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Dataset Development on Photovoltaic Equipment and Manufacturing Enterprises in China (2006–2021)

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Abstract: China is the world's largest market for photovoltaic products and the leading global supplier. The country's photovoltaic manufacturing industry significantly contributes to the green transformation and sustainable development of global energy sectors. The study collects and organizes data on China's photovoltaic equipment manufacturing enterprises and industrial parks utilizing enterprise information platforms such as Qichacha, Tianyancha, and the National Enterprise Credit Publicity System, along with Qianzhan Industry Research Institute resources. Geographical coordinates for these entities are obtained by the Amap open platform, resulting in a comprehensive spatial distribution dataset of photovoltaic manufacturing enterprises and industrial parks across China. This dataset encompasses vital details such as the names of parks and enterprises, their scales, and geographical locations. The study examines the evolving spatiotemporal patterns within China's photovoltaic manufacturing industry. The dataset includes: (1) Information on photovoltaic industrial parks in China (2021); (2) Information on photovoltaic equipment manufacturing enterprises in China (2006–2021); (3) Information on the number of new photovoltaic equipment manufacturing enterprises in China's prefecture-level cities (2006–2021); and (4) Information on the scale of new photovoltaic equipment manufacturing enterprises in China's prefecture-level cities (2006–2021). The data is archived in a single .xlsx file with a total size of 729 KB.

Keywords: photovoltaic power; equipment manufacturing; spatiotemporal analysis; 2006–2021

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Dataset Availability Statement:

The dataset supporting this paper was published and is accessible through the *Digital Journal of Global Change Data Repository* at: https://doi.org/10.3974/geodb.2024.09.06.V1 or https://cstr.escience.org.cn/CSTR:20146.11.2024.09.06.V1.

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1 Introduction

Advancements in photovoltaic power generation technology have significantly reduced costs, establishing the photovoltaic industry as a critical driver of global sustainable development and resilience to climate change. Given the worsening global climate conditions, the strategic importance of the photovoltaic equipment manufacturing industry is increasingly critical for national governments. Hence, countries worldwide are actively fostering the growth of their photovoltaic manufacturing sectors through policy support and industrial planning. Due to the combined effects of policy support and market demand, China has emerged as the world's largest market for photovoltaic products and the leading global supplier. The output value of China's photovoltaic industry reached 1.75 trillion CNY in 2023, with a new installed capacity of 216.88 GW, both ranking first globally[1]. China has developed a comprehensive photovoltaic manufacturing sector, encompassing high-purity silicon materials, silicon ingots, rods, wafers, battery modules, auxiliary materials, and photovoltaic equipment. This comprehensive industry chain has solidified China's position as a dominant player in the global photovoltaic market a competitive edge in producing high-quality solar products[2,3].

From the perspective of the development history of the photovoltaic manufacturing industry, clustering has played a crucial role in the evolution of its industrial organization. However, differences exist in the characteristics of clusters at various stages of development[4]. Recently, many regions have emphasized the photovoltaic manufacturing industry as a critical focus for local industrial development and investment[5]. Driven by active support from local governments, photovoltaic manufacturing projects have been rapidly deployed, and optimizing the spatial layout and organization of local production has become crucial for promoting high-quality regional photovoltaic manufacturing development[6]. Current research on the photovoltaic manufacturing industry primarily addresses the challenges it faces[7], the dynamics of global photovoltaic trade[3], and the transfer and collaboration of technological innovations[8]. Most studies on the spatial and temporal layout of the photovoltaic manufacturing industry concentrate on the period before achieving grid parity in photovoltaic power generation. There is a need to update and deepen the analysis of the spatial organization and evolution of the photovoltaic manufacturing industry to enhance the relevance and timeliness of research[9,10].

An in-depth analysis of the spatial organization evolution of China's photovoltaic equipment manufacturing industry is essential for understanding the underlying logic of the spatial layout of this emerging industrial system. Such an analysis is crucial for optimizing the production organization of the photovoltaic manufacturing sector and can serve as a foundation for developing other emerging industries. Therefore, the dataset provides detailed information on China's spatial distribution of photovoltaic equipment manufacturing enterprises. This includes data on the location of photovoltaic industrial parks and the enterprises' names, registered capital, region, address, business scope, and industry classification, all of which can be utilized to support research and analysis.

