. Global spatial autocorrelation

Global spatial autocorrelation analyzes whether the specified attributes are autocorrelated across the study area [75]. Global Moran's I is the most used measure. Global Moran's I value, z-scores, and p values assess the significance level and explore the spatial clustering pattern of factories within the study area. The formula for calculating Moran's I value is as follows:

$$\text{Moran's I} = \frac{n\sum_{i=1}^{n}\sum_{i=1}^{n} W_{ij}(X_i - \overline{X})(X_j - \overline{X})}{\sum_{i=1}^{n}\sum_{i=1}^{n}(W_{ij})\sum_{i=1}^{n}(X_i - \overline{X})^2} \quad (6)$$

where n represents the number of area units; X_i and X_j are the attribute values of regions i and j, respectively; and W_{ij} denotes the spatial weight matrix.

4. Hotspot analysis

Hotspot analysis helps calculate the Getis-Ord Gi* statistic [76] for each feature in the dataset. The obtained z-score and p value can help identify the spatially high-value clusters (hot spots) or low-value clusters (cold spots) of Nanjing modern factories [77].

3.4.2. Geodetector

The Geodetector method helps detect spatial heterogeneity [78,79]. This approach utilizes q statistics to measure spatial variability, detect explanatory factors, and analyze the interaction between variables [80–82]. Furthermore, this approach identifies the degree of influence of various factors on the spatial distribution of industries. The calculation formula is as follows:

$$q = 1 - \frac{\sum_{h=1}^{L} N_h \sigma_h^2}{N\sigma^2} = 1 - \frac{SSW}{SST} \quad (7)$$

$$SSW = \sum_{h=1}^{L} N_h \sigma_h^2,\ SST = N\sigma^2 \quad (8)$$

In the equation, h = 1, . . .; L represents the strata of the variable Y or factor X; N_h and N are the units in stratum h and the total area, respectively; σ_h^2 and σ^2 are the variances of Y values in stratum h and the entire area, respectively; and SSW and SST represent the within sum of squares and the total sum of squares, respectively. The range of q is [0, 1], with a larger q indicating a stronger explanatory power of the independent variable X on the attribute Y, and vice versa.

3.4.3. Regression Models

OLS regression estimates the dependent variable as a linear function of multiple predictor variables using the least squares method [83]. Geographically weighted regression (GWR) incorporates the spatial location information of the data as parameters into the coefficient estimation of the model [84], serving as one of the primary methods for detecting and modeling spatial heterogeneity. The calculation formula is as follows:

$$Y_i = \beta_0(u_i, v_i) + \sum_{i=1}^{k} \beta_k(u_i, v_i) X_{ik} + \varepsilon_i$$

In the formula, (u_i, v_i) represents the spatial coordinates of the i-th sample point. Y_i and X_{ik} are the observed values of the dependent variable Y and the set of independent variables X_k at the spatial position. k is the number of independent variables. $\beta_0(u_i, v_i)$ is the constant term at the spatial location (u_i, v_i). $\beta_k(u_i, v_i)$ is the value of the continuous function $\beta_k(u, v)$ at point i. ε_i is the random error term.

3.4.4. Industrial Structure Analysis Indices

1. Industrial labor productivity

Industrial labor productivity reflects the proportional relation between labor consumption and production results in the industrial production process. Moreover, it reflects the level of industrial production efficiency. The calculation formula is as follows:

$$\text{ILP} = \text{P}/\text{L} \tag{9}$$

In the formula, ILP denotes industrial labor productivity, P denotes total industrial output value, and L denotes the corresponding workers [85]. We used the total value of industry products and the total number of workers in the corresponding industry to calculate labor productivity.

2. Location quotient

Location quotient (LQ) measures the importance of a specific industry in a specific region [86]. The calculation formula is as follows:

$$\text{LQ} = \frac{e_i/e}{E_i/E} \tag{10}$$

In the formula, e_i denotes the number of employees in industry i in the region, e denotes the total number of employees in the region, E_i denotes the number of employees in industry i in the country, and E denotes the total number of employees in the country. An LQ value less than 1 implies that the development intensity of a certain industry in a certain region is lower than the national average level of similar industries. An LQ value greater than 1 implies that the development intensity of a certain industry in a certain region is higher than the national average level of similar industries [87]. Location quotient analyzes the level of specialization of industries and explores the industries in which Nanjing has comparative advantages.

Based on the above data and methods, we constructed a study flowchart (Figure 2).

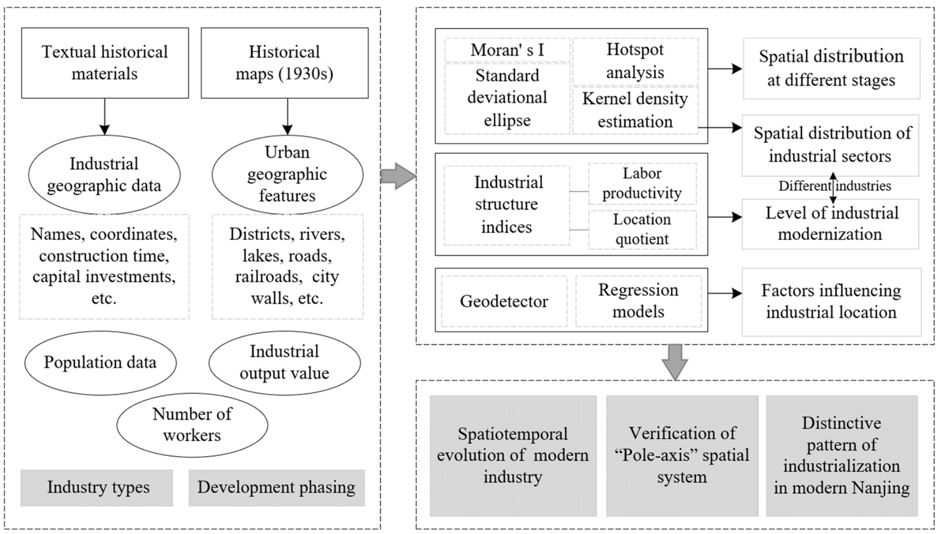

Figure 2. Flowchart of the study.

4. Results

4.1. The Spatiotemporal Evolution of Modern Industry

4.1.1. Overall Characteristics

From 1840 to 1949, the industrial areas in the city showed a "one main, one subsidiary" dual-centered "ladle-shaped" distribution pattern (Figure 3). Modern industries were primarily concentrated in Xinjiekou and the old south of the city (Laochengnan), with a secondary industrial center emerging in Xiaguan. Based on the inverse distance weight coefficient, the results of the global spatial autocorrelation revealed that at the 1% significance level, the Global Moran's l value was 0.08, and the Z value was 4.16. These results suggested that the distribution of modern industries exhibited a positive spatial correlation, indicating a pattern of spatial agglomeration.

