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Analysis of China's Overcapacity and Influencing Factors: Evidence from New Energy Industry

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ABSTRACT

This paper utilizes the annual data of 216 Chinese new energy listed companies from 2008 to 2023 to evaluate their capacity utilization rate and identify the extent of overcapacity using the production function method. Subsequently, we examine the influencing factors of the overcapacity by constructing a fixed effect model. Our findings reveal that from 2008 to 2023, the average capacity utilization rate for China's new energy industry was 24.9%, significantly lower than the normal level, indicating a severe overcapacity issue. The study also highlights that market demand and market price both have a negative impact on China's new energy overcapacity. In other words, the decline of market demand and price will exacerbate the overcapacity. However, the increased market demand in mid and downstream industries may exacerbate overcapacity. This is due to the varying stages of development in different segments of China's new energy industry, which result in different influences of market factors on overcapacity. Moreover, we investigate the diversity of enterprise types and reveal that non-state-owned enterprises have a lower capacity utilization rate compared to state-owned enterprises. In light of the findings, we propose a series of recommendations aimed at effectively addressing the overcapacity issue and fostering the sustainable growth of the new energy industry. Finally, we identify the constraints of the study and present a prospective framework for future research.

Introduction

As the world's largest manufacturing exporter, China has long suffered from overcapacity. According to the National Bureau of Statistics (NBS), China's above-scale industrial capacity utilization rate was 75.1% in 2023 and 73.6% in 1Q2024, a figure that is the third lowest since 2013. Compared to other countries, in 1Q24, the industrial capacity utilization rate was 77.4% in the US and 81.3% in Germany, with China at the lower end of the global scale. There has been a significant decline in key industries such as automobile manufacturing and electrical equipment related to China's new energy sector, with decreases of 7.1 percentage points and 3.1 percentage points respectively from the previous year. The rapid rise of China's new energy vehicles in recent years has enabled the country to rapidly become the world's largest car exporter in 2023 from a net importer of cars in 2019. Data from the China Association of Automobile Manufacturers (CAAM) show that China's new energy vehicle production and sales reached 9.587 million and 9.495 million in 2023, ranking first in the world for nine consecutive years and accounting for 31.6% of all vehicle sales. Recently, the global political and academic debate over China's overcapacity in the new energy sector has intensified. The underlying reason is that China's industrial policy is moving into strategically important high-value-added areas, and China's attempt to move into the higher end of the value chain has raised concerns among stakeholders about whether it will lead to market distortions and competitive imbalances.

On January 29, 2022, China's National Development and Reform Commission (NDRC) and the National Energy Administration (NEA) issued a circular on the “14th Five-Year Plan for a Modern Energy System,” which aims to promote the high-quality development of the energy industry. In addition, on June 20, 2024, Zhang Jianhua, Director of the National Energy Administration, responded to the issue of overcapacity in new energy at a press conference, stating clearly that there is no so-called “overcapacity” in China's new energy industry, and emphasizing that the balance between supply and demand is relative, and imbalance tends to be the norm. At the same time, it is pointed out that a moderate excess of supply over demand can help the whole industry's technological progress and product cost reduction. However, views on whether there is indeed overcapacity in China's new energy industry are not unanimous. As Zhong Chunping and Pan Li (2014) point out, "overcapacity" is often plausibly controversial, and at the international level and in academic research, capacity utilization is usually more scientific and objective than "overcapacity". They also believe that China's current overcapacity problem has been overemphasized and may be distorted. So, from the perspective of capacity utilization, is there overcapacity in China's new energy, and if so, to what extent? What are the deep-rooted causes of overcapacity and the path to resolving it?

Based on the above background, it is of great practical significance to explore the status quo of production capacity and the mechanism of overcapacity in China's new energy industry: (1) The immense size of China's manufacturing sector means that overcapacity is not only a domestic issue for China, but also a global concern. Some experts worry that China's increasing dominance in key industries could hinder the growth of those industries in other countries. For instance, new energy vehicles, currently a major focus, are crucial for many economies, particularly in Europe. Therefore, exploring the issue of China's new energy overcapacity is a useful reference for dealing with trade protectionism, geopolitics, and other concerns. (2) New energy is a green industry, and rationalizing the supply and demand of new energy and its industrial layout will be conducive to promoting the green transformation of countries around the world and facilitating the realization of global sustainability goals. (3) The study of the current development difficulties faced by the new energy industry is of great theoretical and practical significance in guiding the healthy development of China's new energy industry and even the strategic emerging industries, promoting industrial restructuring and transforming the mode of economic development, etc. (4) Our conclusions and policy recommendations may also be applicable to other developing countries that are experiencing rapid growth and following market mechanisms.