2 Metadata of the Dataset

Table 1[11] lists the metadata for China's spatiotemporal development dataset of photovoltaic equipment manufacturing enterprises. It includes the dataset's full name, short name, authors, year of the dataset, data format, data size, data files, data publisher, and data sharing policy, etc.

Table 1 Metadata summary of the dataset of spatial-temporal development of photovoltaic equipment manufacturing enterprises in China

Items	Description
Dataset full name	Spatial-temporal development dataset of photovoltaic equipment manufacturing enterprises in China (2006–2021)
Dataset short name	PhotovoltaicEquipManuChina2006–2021
Authors	Lian, W. H., College of Resources and Environment, University of Chinese Academy of Sciences, lianwenhua21@mails.ucas.ac.cn Zhang, X. P., College of Resources and Environment, University of Chinese Academy of Sciences, zhangxp@ucas.ac.cn Wu, A. P., College of Resources and Environment, University of Chinese Academy of Sciences, wuaiping20@mails.ucas.ac.cn Song, J. W., College of Resources and Environment, University of Chinese Academy of Sciences, songjiawen22@mails.ucas.ac.cn Pan, Z. J., College of Resources and Environment, University of Chinese Academy of Sciences, panzhongjing24@mails.ucas.ac.cn
Geographical region	China (no data available in Hong Kong, Macau and Taiwan)
Year	2006–2021
Data format	.xlsx
Data size	729 KB
Data files	(1) China's photovoltaic industrial parks (2021); (2) Photovoltaic equipment manufacturers in China (2006–2021); (3) New photovoltaic equipment manufacturers by prefecture (2006–2021); (4) Scale of new photovoltaic equipment manufacturers by prefecture (2006–2021)
Foundations	National Natural Science Foundation of China (42271193, 41771133)
Data publisher	Global Change Research Data Publishing &Repository, http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	(1) *Data* are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use *Data* subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute *Data* subject to written permission from the GCdataPR Editorial Office and the issuance of a *Data* redistribution license; and (4) If *Data* are employed to compile new datasets, the 'ten percent principal' should be followed such that *Data* records utilized should not surpass 10% of the new dataset contents, while sources should be noted in suitable places in the new dataset[12]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS, GEOSS, PubScholar, CKRSC

3 Methods

This study collects and organizes data on China's photovoltaic industrial parks and equipment manufacturing enterprises (excluding Hong Kong, Macau, and Taiwan due to data constraints). It obtains industrial park information from the Qianzhan Industry Research Institute[1], while enterprise information is sourced from Qichacha[2] and Tianyancha[3]. The advanced search utilizes keywords such as "photovoltaic equipment" and "photovoltaic manufacturing", with the industry selection set "manufacturing-general equipment manufacturing and specialized equipment manufacturing". After comparing and deduplicating the data from both sources, enterprises founded before December 31, 2021, are selected as the research subjects. A total of 4,680 enterprises are then searched in Qichacha by name, yielding details such as enterprise name, registration time, registered capital, location, address, business scope, and industry. Due to the diverse share structures, the registered capital of foreign-funded enterprises needs standardization using the exchange rate applicable at the time of registration. Hence, the registered capital of foreign-funded enterprises is uniformly treated using the exchange rate applicable at the time of registration. Since geographical coordinates are unavailable on the enterprise search website or in the

[1] Qianzhan Industry Research Institute. https://x.qianzhan.com/.

[2] Qichacha. https://www.qcc.com/.

[3] Tianyancha. https://www.tianyancha.com/.

industrial park database, the Amap open platform's coordinate picker is employed to obtain coordinates based on address information[4]. The process for constructing the database is depicted in Figure 1.