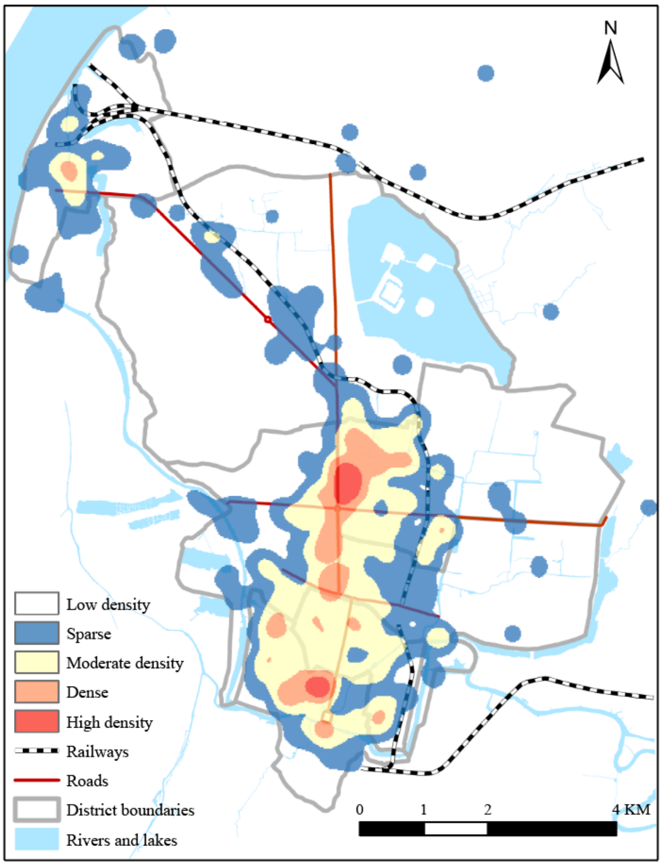

Figure 3. Kernel density of modern industry in Nanjing.

The hotspot analysis results indicated industrial hotspots in Xiaguan (Figure 4). These hotspots primarily hosted large-scale factories: construction plants and machine factories, such as the Fushengji construction plant (with a capital of more than CNY 50,000), the Pukou power plant, and the Wuwanshun wood mill. Industrial cold spots were mainly distributed in Xinjiekou and Laochengnan. The industrial types concentrated in this region were mainly traditional textile industries and small-scale ironworks, wood mills, and construction plants. Examples of these industries include Yantaikun (flannelette factory), Cuiyuantai ironworks, and Chenliji (construction plants, capital of CNY 200). These factories were characterized by their smaller scale and workforce, often stemming from small family workshops.

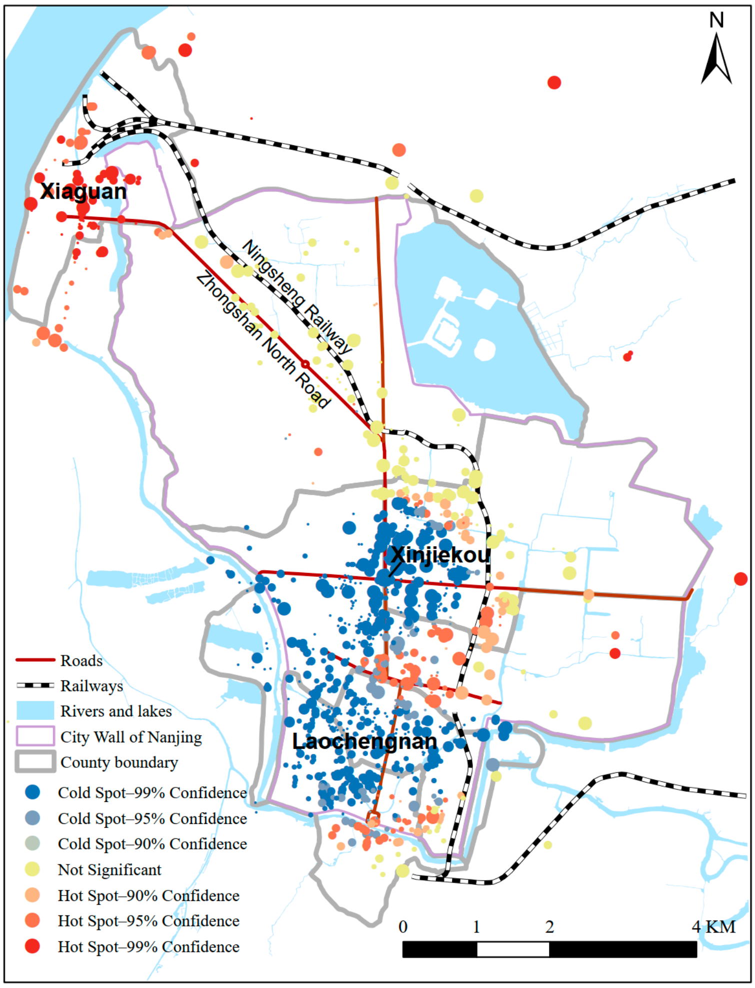

Figure 4. Detection of cold and hot spots of modern industries.

4.1.2. Industrial Centers

Nanjing's industrial center exhibited a gradual northward shift (Figure 5), from Qinhuai District to Gulou District, with a cumulative moving distance of approximately 2.66 km. Between 1840 and 1926, the industrial center was situated within Qinhuai District, initially spanning from north of Jianye Road and later relocating to east of Mochou Road. From 1927 to 1945, the industrial center transitioned from Qinhuai District to Xuanwu District, specifically traversing from Hanzhong Road to Zhongshan East Road. The average migration distance was only 0.44 km, indicating a tendency toward greater stability in the spatial distribution of urban industries. From 1946 to 1949, the industrial center settled in Gulou District, precisely near Shanghai Road.

The results of the standard deviation ellipse analysis revealed that the spatial distribution of modern industries exhibited directional characteristics (Figure 6). There existed a prominent axis in the industrial distribution, and its primary orientation closely aligned with that of Zhongshan North Road, forming a northwest-to-southeast distribution pattern. Over time, the rotation angle of the standard deviation ellipse gradually decreased, signifying substantial growth in industries located in Xiaguan and the northern regions of the city. Industries in Laochengnan experienced a decline. Over the years, the overall coverage of the ellipse expanded, indicating a widening of the urban industrial distribution. During 1938–1945, affected by the war, the coverage area of the ellipse significantly decreased.

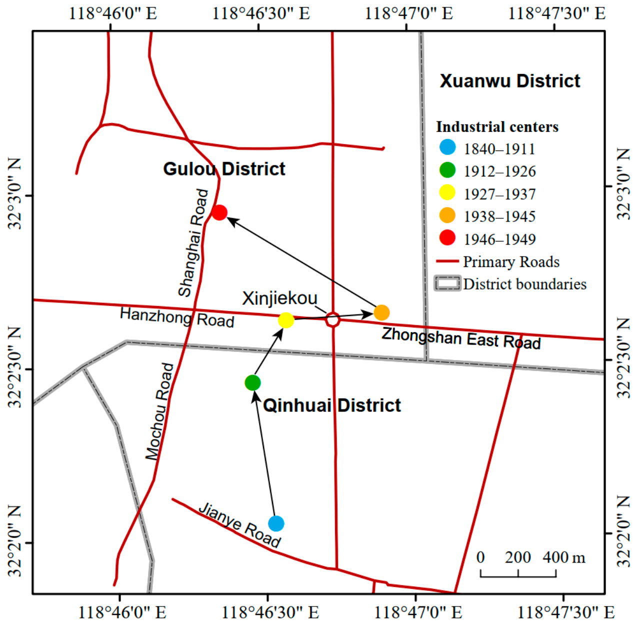

Figure 5. Mean center shift of Nanjing modern industries.

