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Nurturing an Emerging Industry: State Husbandry, Midwifery, and the Development of China's Photovoltaic Sector

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Abstract

This paper explores the role played by the Chinese government in the development of the photovoltaic (PV) industry. As an emerging industry providing clean energy, its development and relatively high costs determine that it cannot be separated from the support of national industrial policies. Based on Evans' theory on the roles of the state, this paper analyzes the government's intervention behaviors primarily from the dimensions of the "husbandry" and "midwifery" roles. The research finds that when private actors meet difficulties in the market, the state plays a "husbandry" role by guiding state-owned enterprises (SOEs) to join the PV sector and M & A businesses, and by engaging in capital and technological cooperation with private companies. Meanwhile, the government plays a "midwifery" role by including PV development in national economic plans, providing financial subsidies, and establishing incentive policies such as feed-in tariffs to back up existing private actors and attract investors and consumers. As the market matures, the national policy orientation has gradually shifted from vigorous support to giving room for market coordination, aiming to facilitate the PV sector to grow independently and sustainably. Overall, the state's active intervention has successfully boosted market confidence, decreased industrial costs, and raised production efficiency, exerting a remarkable effect on promoting China's PV sector.

Keywords

Photovoltaic (PV) Sector, State Role, Industrial Policies

1. Introduction

Photovoltaic (PV) has been an emerging industry in recent decades. PV generates electricity from solar power; therefore, it produces clean energy. These clean-en-

ergy characteristics have drawn sustained regulatory attention and align with the broader policy imperative to replace fossil fuels with low-carbon alternatives. In this way, China has been devoted to developing PV for a long time as a strong economy facing severe environmental problems in certain urbanised areas. In this process, both the Chinese central and local governments have influenced the PV industry growth by forming and implementing various policies and have earned remarkable achievements.

Many scholars have researched the characteristics of the PV industry in China, and they have widely discussed the role of the Chinese government in the development of the PV sector. Some of them oppose the involvement of the state. Yu and Lv (2015) investigate a large number of subsidiaries in the PV industry and state that the PV companies depend too much on government support. Wang and Zhang (2015) have questioned the financial protection that has led to productivity. Yan (2017) has found that the support policies negatively impact corporate inventories and profit margins. However, some scholars hold different opinions. They believe that from the perspective of subsequent industrial development after the financial crisis in 2008, the Chinese government has made the photovoltaic industry out of the crisis by further taking strong supply-side intervention measures (Bao et al., 2022). Guo et al. (2018) have found that the synergistic use of financial, especially fiscal and taxation measures, has a significant positive impact. Dong et al. (2021) have analyzed the impact of factors and concluded subsidies for electricity generation have the maximum utility.

Based on the previous studies on the PV's emerging development, the present study examines the research question that has not been studied: what roles the state play in developing the PV sector in China. Furthermore, this study has certain valuable empirical implications on state involvement in both China and other economies. Particularly, the presence of China's government in the PV sector could illustrate the state behaviour pattern in the state-business interaction in the emerging industry. Meanwhile, China's successful experiences afford lessons for other countries, especially developing countries that pursue incentives for relevant industries to grow.

The next part introduces the research methods, including the analysis framework and the referred materials. The following sections briefly summarize the development history of China's PV sector and the necessity for China's government to conduct an intervention in this sector. On the basis of that, the final part evaluates the state's role by applying Evans' theory, followed by the impacts on the development of China's PV sector from the state's role.

2. Research Methods

The present study applies the theory of Evans (2012) on the roles of the state in the interaction between the state and business to analyze the Chinese government's roles in the PV sector. Evans (2012) identifies four categories of state role in industrial development: demiurge, custodian, husbandry, and midwifery. The

demiurge role denotes the state acting directly as producer, typically through SOEs, while the custodian role involves the state constraining private participation through regulation. Both reflect a pessimistic view of private actors' capacity. By contrast, the husbandry role captures instances in which the state nurtures and supports existing private or mixed-ownership actors—for example, by guiding SOEs to partner with struggling private firms or by facilitating mergers—without displacing them; an action is classified as husbandry when the state steps in alongside (rather than instead of) market actors to shore up viability and build capacity. The midwifery role covers state efforts to bring new private actors into being or to stimulate demand—such as including an industry in national plans, providing subsidies, or setting feed-in tariffs—so that a sector can develop under predominantly private ownership. In order to promote an emerging industry, the evidence presented below demonstrates that China's government has concentrated primarily on the husbandry and midwifery roles.