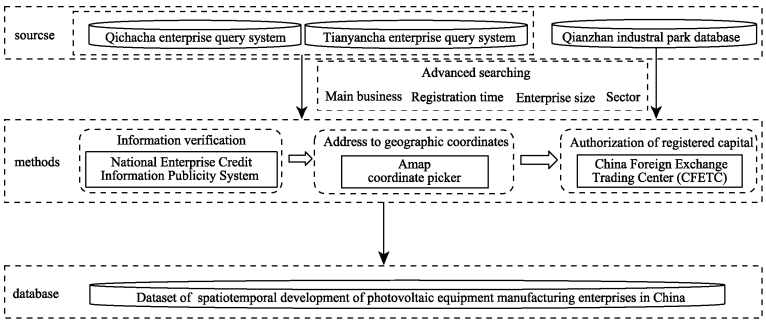

Figure 1 Flowchart of the dataset development

4 Data Results and Analysis

4.1 Data Composition

The dataset detailing the spatiotemporal development of photovoltaic equipment manufacturing enterprises in China from 2006 to 2021 comprises four principal elements: (1) information on photovoltaic industrial parks in China (2021); (2) information on photovoltaic equipment manufacturing enterprises in China (2006–2021); (3) information on the number of new photovoltaic equipment manufacturing enterprises in China's prefecture-level cities (2006–2021); and (4) information on the scale of new photovoltaic equipment manufacturing enterprises in China's prefecture-level cities (2006–2021).

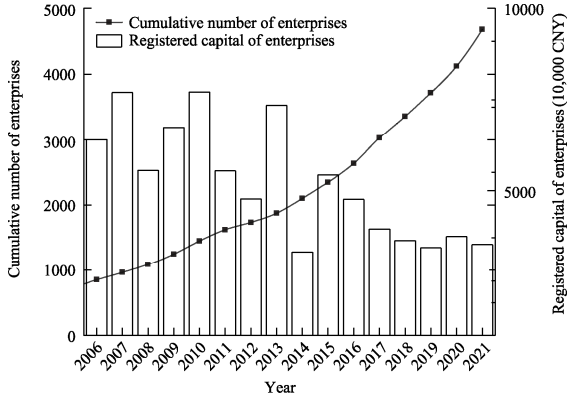

Figure 2 Changes in the number and registered capital of photovoltaic equipment manufacturing companies in China (2006–2021)

4.2 Data Results and Analysis

China's photovoltaic equipment manufacturing industry witnessed substantial growth during the study period, fueled by favorable policies and robust market demand. The number of related companies rose from 849 in 2006 to 4,680 in 2021. In contrast, the average registered capital of these new companies exhibits a declining trend, decreasing from 64 million CNY in 2006 to 35.12 million CNY in 2021 (Figure 2). As the industry matures, newer entrants typically possess less registered capital than their predecessors. This phenomenon stems from several factors: firstly, dominant enterprises have already overcome significant entry barriers by swiftly gaining market share, with many subsequent entrants being subsidiaries of these pioneering companies; secondly, local governments frequently provide business support and infrastructure to nascent enterprises, lowering their initial capital requirements and contributing to the overall

[4] Amap open platform. https://lbs.amap.com/.

reduction in registered capital.

Photovoltaic industrial parks are instrumental in the growth of the photovoltaic manufacturing sector. These parks enlarge the market scale, heighten industrial concentration, and bolster the overall competitiveness of enterprises inside the park, driving the industry toward high-end, intelligent production. China boasted 68 photovoltaic industrial parks (Figure 3) by the end of 2021. Most parks are strategically situated in regions endowed with advanced industrial infrastructure or copious solar energy resources. Jiangsu Province hosts the most parks, totaling 10, followed by Shandong with 8, Zhejiang with 6, and Qinghai with 5.

Figure 3 Map of spatial layout of photovoltaic industrial parks in China

Based on this dataset, the study analyzed the spatial organizational evolution of the photovoltaic equipment manufacturing industry, employing the stage division framework established in the existing literature[13]. Figure 4 illustrates the specific results. The spatial organization of the industry displays pronounced spatial agglomeration traits, forming an "East-Central-West" ladder-type decreasing pattern of spatial differentiation. The primary agglomerations are concentrated in the Yangtze River Delta, Beijing-Tianjin-Hebei, and Pearl River Delta regions. Secondary agglomerations are situated in and around regional centers such as Wuhan, Zhengzhou, Chengdu, and Xi'an, while smaller-scale agglomerations have emerged in Jiuquan, Zhongwei, Shihezi, and Baotou.