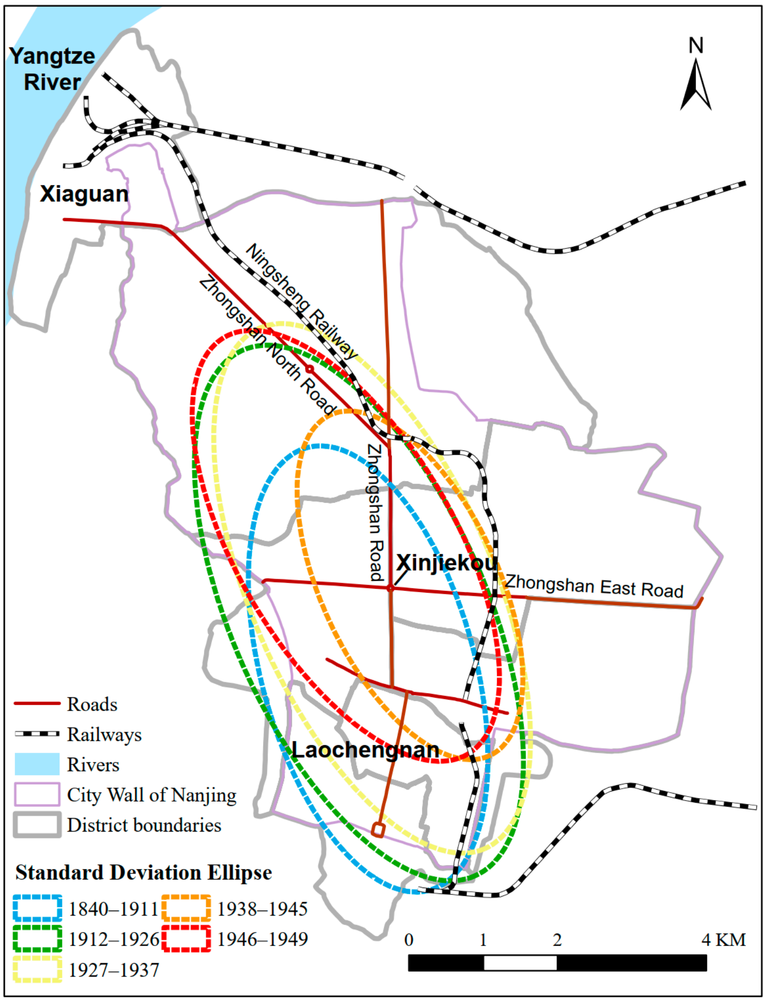

Figure 6. Standard deviation ellipse of Nanjing modern industries.

4.1.3. Spatial Evolution Patterns at Different Stages

In the emerging stage (1840–1911), industries were primarily concentrated in Laochengnan, specifically south of Hanzhong Road (Figure 7a). In the background of the Self-Strengthening Movement, a group of bureaucrats, landlords, compradors, businessmen, and overseas Chinese gradually became involved in the establishment of industrial and mining enterprises. The traditional textile industry, including brocade, silk, and satin production, remained dominant (Figure 8). Moreover, several privately owned factories engaged in machine manufacturing, construction materials industry, and food and beverage manufacturing were built and put into operation.

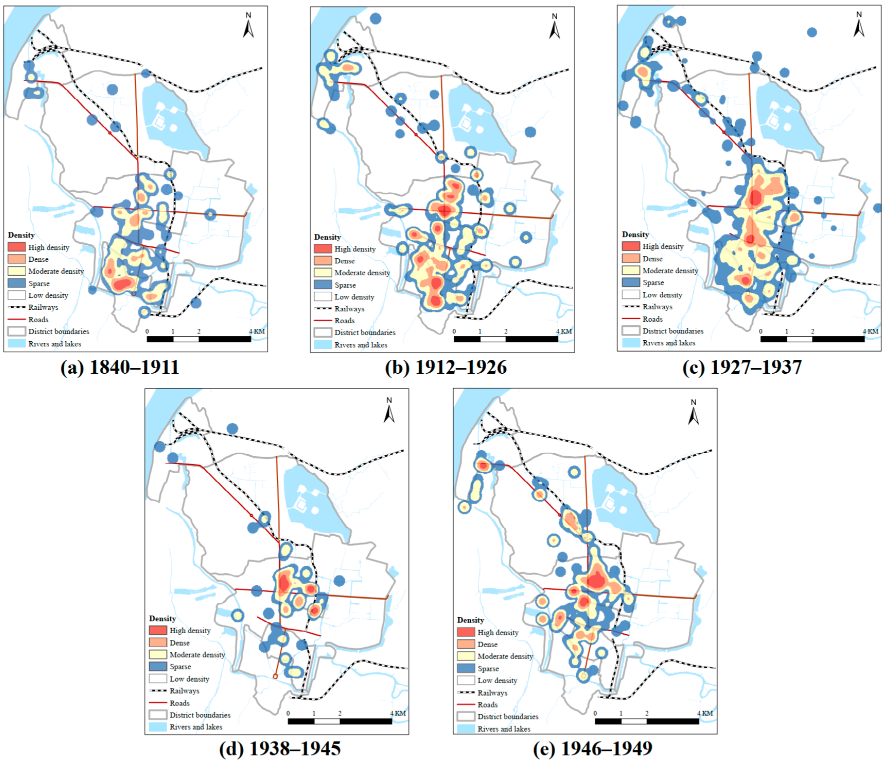

Figure 7. Spatiotemporal evolution of modern industry in Nanjing: (**a**) 1840–1911; (**b**) 1912–1926; (**c**) 1927–1937; (**d**) 1938–1945; (**e**) 1946–1949.

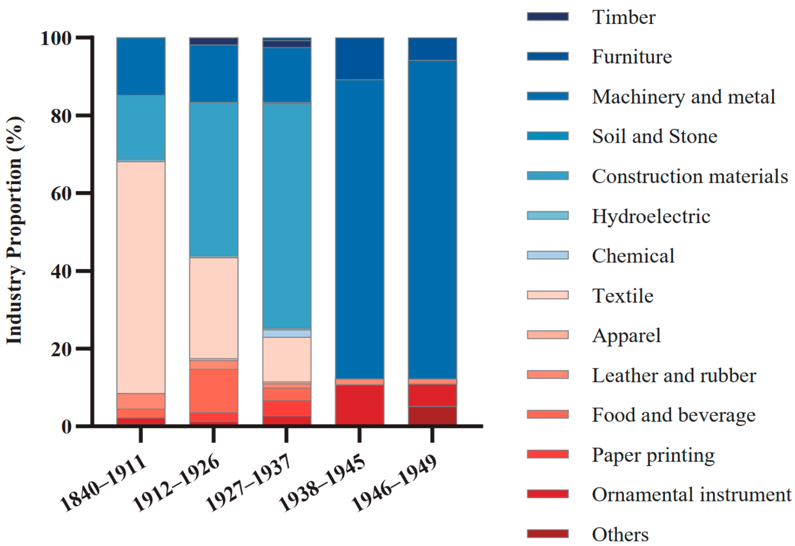

Figure 8. Scales of Nanjing modern industry development in different stages.

In the primary development stage (1912–1926), the pace and scale of modern industry development in Nanjing surpassed those of the preceding period. The urban industrial footprint expanded from Laochengnan to encompass the areas around Xinjiekou and Gulou in the city center (Figure 7b). Factories began to emerge in Xiaguan. Following the success of the 1911 Revolution, the national bourgeoisie had a strong appetite for industrial development and took proactive measures. In addition, the outbreak of the First World War led European imperialist countries to ease their economic aggression, resulting in reduced imports for China and expanded domestic and foreign markets. This provided opportunities for industrial development. The proportion of the textile industry gradually declined, and the construction materials, machinery and metal manufacturing, and food and beverage manufacturing industries experienced significant growth (Figure 8).

Nanjing's modern industry took shape during the rapid development stage (1927–1937). Urban industrialization expanded to the north and east of the city, further extending the industrial landscape. Simultaneously, urban industrial space spread downward along the Zhongshan North Road to Xiaguan, with industries along the riverside and railway gradually developing (Figure 7c). The period from 1927 to 1937 marks a prosperous and politically stable era in China's history, often referred to as the "Nanjing decade." With the establishment of the Nanjing Nationalist Government, the city's population increased, leading to the construction of numerous urban buildings and an increased demand for various industries. During this period, the number of new factories increased significantly, and industries underwent continuous refinement and expansion. New industries experienced rapid growth, which can be accredited to the rising demand and policy support. This included flour mills, rice mills, machine factories, brick and tile factories, construction factories, and printing industries. In particular, the construction materials industry witnessed a remarkable growth (Figure 8). Furthermore, urban public utilities such as the Capital Power Plant (1928) and Nanjing Waterworks (1933) were constructed during this time.