The present study draws on various types of materials. As the PV is an emerging and promising sector, plenty of business reports provide inferences for investors and administrative officers, and some websites collect policy information. In addition, data and estimates are drawn from non-profit organizations aiming to promote the clean energy, including solar energy, including the International Energy Agency (IEA), founded in 1974, an autonomous body within the framework of the Organization for Economic Cooperation and Development (OECD), as well as World Resource Institute.

3. The Development of the PV Sector in China

The real photovoltaic industry in China started in the late 1990s and started relatively late compared with European and American countries (Wang & Ju, 2015). At the beginning of this century, China entered the stage of PV industrialization with the establishment of polysilicon solar cell production lines in Wuxi and Baoding. During the same period, European countries, represented by Germany, introduced policies to subsidize solar power generation, and the rapidly growing downstream demand provided a broad market for Chinese PV cells and module products (European Parliament, 2007). The Chinese government quickly seized the opportunity and introduced various policies such as investment subsidies, tax incentives, financing support, and poverty alleviation to encourage PV manufacturing enterprises to increase production capacity and promote the rapid expansion of the PV industry. Due to the government's strong support and the positive response of enterprises, China's PV industry developed rapidly. It has gradually made remarkable achievements during the first ten years and has become a backbone emerging industry with international competitive advantages (He & Xiao, 2018). However, the industrial policy that focuses too much on the supply side has caused the Chinese PV industry to rely heavily on foreign markets, and the domestic market has grown slowly. Bao et al. (2022) concludes that, in general, China's photovoltaic industry has a "two-outside" pattern (polysilicon and pho-

tovoltaic power generation systems).

Two categories of factors converged to produce the post-2008 crisis. Externally, the global financial crisis compelled EU governments—led by Germany—to curtail feed-in tariff support for solar power generation from 2008 onward, sharply contracting the export market on which Chinese producers depended. In 2011 and 2012, the United States and the European Union launched anti-dumping and countervailing-duty investigations into Chinese PV modules, imposing tariffs that further restricted access to overseas markets. Internally, the industry was structurally exposed: a "two-outside" pattern had emerged in which both upstream polysilicon inputs and downstream power-generation demand were heavily reliant on foreign sources, leaving domestic capacity severely overextended (Bao et al., 2022). Rapid capacity expansion, driven partly by uncritical local government support for industrial parks regardless of market signals, had created persistent overcapacity and compressed profit margins. These internal vulnerabilities meant that, when the external shocks struck, Chinese firms faced a perfect storm of falling revenues and rigid costs: companies locked into long-term polysilicon procurement contracts at pre-crisis prices found their raw-material costs unchanged while selling prices collapsed. The result was large-scale losses, suspension of production, and in some cases bankruptcy. Each vulnerability motivated a distinct state response: export dependence prompted policies to cultivate the domestic market, while overcapacity drove consolidation measures such as mergers, stricter technical access thresholds, and the elimination of outdated production lines.

To save the PV industry that has fallen to the bottom, regulatory policies represented by the "Several Opinions of the State Council on Promoting the Sustainable Development of the Photovoltaic Industry" have been issued, mainly including several guidelines for the PV manufacturing industry on further optimization, led by the National Development and Reform Commission and Ministry of Finance. The general idea and guiding ideology encourage innovative advanced technologies to eliminate outdated production capacity and promote market growth in every province and city. Other things being equal, the state tried to correct the market failure resulting from the lack of information about demand decline and shortcomings in technology innovation (Wolf, 1987). Besides raising the technical access threshold, the state has supported major enterprises to implement mergers and reorganizations through market access such as taxation, financing, and other credit resources. Particularly, the Chinese government encourages SOEs and private to cooperate in implementing the strategy of expanding the international market, using domestic and international markets simultaneously to promote downstream development to absorb excess capacity in the upper reaches (Bao et al., 2022).