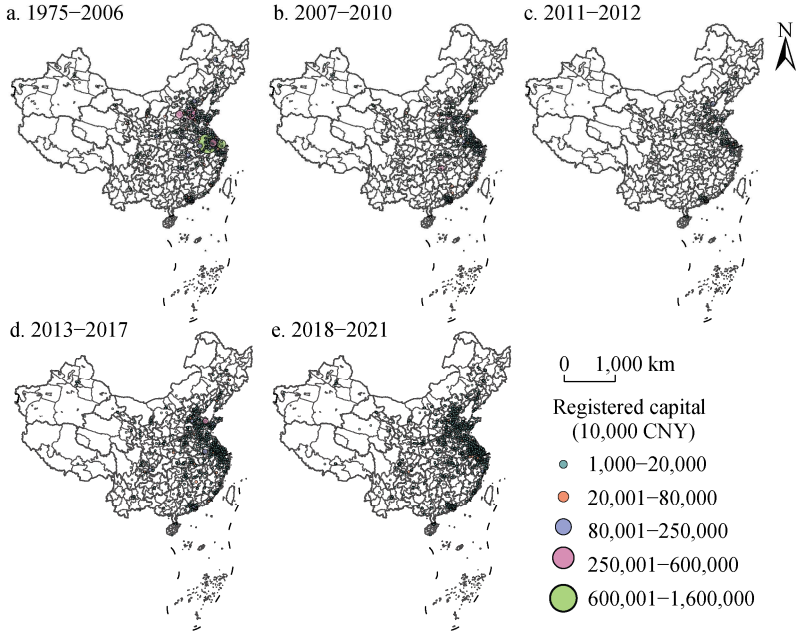

Figure 4 Maps of evolution of the spatial and temporal layout of photovoltaic equipment manufacturing enterprises

During the initial years of the study, regarding the spatial and temporal evolution of firm numbers, new firms were predominantly concentrated in Jiangsu, Shandong, and Hebei, followed by regional centers in the central and western regions, such as Xi'an and Chengdu,

where the number of new firms was comparatively high. In the middle period of the study, photovoltaic manufacturing enterprises increasingly settled in eastern cities like Jiangsu, Anhui, and Zhejiang, while cities in the central and western regions, such as Changsha and Chongqing, began to attract more enterprises. In the later stages of the study, eastern provinces and cities continued to be highly attractive to photovoltaic manufacturing enterprises due to their robust industrial bases. However, certain central and western cities, such as Baotou, Qujing, and Jiuquan, persisted in attracting photovoltaic enterprises, benefiting from local advantages, including government incentives in Baotou, affordable hydropower resources in Qujing, and abundant solar radiation in Jiuquan.

From the perspective of the spatial and temporal development of enterprise size, large enterprises were primarily established in the early agglomeration regions of the Yangtze River Delta and Beijing-Tianjin-Hebei, whereas enterprises in the Pearl River Delta region, another early agglomeration area, tended to be smaller. The size disparity between the Beijing-Tianjin-Hebei region and the other two can somewhat be attributed to the fact that the capital types of enterprises are mainly dominated by state-owned enterprises. In contrast, the disparity between the Yangtze River Delta and the Pearl River Delta is chiefly due to differences in the division of labor within the industrial chain and each region's infrastructure and production requirements. In the later stages of the study, aside from some large upstream silicon raw material companies, most new firms were smaller. In addition to the factors above, this trend can also be attributed to many newly established companies being auxiliary firms providing products and support to leading enterprises, benefiting from the lower operational costs of these larger firms. Large-scale enterprises remain concentrated in the Yangtze River Delta, Beijing-Tianjin-Hebei, and other pioneering regions, with smaller enterprises more sporadically distributed near leading companies and in silicon raw material production bases.

In general, China's photovoltaic equipment manufacturing industry shows distinct signs of spatial agglomeration. However, an analysis of Moran's *I* index for the number of existing enterprises in prefecture-level cities (Table 2) reveals that this trend is gradually weakening despite the clear trend of industrial agglomeration. Initially, industries tended to cluster due to factors such as economies of scale, technological innovation, knowledge spillovers, and supply chain synergies. However, with the diversification of market demands, diseconomies of scale, shifts in the policy environment, technological advancements, cost reductions, and local government investment promotion, the spatial layout characteristics of the industry have gradually shifted from agglomeration to diffusion. Figure 4 indicates that the photovoltaic equipment manufacturing industry is expanding beyond its initial core regions, showing a decreasing spatial layout from east to west. In the eastern region, photovoltaic enterprises are primarily located in and around the core cities, whereas in the central and western regions, they are mainly concentrated in provincial capitals and cities with abundant solar energy resources.