Nanjing's industrial modernization process was abruptly halted during the stagnant development stage (1938–1945), resulting in a significant reduction in industrial capital and a sharp contraction in the scale of new factories. The development of new factories was mostly confined to Xinjiekou and the eastern parts of the city, while others were scattered (Figure 7d). The situation worsened in December 1937 when the Japanese army occupied Nanjing. They launched destructive attacks on the city's industries and seized control of factories through "military management" strategies. The primary focus of industrial activity shifted to machinery and metal manufacturing (Figure 8), primarily geared toward fulfilling military demands. Consequently, Nanjing's modern industry suffered a devastating blow.

In the decline stage (1946–1949), industries were mainly distributed in Xinjiekou, along Zhongshan North Road, and Xiaguan, with a noticeable decrease in the construction of new factories in Laochengnan compared with pre-war times (Figure 7e). Following the war, when the Nationalist government returned to Nanjing, the city's industrial sector witnessed a short-term "prosperity". However, this growth was short-lived due to subsequent conflicts, shortages of supplies, currency devaluation, rising prices, and inflation. Bureaucratic capital exerted significant control over industrial development, resulting in a significant shift of capital toward commercial ventures. Private industry faced considerable challenges, with new factories primarily specializing in machinery, metal manufacturing, and furniture production, while the traditional textile industry completely declined (Figure 8).

4.2. Industrial Sectors in Modern Nanjing

4.2.1. Level of Modernization across Different Industries

The development of Nanjing's industry in modern times was marked by two key aspects: an increase in the number of newly built factories and a diversification of modern industrial types. The 1930s represented the zenith of modern industrial development, and data from industrial surveys conducted during this period were used to assess the level of modernization across various industries based on the industrial structure indices.

In terms of industrial labor productivity (Table 4), the average value for modern Nanjing industries in the 1930s was CNY 2379 per person. Notably, the flour industry exhibited the highest industrial labor productivity, exceeding the average by more than tenfold. Industries with above-average labor productivity included rice milling, egg production, hydropower, and briquette industries. The sand-turning industry had the lowest industrial labor productivity. The disparity in labor productivity was attributed to the varying nature of industrial sectors and levels of mechanized production. According to the location quotient analysis (Table 5), the food and beverage manufacturing industry, paper printing industry, hydroelectric industry, and soil and stone manufacturing in Nanjing demonstrated significant comparative advantages on a national scale. The location quotients for the food and beverage manufacturing, paper printing, and hydropower industries exceeded 1.5, highlighting significant comparative advantages in similar industries in the country. Machinery and metal manufacturing, metallurgical, chemical, and textile industries faced challenges in keeping up with the national average in terms of competitiveness.

Table 4. Industrial labor productivity in 1930s Nanjing.

Industry Types [1]	Number of Employees	Total Product Value (CNY)	Industrial Labor Productivity
Flour	300	8,829,920	29,433.07
Rice	750	6,250,000	8333.337
Egg	300	2,360,196	7867.32
Water	69	500,000	7246.38
Briquette	49	200,000	4081.64
Coking	16	36,000	2250.00
Soap	90	189,000	2100.00
Ice	30	60,000	2000.00
Printing	2750	1,875,000	681.82
Brick	900	600,000	666.67
Silk	2600	1,500,000	576.92
Glass	70	40,000	571.43
Cotton	1230	650,000	528.46
Sand-turning	699	347,500	497.14
Average	9853	23,437,616	2378.73

[1] Due to limitations of data availability on workers in modern China, which differ from the classification in 3.3.1 the industrial classification criteria from the original statistics have been retained in the calculation of the indicator here.

Table 5. Location quotient of industries in 1930s Nanjing.

Industry Types [1]	Location Quotient
Food and beverage manufacturing	2.53
Paper printing industry	2.16
Hydroelectric industry	1.98
Soil and stone manufacturing	1.39
Machinery and metal manufacturing	0.55
Metallurgical industry	0.40
Chemical industry	0.24
Textile industry	0.23

[1] Eight representative industries were selected for the calculation of location quotient.

The aforementioned results underscore the transitional and gradual nature of Nanjing's industrial modernization process. Research has indicated that the development of urban industry in modern Nanjing was partial, incomplete, and characterized by a low level of modernization. During this period, only a handful of modern enterprises had fully adopted large-scale machinery for production. Most of them were transitional factories, half-new and half-old. In the realm of food and beverage manufacturing, the flour industry oriented itself toward foreign markets and successfully implemented modern large-scale machine production. It stood out as a sector with the highest degree of mechanization, establishing advantages in the national market. However, most local rice processing was undertaken by small machine-based rice factories. These small and medium machine-based factories were still in the process of transitioning from traditional manpower and animal-powered workshops to the emerging model of new grain processing facilities. The paper printing industry, soil and stone manufacturing, and machinery and metal manufacturing were composed of workshop-type factories employing a limited workforce (less than 30) and using small-scale machinery. A few traditional handicraft industries had begun to embrace modernization driven by advancements in machinery. In the textile industry, silk, cloth, and towel factories were akin to manual workshops. These factories operated with a low degree of mechanization, resulting in lower levels of industrial labor productivity. However, during the same period, neighboring cities like Nantong and Suzhou had made more progress in the textile industry. Suzhou's textile factories had introduced advanced foreign looms for production and had successfully distributed their products across the country. Overall, the analysis of industrial structural indices indicates the issues of the simultaneous presence of modern machine and handicraft industries, low productivity levels, and the irrational internal industry structure.

4.2.2. The Spatial Distribution of Industrial Sectors

Based on the aforementioned industrial center analysis, taking Xinjiekou as the center of the circle and making buffer zones at intervals of 1 km, the number and distribution of different enterprises in each circle were determined separately (Figure 9), which helped us better understand the differences in the number and density of different types of industries in Nanjing in the modern period. To ensure reliability, industries that have more than 20 plants were only considered.

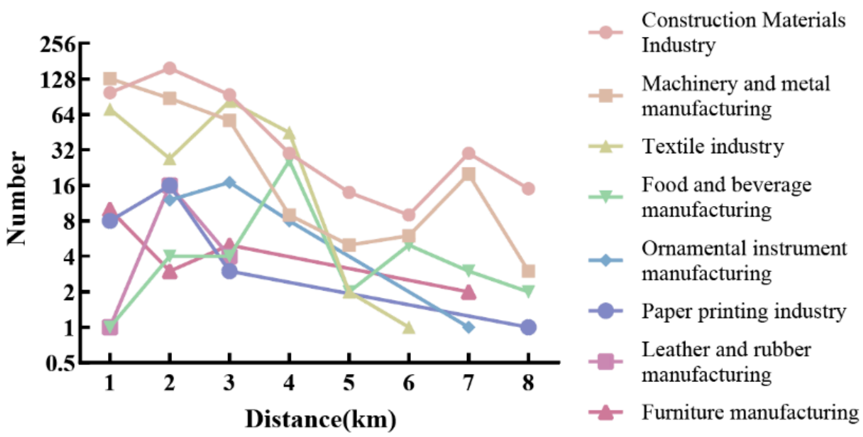

Figure 9. Circle density of industrial distribution in Nanjing.

Industries of various types in modern Nanjing were mainly distributed within a 3 km radius centered on Xinjiekou. The number of factories gradually decreased as one moved away from the center toward the periphery. Within the range of 1–2 km, the highest proportions of the construction materials industry, paper printing industry, leather and rubber manufacturing, and apparel manufacturing were observed. In the 2–3 km range, the textile industry, ornamental instrument manufacturing, timber manufacturing, and chemical industry were more concentrated. Notably, there was a minor peak in the distribution of the construction materials and the machinery and metal manufacturing industries within the 6–7 km range. Accordingly, the spatial distribution of industry exhibited the pattern of "center-periphery-subcenter".