4. The State's Roles

According to MGI's report (MGI, 2010), the government needs to tailor the specific policy to stimulate the private sector to grow with high competitiveness.

Competitiveness is regarded as the capacity to increase productivity or expand employment. For the PV sector, because it technically belongs to the manufacturing sector, it is essential that the enterprises offer relatively high-quality PV products at a competitive cost to the market. The government's tools are used very widely, which vary from protecting local players from international competition to providing incentives for a local manufacturer to export or establishing large scale SOEs to cooperate with private enterprises in the field of R & D and market expansion. For instance, the state can make policies to establish trade barriers or enter regulations to protect local production. It can also provide local companies with preferential fiscal subsidies or capital resources to lower costs for acquisition and expansion in the foreign market.

Besides, solar photovoltaic manufacturing is both a technology-intensive industry and a capital-intensive industry (Yuan, 2013). The cost of development of the solar photovoltaic industry is relatively high. These industrial characteristics determine that the development of the photovoltaic industry cannot be separated from the support of the government's industrial policies. Therefore, the industrial policies, especially the incentive policies, have played a very important role in boosting the development of the PV industry.

In China's PV sector development, local governments exercise considerable autonomous discretion alongside—and at times in tension with—central government directives. A concrete illustration of this divergence concerns subsidy disbursement: the central government's feed-in tariff and Golden Sun subsidies were formally administered through national ministries, but local governments were responsible for approving project applications and, in many cases, supplemented central subsidies with provincial or municipal grants to attract investment to their jurisdictions. This competition among localities to cultivate PV industrial parks led several provincial governments to approve capacity expansions well beyond what national planning targets envisaged, contributing directly to the overcapacity documented by Bao et al. (2022). In Jiangsu and Xinjiang, for instance, local incentives—including subsidised land, discounted electricity, and tax holidays—encouraged rapid entry by firms that did not meet the technical standards the central government subsequently sought to enforce through its 2013 consolidation measures. The divergence had two effects on industry outcomes: in the short run, local competition accelerated capacity growth and drove down module prices faster than central planners had anticipated; in the medium run, it amplified overcapacity cycles and delayed the consolidation that the central government's husbandry policies were designed to achieve. Notwithstanding these tensions, the policies of the governments at all levels share an overarching orientation toward the husbandry and midwifery roles, as elaborated below.

4.1. Husbandry Role

In regard to the combination of support and prodding, the state plays the husbandry role in the PV sector (Evans, 2012). The husbandry form is embodied in

that the government takes over the emerging sectors by setting up state-owned enterprises when the private actors meet difficulties involved in the market. In China's PV sector case, the state plays like a husband in many forms.

- At the central government level, guided by the State-owned Assets Supervision and Administration Commission of the State Council (SASAC), plenty of state-owned enterprises join the PV sector. The SOEs usually have adequate financial support from the state policy banks, such as the China Development Bank. Therefore, they are more capable of surviving in the new business sector. In terms of the M & A business, the state-owned solar panel glassmaker Luoyang Glass has taken over the management of two rivals and plans to acquire controlling stakes in them (Shaw & Hall, 2022).
- Moreover, Chinese SOEs come to the PV sectors by engaging in cooperative ties with the private actors. Some SOEs have dominated the acquisition of the PV private companies with huge investments in the PV sectors, but they seek opportunities to participate in joint programs so that the SOEs and private ones can take each other's advantages, the capital resources and advanced management and R & D experience respectively. For instance, according to the 2020 annual report, Solar developer China Shuifa Singles and fellow state-owned entity HECIC Huineng planned to jointly capitalize an RMB360 million seven-year fund to invest in clean power projects, including solar, wind, hydrogen, energy storage and intelligent energy facilities. Beyond that, the national capital also cooperated with the private actors on research and technology (Shaw & Hall, 2022). This could be exemplified by the slippers-to-solar manufacturer Golden Solar, which has identified state-owned power company China Three Gorges Corporation as a partner in the project to develop a National Engineering and Research Center for High Efficiency Solar Cell Equipment and Technology.

4.2. Midwifery Role

At all levels, the central and local governments also play the midwifery role in China's PV sector. The midwifery state promotes a new sector by adopting various policies and techniques to back up the market's existing private actors. In comparison, the custodian also affects the industry through regulative tools, but it is based on the negative perception of the private sector. The two typical forms, subsidies and incentives, are both implemented by China's governments toward the PV industry.

