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Operating performance, industry agglomeration and its spatial characteristics of Chinese photovoltaic industry

Lingxian Zhang [a,b], Jieqiong Wang [a], Haojie Wen [a], Zetian Fu [a,b], Xinxing Li [a,*]

[a] China Agricultural University, P.O.209#, 17 Qinghua Donglu, Haidian District, 100083 Beijing, China
[b] China Key Laboratory of Agricultural Information Acquisition Technology (Beijing), Ministry of Agriculture, Beijing, China

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ABSTRACT

China is the world's largest energy consumer and is also leading in the solar photovoltaic industry. The solar energy industry, with advantageous clean and highly efficient production, is integral in maintaining the sustainable energy supply in an environmentally sensitive manner. Further development of the Chinese photovoltaic industry requires a status assessment for the current industrial setting. An analysis on the 58 Chinese photovoltaic listed enterprises is conducted in this study to analyze the operating performance, industry agglomeration and spatial characteristics of Chinese photovoltaic industry. Comprehensive analysis and evaluation of the enterprises' operating performance are based on financial data by utilizing the Data Envelopment Analysis (DEA) method; Systematic analysis examines spatial characteristics through the application of the spatial autocorrelation analysis method. Results confirm the Chinese photovoltaic industry preliminarily appeared industry agglomeration with enterprises mainly distributed in east and north China, and gathered in developed coastal provinces. Superior performing photovoltaic enterprises are specifically located in north China. Most of the enterprises are in the up-stream or mid-stream of the photovoltaic industrial chain. Overall operating performance of the photovoltaic industry in China suffers from weak profits due to low technical efficiency. The key to improve the future development of these enterprises is the improvement of operating performance by strengthening technical efficiencies. Concurrently, governmental guidance should address profitable photovoltaic industry investments and improvement of production rates.

Contents

* Corresponding author.
E-mail addresses: zhanglx@cau.edu.cn (L. Zhang), lxxcau@cau.edu.cn (X. Li).

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1. Introduction

Energy use has developed into a crucial concern as energy demand in the world has rapidly increased since the outbreak of the world energy crisis in 1973 [1]. Approximately 80% of the world's energy demand is served by fossil fuels [2] that are associated with dramatic environmental issues, such as climate change and global warming. Alternative resources of energy are then gaining attention as a method to supply needed energy [1].

Solar power is the leader in emerging energy and significantly contributes to environmental and socioeconomic benefits. The advantages of solar power is free, clean, abundant and easy to develop which has attracted extensive worldwide attention [3,4].

Solar photovoltaic (PV) industry as a rising renewable energy industry transform solar energy into electricity by utilizing the PV effect of solar cells combined with solar radiation reaching the earth's surface which varies from 0.06 kW/m^2 at high latitude to 0.25 kW/m^2 at low latitude [5]. Total global ice-free land is approximately 13000MHa, and collected solar power theoretically is approximately 21840TW [6], indicating the solar industry retains abundant resources, and may generate adequate energy to meet the increasing demand by combining with relative technology.

Solar PV application is expanding rapidly, crossed an important milestone with the total capacity of 100 GW, placing it as the third largest capacity producer after hydro and wind energy in 2012 [6]. More solar PVs were added worldwide in 2014 than wind power capacity with growth in global capacity averaging approximately 55% annually over the past five years [7].

China is rich in solar resources with daily average radiation of 4 kWh/m^2 per day and more than two-thirds of the country receiving radiation in excess of 5000MJ/m.yr with more than 2200 h of sun [8]. China facing dual pressure from clashing progress as the economy and population has expanded rapidly while advancing energy consumption, resulting in harmful CO_2 emissions. China became the largest energy consumer and CO_2 emitting country in the world in 2009 [9], further the traditional energy resources cannot meet the energy demand by 2020 and the CO_2 emission will be more seriously. It is necessity to develop renewable energy sources [10].

Chinese government has designated the PV industry as a strategic emerging industry for its development [11]. PV industrial parks have been developed in 300 out of 600 Chinese cities [12,13] and presently, the PV industry of China continues to experience enormous growth, becoming the fastest growing renewable energy industry after wind power generation in the world. China has been the largest photovoltaic manufacturing nation since 2008 when it achieved status as the largest producer of solar panels in the world [8,14]. Market share of Chinese PV has increased from 1% to 35% in the last 8 years with simultaneously increased quality production [15].

The last twenty years have seen the growth of both solar PV manufacturing capacity and deployment in China, yet this growth has followed a very erratic path [16]. From the international perspective, Chinese PV industry faces several challenges, such as the EU and US “anti-dumping and anti-subsidy”, the re-emergence of the international enterprises etc. [11]. From the domestic perspective, there also exist a lot of issues, such as the downturn market, unbalanced supply-demand, shortage of relevant technology and the high driving costs [17–19]. Thus it can be seen that the hortative policies established by the central government are difficult to implement by local government due to the local behalf [10].

To address the needs of the fast health growth of Chinese PV industry, it is critical to promote the product competitiveness and the regional advantage of natural resources and industry agglomeration of Chinese PV industry in different region. It is of great significance to study operating performance, industry agglomeration and its spatial characteristics of Chinese photovoltaic industry.

Most qualitative research related to the Chinese PV industry focus on its development status, the remaining problems such as high investment risks, low product price, over-dependence on foreign markets, and the supply policies [10,11,17]. Qualitative research mostly focused on the Structure Conduct Performance (SCP) analysis, Strengths Weaknesses Opportunities Threats (SWOT) and other economic analysis method. Examples of these methods include: Yuan Jiahai et al. [20] estimated the generation cost of distributed PVs in China by applying a levelized cost of electricity (LCOE) analytical framework, proposed a series of policy packages to address the resulting issues; Zhao Xingang et al. and Wu Hao et al. [21,22] reviewed the present status and the development trend of Chinese PV industry, analyzed the issues and effects on the development of the industry; Zhang Sufang [8] analyzed China's PV industry development and policy; Zhi Qiang et al. [23] analyzed Chinese PV policies, comparing them with other developed countries' from the perspective of supply-demand, declared government should reinforce market demand-side while gradually exiting the production supply-side. There less quantitative research on Chinese PV industry, most of them are primarily utilize the learning curve theory, analytic hierarchy process and the DEA analysis method. Da Zhang et al. [24] studied the cost reduction trend by using the learning curve theory and set different scenarios to estimate time and the total learning cost of PV power's grid parity. Tang Yong et al. [25] analyzed the key technology of Chinese PV industry by using the Delphi-AHP (analytic hierarchy process). Jasper Rigter and Georgeta Vidican [26] pointed that the cost of small scale PV in China has decreased and its optimal feed-in tariffs vary widely between regions. Liu Xueqin et al. [27] made evaluation on Chinese PV listed enterprises' operating performance by applying the DEA method to explore the development status of the PV industry. However, there also lacks research on the industry agglomeration and spatial characteristics of Chinese PV industry.

In this context, this paper aims to combine the qualitative and quantitative method to identify the intrinsic way to promote the development of Chinese PV industry from the perspective of its