The spatial density analysis mainly revealed the following characteristics (Figure 10): (1) The construction materials manufacturing industry, the machinery and metal manufacturing industry, and the textile industry displayed large density centers within the city. (2) The construction materials manufacturing and the machinery and metal manufacturing industries had multiple density centers, each of a significant scale, illustrating a distribution pattern of "large dispersion, large agglomeration". The textile industry, the food and beverage manufacturing industry, and the furniture manufacturing industry exhibited a "large scattered, small agglomeration" pattern. The ornamental instrument manufacturing industry, the paper printing industry, and the leather and rubber manufacturing industry exhibited a "small scattered, small agglomeration" pattern. (3) In terms of the distribution of circles in each density center, the construction materials manufacturing industry, the machinery and metal manufacturing industry, and paper printing industry were clustered at high densities in the core circles, indicating a strong centripetal nature of their location choices. The textile industry, the ornamental instrument manufacturing industry, and the leather and rubber manufacturing industry were more inclined to form a high-density cluster along the riverbank in Laochengnan. The machinery and metal manufacturing industry and the construction materials manufacturing industry tended to align toward the city's main roads and railroads and had established a sub-level agglomeration center in Xiaguan. Overall, significant differences were observed in the spatial distribution of factories based on the type of industry.

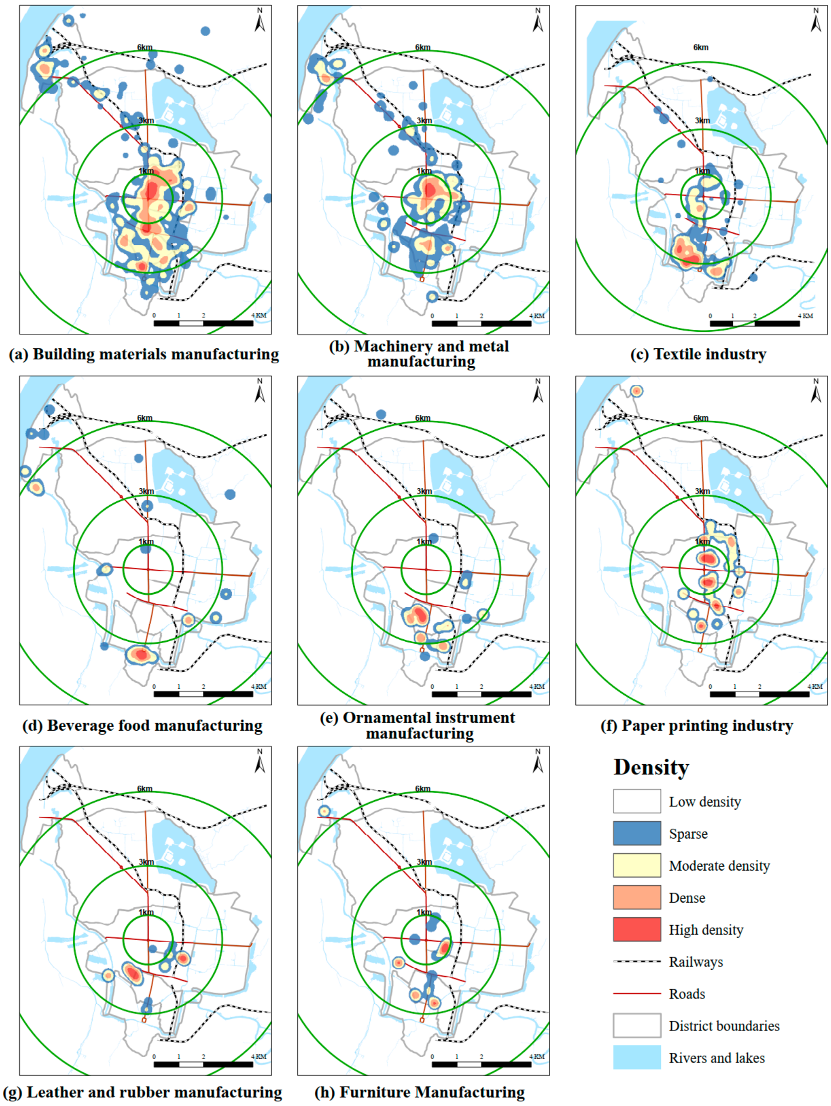

Figure 10. Kernel density of different industries in Nanjing: (**a**) Building materials manufacturing; (**b**) Machinery and metal manufacturing; (**c**) Textile industry; (**d**) Beverage food manufacturing; (**e**) Ornamental instrument manufacturing; (**f**) Paper printing industry; (**g**) Leather and rubber manufacturing; (**h**) Furniture Manufacturing.

5. Discussion

5.1. Factors Influencing Industrial Location in Modern Nanjing

The Geodetector analysis identified dominant factors in industrial distribution. Considering the availability of historical data, seven factors were selected from two aspects: natural geographical factors (elevation, slope, rivers, and lakes) and socio-economic factors (population density, roads, and railways). The results (Table 6) indicated that roads and population density were the primary dominant factors in industrial distribution, with no significant difference between them. Elevation, rivers, and lakes had a relatively small influence on the industrial spatial distribution, with q values < 0.05. Railways and slope showed nonsignificant q values. Overall, socio-economic factors had a more pronounced impact on the industrial spatial distribution compared with natural geographical factors.

Table 6. Results of GeoDetector.

Factor Analysis	Natural Geographical Factors				Socio-Economic Factors		
	Elevation	Slope	River	Lake	Population Density	Road	Railway
q value	0.035	0.002	0.009	0.005	0.193	0.263	0.001
p value	0.000	0.436	0.000	0.019	0.000	0.000	0.973

The results of the OLS regression analysis show that the VIFs for all factors are below 7.5, indicating no multicollinearity issues. Among these, population density and roads achieve statistical significance at the $p < 0.01$ level. The model reports an AICc value of 16,141.7, an R^2 of 0.259, and an adjusted R^2 of 0.258. However, the OLS model fails to account for spatial effects. To address this limitation, the GWR model is conducted. This model significantly outperforms the OLS model, with an R^2 of 0.410 and an adjusted R^2 of 0.408. Specifically, roads generally contribute positively to the industrial layout, exhibiting significant promotional effects in Laochengnan and Xiaguan. Population density also promotes industrial layout, showing positive effects in all areas except the northeast. Additionally, the results from the GWR model demonstrate significant spatial heterogeneity in the impact of different social factors on Nanjing's industrial layout.

The Geodetector and GWR methods were initially used at a single time scale due to the limited available data. To enhance the accuracy of the analysis, a temporal evaluation was conducted, focusing specifically on three key factors: roads, railways, and water systems. Statistical assessments were conducted for the number of factories located within the proximity of these factors (specifically within 300 m of roads, 500 m of railways, and 300 m of water systems) over five distinct historical periods. The findings (Table 7) revealed a consistent increase in the number of factories located within a 300 m radius of urban roads, with more than 70% of factories placed within this proximity from 1946 to 1949. In the 500 m buffer zone around urban railways, there was a continuous increment in the number of factories, with a slight decline observed in the subsequent phases. The quantity of factories situated within the 300 m buffer zone of water systems exhibited an initial marginal surge followed by a substantial decline. This pattern aligns with the prevalent trend in the early urban industrial development, where the selection of industrial locations gradually diminishing their reliance on natural factors such as rivers as science and technology advanced, simultaneously augmenting their dependence on the transportation network.

Table 7. Factory proportions within different buffer zones.