- Firstly, developing solar power has been recognized as a national target. At the central government level, the PV related marks were stated in the integral economic plan in China, proved by the 13th Five-Year Plan of Solar Power Development being issued in 2016. Besides, a Solar PV for Poverty Alleviation Program was launched in 2014, affirming the role of PV in poverty alleviation (Yuan et al., 2018). In terms of the local governments, the development of the PV industry appeared in the Government Work Report in provinces and mu-

nicipalities directly under the central government, including Guangdong, Shanghai, Beijing, etc., and became the focus of work pushed by local governments in 2022, which aims to induce existing entrepreneurs to take on more challenging efforts, including replacing the outdated technologies with advanced ones.

- Secondly, the governments at all levels established various solid incentive policies and adjusted the policies to coordinate with the market status. In 2009, the Ministry of Finance, the Ministry of Science and Technology, and the Bureau of Energy jointly released the Notice on the Implementation of the Golden Sun Demonstration Project, which was the first official supportive policy in the PV area. Principally, the competent administrative department shall subsidize 50% to 70% of the total investment in the photovoltaic power generation system and its supporting power transmission and distribution projects, especially before the project is finally completed (King & Wood, 2021). In 2013, the National Development and Reform Commission issued a Notice on Applying Price Leverage to Promote the Health Development of the PV Industry and suspended the Golden Sun project. Since then, installing the PV could earn two parts of revenue, the subsidies, and the feed-in-tariff, which is the profits from selling the electricity power to the State Grid Corporation of China by connecting the PV to the national power grid, respectively. In this period, the price of electric power generated by PV was equal to the local coal-fired unit electricity price.
- The competent department adjusted the electricity price rule by announcing the Notice on Improving the Photovoltaic Power Feed-in-Tariff Mechanism. This document required that the actual price of electricity shall be determined through market competition, and the final price of electricity for each project shall not be higher than the guided price in the resource area divided by the government (King & Wood, 2021). The change in this phase depicted the weakening support and inducing the market mechanism to be more functioning. The central government further loosened its intervention in 2021 when releasing the Notice on the New Energy Feed-in-Tariff Policy 2021. The Notice raised that, since 2021, the central government shall no longer provide subsidies and shall implement grid parity for newly registered centralized PV power stations and industrial and commercial distributed PV projects. The grid parity means that the feed-in tariff shall be equal to or lower than the existing average electricity generating cost.

4.3. Trade-Offs and Unintended Effects

While the state's husbandry and midwifery roles produced the benefits documented above, they also generated significant trade-offs and unintended effects that must be acknowledged within the same analytical framework.

First, the midwifery instruments—particularly subsidies, feed-in tariffs, and local industrial-park incentives—simultaneously stimulated growth and amplified

overcapacity cycles. Because the state guaranteed revenues through above-market feed-in tariffs and subsidised entry costs, private and state-owned actors flooded the market beyond demand, producing the structural overcapacity that Bao et al. (2022) and Yu and Lv (2015) document. This is not a failure of the midwifery role per se—stimulating supply-side entry is precisely what midwifery entails—but it reflects the absence of sufficiently granular demand-side intelligence and a mechanism to restrain excess entry once viability was established.

Second, subsidy arrears became a recurrent fiscal problem: as installed capacity expanded rapidly after 2013, the central government's subsidy liability grew faster than the renewable-energy surcharge revenue collected to finance it, leaving many project developers with unpaid subsidy claims for several years (King & Wood, 2021). This delayed cash flow undermined the financial viability of smaller enterprises, partially offsetting the investment confidence that midwifery policies sought to build.

Third, local protectionism, a structural by-product of competitive husbandry at the sub-national level, fragmented the national market: some provincial governments favoured locally manufactured equipment in procurement, reducing competitive pressure on domestic firms and contributing to quality heterogeneity across the sector.

Fourth, the rapid capacity expansion associated with both husbandry (SOE entry) and midwifery (subsidy-driven private entry) contributed to episodes of low-quality product proliferation before technical standards were sufficiently enforced.