Table 2 Statistics of Moran's *I* index of the number of photovoltaic equipment manufacturing enterprises in prefecture-level regions in China

	2005	2010	2012	2017	2021
Moran's *I*	0.455,59	0.481,96	0.474,93	0.461,44	0.404,93
Expectation index	–0.002,77	–0.002,77	–0.002,77	–0.002,77	–0.002,77
variance (statistics)	0.001,02	0.001,01	0.000,99	0.001,01	0.001,00
z-score	14.292,09	15.201,23	15.117,14	14.580,64	12.887,27
p-values	0	0	0	0	0

5 Conclusion and Discussion

After more than two decades of development, China's photovoltaic equipment manufacturing industry has emerged as a significant player in the global photovoltaic sector, contributing substantially to the global transition to clean energy and climate change mitigation. This study aims to analyze the evolution of the spatial layout of China's photovoltaic equipment manufacturing industry. It seeks to provide theoretical insights into the mechanisms that drive the spatial layout evolution of this emerging industrial system, optimize the organization of photovoltaic equipment production, and offer strategic guidance for developing other emerging industries.

This study relies on a dataset containing information on photovoltaic equipment manufacturing enterprises and related industrial parks as of the end of 2021. The dataset encompasses 68 industrial parks and 4,680 enterprises, with comprehensive data on each, including names, business statuses, registration times, registered capital, and business scopes. Data from multiple sources are cross-verified to ensure comprehensive coverage and high accuracy during the database's development. In the data cleaning phase, consistency is enhanced by standardizing and unifying fields such as registered capital, place of registration, and business scope. At the spatiotemporal level, the dataset incorporates time dimensions, spatial scales, and enterprise sizes and utilizes geocoding to visualize the data, ensuring a more precise representation of the evolutionary dynamics of the photovoltaic manufacturing industry from a multi-dimensional perspective. The analysis reveals that the number of firms in the photovoltaic equipment manufacturing industry increased rapidly during the study period, although growth has decelerated since 2018. Concerning enterprise size, there is a noticeable downward trend in average registered capital. The spatial and temporal analysis shows the industry's spatial layout exhibits significant agglomeration characteristics. However, this trend has gradually weakened with the industry's expansion, and the distribution of enterprises is now dispersing from core regions such as the Yangtze River Delta to peripheral cities and municipalities. Regarding enterprise scale, large enterprises are predominantly concentrated in economic hubs like Shanghai and Beijing and in resource-rich provinces such as Shaanxi, Guizhou, and Sichuan.

The study's dataset provides a comprehensive overview of the evolution of China's photovoltaic equipment manufacturing industry, encompassing both spatial and temporal dimensions. It is a solid foundation for a nuanced understanding of the industry's development trajectory, informed projections of its future direction, and formulating strategies for its integration into local economies. The dataset offers detailed insights into micro-level characteristics, including enterprise scale and geographical distribution, and captures macro-level industry trends. This robust dataset supports informed policy-making by enabling researchers to apply advanced analytical techniques to explore the industry's dynamics. It allows for examining multi-dimensional factors, such as economic linkages between regions, inter-enterprise cooperation and competition, and the influence of the social environment on industrial development. These studies provide a comprehensive assessment of the impact of photovoltaic equipment manufacturing on regional economic development, industrial upgrading, and employment, thus offering a scientific basis for more targeted and effective industrial policies and strategies.

Author Contributions

Zhang, X. P. contributed to the development and design of the dataset, as well as the revision of the data paper. Lian, W. H. was responsible for the design of the dataset development and research and authored the data paper. Wu, A. P., Song, J. W. and Pan, Z. J.

assisted in revising and refining both the dataset and the article.

Conflicts of Interest

The authors declare no conflicts of interest.

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