Period	Water	Railway	Road
1840–1911	45.45%	18.18%	46.59%
1912–1926	58.3%	21.97%	52.02%
1927–1937	52.71%	27.5%	54.82%
1938–1945	29.23%	29.23%	67.69%
1946–1949	34.64%	27.45%	71.90%

Rivers served as both a source of water and vital transportation routes for early industrial development. Adjacent to the Yangtze River, Nanjing featured an intricate network of inner-city waterways within its city walls, including Qinhuai, Jinxiang, and Zhenzhu rivers. Urban expansion and population growth increased sewage discharge and accumulated construction debris, thereby resulting in the deterioration of the hydrological environment. The reduced capacity of river transport and the development of overland transportation subsequently diminished industrial reliance on river-based logistics. Furthermore, the continuous expansion of the urban road network facilitated transportation conditions for industrial development [88]. Constructed in 1928, Zhongshan Road spanned the northern, central, and eastern parts of the city, altering the spatial structure of Nanjing's urban landscape and becoming the central axis of Nanjing. Concurrently, the introduction of power machinery revolutionized transportation methods. The opening of Jiangnan railway's Nanjing−Wuhu line in 1936, connecting with the Shanghai−Nanjing line, strengthened intercity connections and promoted trade and commerce between regions. Moreover, population growth was a key indicator of urbanization during this period. From 1928 to 1936, Nanjing's registered urban population surged from 490,000 to 1.18 million [89]. Despite a population decline during the war years, the return of the Nationalist government in 1945 led to a rapid rebound in the registered urban population, reaching nearly 900,000. By 1948, Nanjing's population stood at approximately 1.03 million. This growing population not only provided the labor force needed for the industries but also enhanced the market potential, thereby stimulating industrial production growth. However, due to the limited available data, the discussion on the influencing factors is not yet comprehensive.

5.2. Distinctive Patterns of Industrialization in Modern Nanjing

Section 4.1 discusses the analysis of influencing factors at the micro level of industry distribution. According to the existing historical studies, during the modernization process, the political status and political situation of Nanjing were among the most significant factors influencing its modern industrial development. Therefore, this section further analyzes the historical background of Nanjing's industrial development from a macro perspective, comparing it with other cities of the same period to distill its unique pattern of industrialization.

From the perspective of internal political status, Nanjing has long been a crucial political center in China. It served as the capital during crucial periods such as the Taiping Heavenly Kingdom, the temporary government of the Republic of China, and the ruling of the Nationalist Party. The city's political significance inherently promoted government interventions aimed at its industrialization. In 1929, the Capital Plan (Shoudujihua) was promulgated, marking the first systematic urban planning in the history of Nanjing. It encompassed all aspects of urban development and construction (Tsui, 2012). Newly built urban transportation and public infrastructure provided conditions for industrial development. Moreover, the construction demand of public facilities affected the industrial structure and production scale. In the modernization process, industrialization paved the path for the large-scale construction of cities. The development of industry and the implementation of urban planning in Nanjing progressed simultaneously. Urban industry could respond positively to urban space development decisions and facilitate the pace of modernization. However, external political situations had a negative impact on industrial development. Particularly in 1937, the outbreak of successive wars interrupted the modernization process of Nanjing's industry, leading to irreparable losses in the city's urban development. Under the dual influence of the internal and external factors, Nanjing's industrialization pattern exhibited government urban planning intervention, synchronized urbanization, and insufficiently balanced development.

Considering the above internal and external factors, this study compared the industrialization pattern of Nanjing with that of other cities (Table 8). Even though both are Chinese cities, Nanjing, as a political city, and Shanghai, as an economic hub, exhibited different industrialization patterns. During that period, the urban administrative power in Shanghai was divided among the International Settlement, the French Concession, and the Chinese city proper. Under this unique political system, no authority had the power to regulate industrial development at the national level, without the intervention of urban planning and regulations; however, the stable political environment within the settlements provided assurance for industrial development, eventually leading to the coexistence of two industrial models: the widely distributed small workshop system and the new factory system of large integrated mills [53]. Shanghai emerged as the manufacturing and industrial center of China during that era. Next, the analysis focuses on cities that have not undergone government planning and semi-colonial intervention. Almost uniquely among non-European countries, Japan was neither colonized nor did it suffer quasi-colonial interventions. Thus, Tokyo's tradition of crafts-based production was preserved. Modern industry first transformed the areas where handicraft production was concentrated in the city and then expanded the city boundaries outward. Tokyo underwent "industrial urbanization" from 1880 to 1930, where industrialization preceded attempts at urban planning, and the processes of industrialization and urbanization occurred simultaneously. This process laid the foundation for the development of large-scale, mixed-use districts, which is a common characteristic of Japanese cities (Waley, 2009). During the industrial development process in North American cities, political intervention and deliberate planning influenced the spatial locations. In a carefully planned process of industrial suburbanization, industrial parks, company towns, and industrial suburbs received clear and well-defined planning and governance [90]. In contrast to Nanjing's industrialization where urban planning was interrupted by war, North American cities witnessed political interventions and conscious planning that shaped the spatial patterns during their industrial development. North America experienced deliberate and carefully planned industrial suburbanization, with the clear planning and governance of industrial parks, company towns, and industrial suburbs [90].

Table 8. Comparison of different urban industrialization patterns.

City	Government Interventions (Internal Factor)	Semi-Colonial Interventions (External Factor)	Industrialization Patterns
Nanjing, China	√	×	Disrupted industrial planning; synchronized urbanization; insufficiently balanced development
Shanghai, China	×	√	Coexistence of widely distributed small workshop system and the new factory system of large integrated mills
Tokay, Japan	×	×	Industrial urbanization; modern industry developed based on the tradition of craft-based production
North American cities	√	×	Clear and well-defined industrial location

Different cities experienced varying degrees of government and semi-colonial intervention, resulting in distinct industrialization patterns and diverse impacts on urbanization. Nanjing exemplified a unique industrialization pattern characterized by disrupted industrial planning, synchronized urbanization, and inadequately balanced development, representing the traditional, politically oriented urban industrialization in China.

5.3. Verification of the "Pole-Axis" Spatial System

The "pole-axis" system reflects the objective laws of socio-economic spatial organization and the formation of spatial structures. It is considered the optimal structure for regional development [91,92]. "Poles" refer to central cities at all levels, whereas "axes" refer to industrial agglomerations connected by transportation, communication, energy, and water corridors. This theory reveals the relation between socio-economic development and the evolution of spatial structure at different stages of regional development. In addition, it highlights the intrinsic mechanism of "pole-axis" interaction. Until now, the theory has been employed in the field of arranging the overall pattern of national spatial development [93]. Also the theory has been widely used in regional spatial development [94,95], spatial planning for tourism [96], and regional ecological risk assessment [97]. Research has revealed that in terms of the configuration of productive forces and the spatial organization of social development, the industrial development in modern Nanjing conforms to the spatial structure pattern of the "pole-axis" system (Figure 11). In particular, the first three periods of modern Nanjing's industrial development coincide with the first three stages of the formation of the "pole-axis" spatial system proposed by Lu [92].