These effects do not negate the overall positive trajectory of China's PV sector, but they illustrate that the husbandry and midwifery roles carry intrinsic tensions: the same state actions that nurture an emerging industry and attract new entrants may, if poorly calibrated or incompletely sequenced, generate the overcapacity, fiscal liabilities, and local capture that later require additional state intervention to correct.

4.4. The Impacts on China's PV Sector from the State's Roles

The midwifery role helps to attract more investors and consumers into the PV sector and thus helps the industry to grow. First, the official report and documents delivered the unequivocal message that the PV would be the development direction of the energy and indicated that government would further cultivate this sector by various means. In addition, China government have a relatively strong intervention capacity in the economic actors and the market trends, meaning that the sector with policy preferences tends to grow well. Consequently, the investors build confidence in the PV sector and are convinced that the PV sector would have a positive development prospect, and they are willing to give it a shot.

The regulative measures implemented in the PV industry attract more consumers by offering financial interests. The incentive policies are solid and have extensive coverage in China. Specifically, the PV generating electricity could be directly

used by the equipment owners freely. Also, the subsidies for applying the PV equipment equates with the profits for the PV buyers. Next, the regulations allow the PV owners to sell the electricity to the State Grid Corporation of China by connecting to the power grid. In this way, the citizens, building owners and enterprises could earn additional interests from two to three approaches, the income from subsidies, the savings of power costs, and the revenue as a feed-in-tariff from selling the surplus power. These incentives, coupled with the long-term durability of solar PV systems, make them an attractive investment for project developers. Accordingly, many individuals would like to consume PV products for the tempting benefits particularly guaranteed by the governments' policies.

Empirical indicators confirm that the husbandry and midwifery roles of the state produced measurable outcomes across three dimensions. First, module prices fell dramatically: the average selling price of Chinese crystalline-silicon modules declined from approximately USD 4.00 per watt-peak in 2008 to below USD 0.25 per watt-peak by the early 2020s, a reduction of more than 93 percent, driven by scale economies and technology learning that preferential financing and procurement policies helped accelerate (IEA, 2022; Bao et al., 2022). Second, the levelised cost of electricity (LCOE) from utility-scale solar in China fell by over 80 percent between 2010 and 2022, enabling the grid-parity transition formalised in the 2021 feed-in tariff reform (IEA, 2022). Third, annual installed capacity grew from roughly 0.3 GW in 2010 to 53 GW of newly added capacity in 2021 alone (Shaw & Hall, 2022), with China accounting for approximately one-third of global cumulative installations. The feed-in tariff mechanism directly underpinned demand growth by guaranteeing revenue to project developers, thereby justifying large-scale private investment; once LCOE reached grid parity, the state withdrew guaranteed subsidies—confirming that midwifery support had achieved its objective of enabling market self-sufficiency. The preferential fiscal subsidies and technical access thresholds associated with husbandry intervention accelerated quality improvement and consolidation, contributing to the cost reductions documented above.

5. Conclusion

The Chinese government has the motivation to promote the PV sector for several reasons. Firstly, it is an emerging industry that is weak and requires capital and policy support to grow. Then, it generates sustainable and clean energy that is beneficial for China's economy and society.

The state exercises a remarkable effect on promoting the PV sector in China by playing husbandry and midwifery roles. Firstly, the state directly involved itself by guiding state-owned enterprises to enter the PV business and cooperate with private companies. Secondly, the Chinese government also serves the midwifery role considering it involved the development of the PV sector in the national economic plans and has formed and implemented many incentive policies, including subsidies and feed-in tariffs favouring the consumers, investors, and producers in the

area. Meanwhile, the incentive policies are adjusted according to the market conditions; for instance, as the market matures, the degree of the policy encouragement has witnessed mitigation.

The role of the state has successful effects, proved by the promising market condition. Quantities of consumers are attracted to install the PV equipment due to the government's positive recognition embodied by adding the PV development into economic plans and incentive policies represented by subsidies and feed-in tariffs. The producers are also willing to rush into the PV production with confidence towards the sector contributed by the attitude of the government. The decreasing costs and price of PV equipment and the rising installations could illustrate the positive impacts of China's state role in the development of the sector.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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