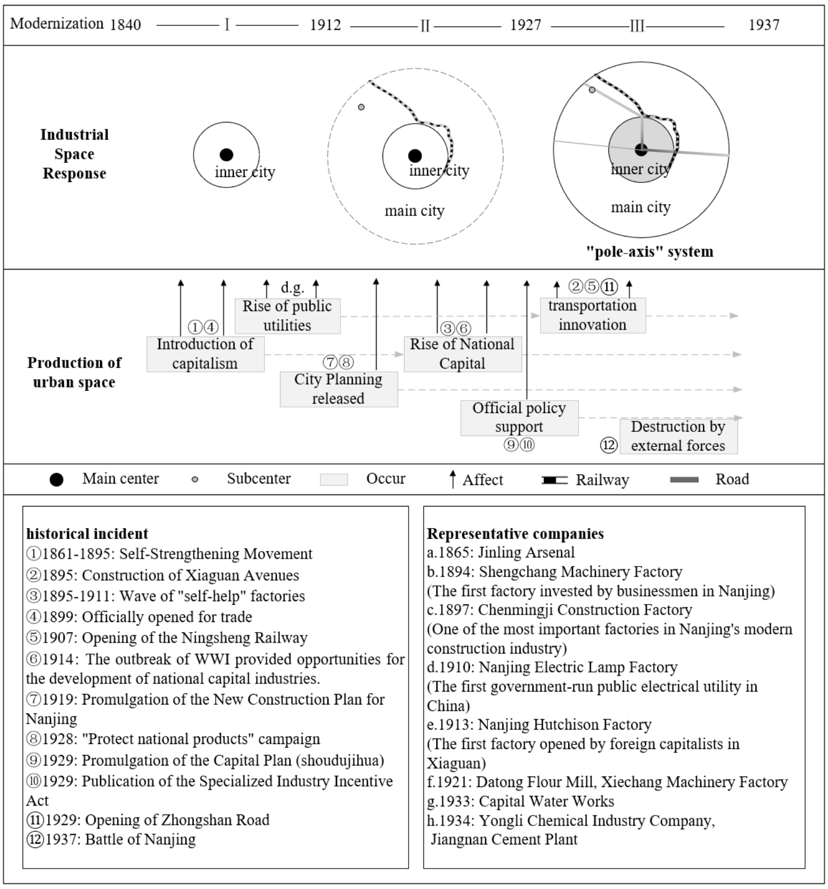

Figure 11. Evolution mechanism of modern industry in Nanjing from 1840 to 1949 based on "pole-axis" system.

In the first stage, the equilibrium stage before "pole-axis" formation, the socio-economic object is characterized by an agrarian society, exhibiting a state of order, disorganization, and inefficiency. In pre-industrial Nanjing, human activities were concentrated along the Qinhuai River due to its dependence on water resources. The emergence of modern industry (1840–1911) led to a fragmented industrial distribution space, primarily within the traditional residential area in Laochengnan. In the second stage, socio-economic objects began to cluster, and poles and axes began to form simultaneously, resulting in localized organization. During the primary phase of modern industry (1912–1926), with Xinjiekou as the "pole" and the Ningsheng railway as the "axis", urban industry began to exhibit an organized state, regional resource development, and rapid economic growth. In the third phase, the framework of the main "pole-axis" system was formed, with rapid socio-economic evolution and remarkable changes in the spatial structure. During the stage of rapid development of modern industry (1927–1937), Zhongshan Road, an important transportation artery, and the parallel extension of the Ningsheng railway further strengthened the influence of the northern part of the city from Gulou to Xiaguan linear infrastructure bundle as an "axis". Thus, modern industry exhibited the pattern of "pole-axis–polygon." A spatial pattern emerged with Xinjiekou as the "pole", Zhongshan Road as the "axis", and Xiaguan as the new agglomeration area. Zhongshan Road had a strong economic attraction and cohesion to the nearby areas, creating a diffusion effect, combining with regional productivity factors to form new productivity and promote socio-economic development. In the fourth stage, the "pole-axis" spatial structure system was formed. The region entered a fully organized state, resulting from the long-term self-organization process of socio-economic factors and scientific regional development planning. However, due to the interruption of the war (1938–1945), Nanjing's modern industry failed to enter the formation stage of the "pole-axis" spatial system. To sum up, the "pole-axis" spatial system is an objective law reflecting the spatial organization of society and economy. The empirical study of Nanjing reflected the general process of early urban modernization in China.

6. Conclusions

This study integrates interdisciplinary methods including GIS, modern history, urban studies, and textual data mining to examine the spatiotemporal evolution, industrial agglomeration characteristics, and influencing factors of urban industry in Nanjing from 1840 to 1949. Through comparisons, it distills an industrialization pattern specific to politically oriented cities. Furthermore, the spatiotemporal evolution of modern Nanjing industry validates the theory of the classic "pole-axis" spatial system.

The results indicated that the industry exhibited a "one main, one secondary" dual-center "ladle-shaped" arrangement. Over time, the industrial clusters of the city shifted northward and eastward, resulting in the emergence of an industrial sub-center. An analysis from the industry-type perspective revealed a distinct "center-periphery" differentiation in modern Nanjing, with varying levels of modernization observed across different industrial sectors. At the micro level, the primary factors influencing the industrial location in Nanjing were transportation and population density. At the macro level, the industrialization pattern in Nanjing was shaped by government and colonial interventions. Compared with other cities, this study identifies the unique characteristics of Nanjing as a politically oriented center in terms of industrialization, marked by disrupted industrial planning, synchronized urbanization, and insufficiently balanced development. Finally, the discovered spatiotemporal pattern of Nanjing's industry validates the "pole-axis" spatial system, reflecting the general principles of regional economic spatial organization and serving as a microcosm of China's urban modernization transition. Based on the findings of this study, the policy recommendations are as follows. Industrial heritage preservation should be integrated into the development policies of urban structures [98]. (1) It is recommended to promote industrial heritage tourism to draw public engagement in heritage preservation, thereby strengthening the residents' sense of cultural identity and historical continuity [98]. (2) For future urban planning, it is advisable to optimize the spatial relationship between industrial locations and residential, commercial, and recreational areas. This approach ensures harmonious coexistence among different urban zones. (3) Furthermore, fostering diversified development within the industrial sector is crucial. Leveraging the strengths of local industries, while avoiding over-reliance on any single industry, can enhance the economic resilience and risk resistance of a city [99].

This study quantitatively analyzed the historical spatiotemporal evolution of urban industry, providing a reference for the assessment and preservation of industrial heritage values, as well as offering valuable insights for urban planning and development. Although this study represents the application of GIS methods in the humanities that enriches the temporal dimension of historical research, its limitations must be acknowledged. Studies concerning historical geographic data should consider text data mining techniques to explore more efficient data collection solutions. More focus should be placed on the mutually reinforcing relation between urbanization and industrialization in the modernization process. Additionally, due to the complexity of political factors and the scarcity of historical data, we did not quantify them for inclusion in our correlation analysis. Future studies could further explore the relationship between political interventions and industrial development by developing indices or employing expert evaluations. We aim to explore these areas in our future research endeavors.

Author Contributions: Conceptualization, Chun Wang and Gang Chen; methodology, Chun Wang and Yixin Liang; software, Chun Wang; validation, Chun Wang and Yixin Liang; formal analysis, Chun Wang; investigation, Chun Wang; resources, Chun Wang; data curation, Chun Wang and Gang Chen; writing—original draft preparation, Chun Wang; writing—review and editing, Chun Wang and Yixin Liang; visualization, Chun Wang and Yixin Liang; supervision, Gang Chen; project administration, Gang Chen; funding acquisition, Gang Chen. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

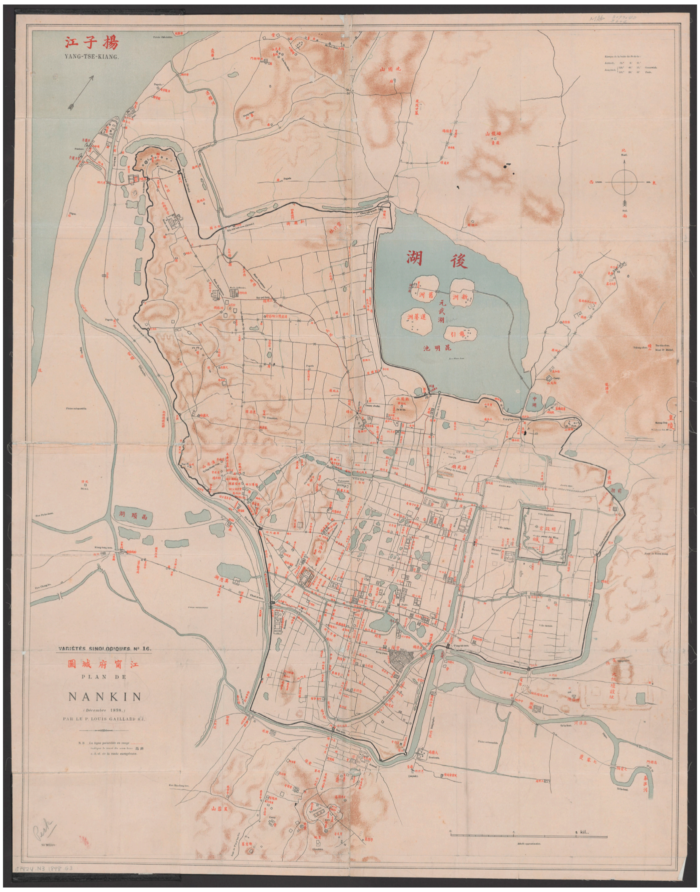

Figure A1. The Map of Jiangning Prefectural City (1898) [100] was completed by P. Louis Gaillard. It displays the urban boundaries and geographical features of Nanjing as of 1898 and is used in the research to define the scope of the study area.

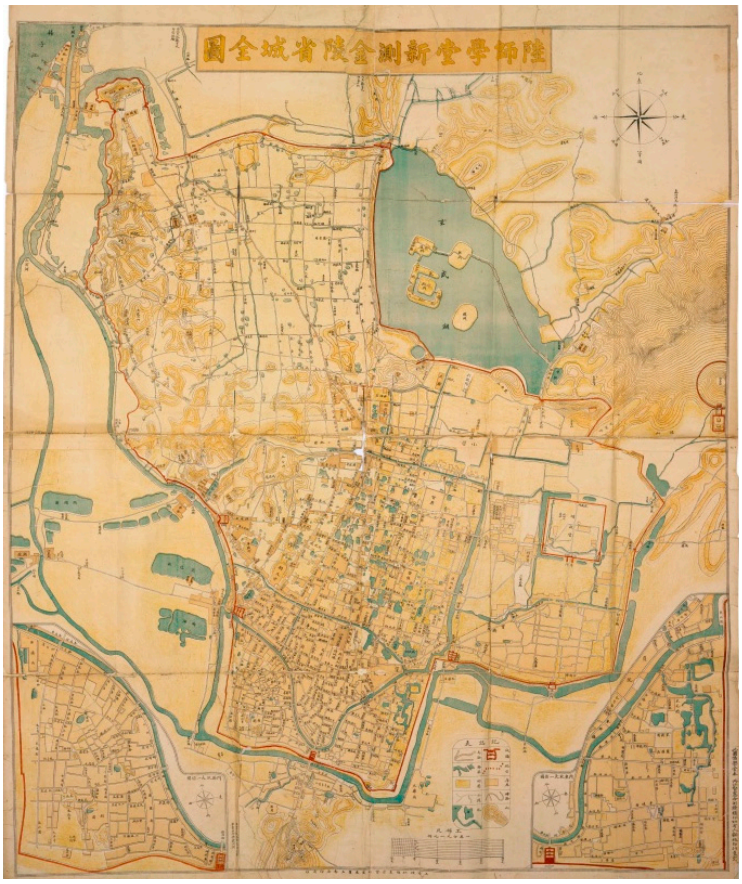

Figure A2. The New Survey Map of the Provincial City Jinling by the Army Academy (1909) [101] is the earliest map of Nanjing measured by the Chinese using modern surveying and mapping techniques. The scale of the map is 1:10,000. This map is used to define the scope of the study area.

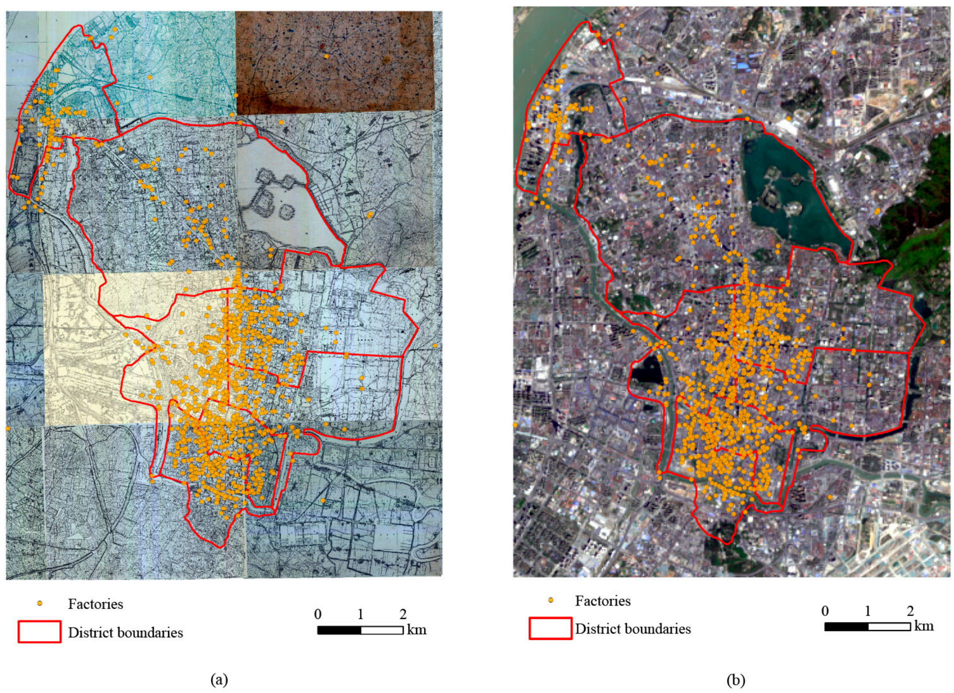

Figure A3. The study area. (**a**) Nanjing aerial survey topographic map (partial). (**b**) Landsat 8 image of the study area (2021).

Table A1. Detailed data source for industrial geographic analysis.

Data Classification	Authors/Editors	Title	Year of Publication
Nationwide	Dajun Liu	Report of the China Industrial Survey	1937
	Zhen Chen	Materials on Modern Industrial History of China (Third Series)	1961
Regional	International Trade Bureau, Ministry of Industry	China Industry Journal (Jiangsu Province)	1933
	Statistics Division, Economic Research Institute, Construction Committee	Chinese Economic Records (Nanjing)	1935
	Department of Special Collections, Nanjing Library, Economic History Group, Jiangsu Academy of Social Sciences	Industrial Survey Statistics of Jiangsu Province (1927–1937)	1987
	Nanjing Local History Codification Committee	Journal of Construction Materials Industry	1991
	Nanjing Local History Codification Committee	Journal of Nanjing Second Light Industry	1994
	Nanjing Local History Codification Committee	Nanjing Commercial Journal of Daily Industrial Products	1996
	Nanjing Local History Codification Committee, Nanjing Machinery Industry Journal Compilation Committee	Journal of Nanjing Machinery Industry	1998
	Zhaiwei Sun et al.	The History of Modern Ethnic Industry in Jiangsu	1999
	Gazetteer of Nanjing Editorial Committee	Gazetteer of Nanjing	2012
	Nanjing Local History Codification Committee	Nanjing Compendium	2014
	Bei Xia, Deng Pan	Nanjing Centennial Urban History (Industrial and Agricultural Volume) (1912–2012)	2014

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