Literature Review

The term "overcapacity" was first proposed by the American economist Chamberlin in "The Theory of Monopolistic Competition" (1933). It was first defined by Chamberlin in 1947 from the perspective of microeconomics as a state of inefficiency in economic organization that deviates from "perfect capacity" under the equilibrium conditions of imperfect competition. From a micro perspective, Chinese scholars argue that the excess production capacity formed by firms' actual output being seriously lower than the reasonable range of expected capacity is called overcapacity (Lu Feng, 2009; Cao Jianhai and Jiang Feitao, 2010).

A full understanding of the causes of overcapacity is a necessary condition for improving capacity utilization and resolving overcapacity. As developed countries in the West have relatively sound market mechanisms, researchers have explored the causes of overcapacity from the perspective of market factors; Kaldor (1935) pointed out that in the oligopoly and monopoly markets, the incumbent would deter potential entrants with excess capacity, and Hilke (1984) empirically proposed the basis for the deterrent effect. Some literature examines, in the context of economic growth modeling, that firms in equilibrium also have excess capacity when there is uncertainty in demand (Sheshinski and Drèzer, 1976) or fluctuations in the marginal productivity of capital (Greenwood et al., 1988). China's economic system and industrial structure are different from those of Western countries, so the causes of excess capacity are different. Wu Chengkuan (2022) pointed out that the distortion of the local government's behavior due to the planned economy part and incomplete market-oriented reforms that still exist in China's economic operation are the fundamental causes of Chinese-style overcapacity. Government behavior is an important reason affecting the overcapacity of Chinese firms, Geng Qiang et al. (2011) introduced capacity utilization into the RBC model and found that increased policy subsidies will form overcapacity more quickly. Yan et al. (2020) explored the impact of government financial subsidies on the economy, innovation performance, and overcapacity in China's strategic emerging industries. They concluded that, in general, there is overcapacity in China's strategic emerging industries, and that financial subsidies can significantly improve the economic performance of enterprises, but also worsen the overcapacity at the same time.

Some scholars have also studied from the market perspective, such as Lin Yifu et al. (2010), who proposed the "surge phenomenon" of investment from the perspective of information asymmetry. Dong and Su (2022) used a three-stage investment model and found that the market's influence on investment is stronger than that on capacity withdrawal, thus leading to overcapacity.

Regarding the new energy industry, there have been several literatures exploring the problem of overcapacity in China's new energy industry. For example, Wang Hui and Zhang Yueyou (2015) used the production function method to measure capacity utilization and pointed out that China's photovoltaic industry has more serious overcapacity, and it is composed of structural overcapacity and institutional overcapacity. Zhang Huiming et al. (2016) used a threshold regression model and found that government subsidies have exacerbated the risk of solar energy firms' overcapacity, but they help to solve the overcapacity problem of wind energy firms. Wu Chunya et al. (2015) analyzed the overcapacity situation of PV and wind energy listed industries by using the multi-stage solution method of the guided DEA model and pointed out that the overcapacity is the result of the joint action of "market failure" and "government failure" in the complex environment. Most scholars regard government intervention as the cause of overcapacity in the new energy industry (Yu Donghua et al. 2015; Hu Hui et al. 2020; Zhang Qin, 2023).

To summarize, most of the current scholars' research on China's new energy focuses on the government policy level and seldom analyzes it from the market perspective. Most scholars mainly focus on the photovoltaic and wind energy industries when selecting new energy industries. This paper joins the exploration of market demand and market price factors to further develop the scope of research on the impact mechanism of China's new energy overcapacity. Expanding the new energy industry to include upstream solar, wind, nuclear, and photovoltaic industries, as well as downstream lithium batteries and new energy automobiles, this paper has a broader coverage and provides a more comprehensive view of the development of China's new energy industry from a holistic perspective. In addition, the data selected in the previous article is earlier, and the development of the new energy industry is updated faster, this paper selects the latest data up to 2023 to better explore the current new energy production capacity, which is of great policy significance in guiding the development of China's new energy industry.

Research Design

Key Variables

(1) Explained Variables. Overcapacity (OC). We use the difference between potential ■(^@Y) and actual output Y estimated based on the production function method to measure the overcapacity, while taking the natural logarithm of this value to reduce data volatility.

(2) Explanatory Variables. Huizinga (1993) used cost margin as an indicator of relative market price in his study of the effect of price on investment in manufacturing. Moser et al. (2017) argued that price fluctuations may affect the selling price or the cost of goods sold; in most cases, price fluctuations are reflected in gross margins. Dong Kaiqiang and Su Wei (2022) argued that cost margin is a good market price signal in which the information includes output and input prices. Therefore, we select cost margin (MP) as a measure of market price factor. In addition, we use the inventory turnover of manufactured goods (MD) as a proxy variable for market demand. On the one hand, the inventory turnover of manufactured goods offsets the price factor by dividing sales by the value of finished goods. On the other hand, typically, firms' inventory fluctuations are closely related to market demand (Kolias et al., 2011; Braguinsky et al., 2015), and the higher the market demand, the faster the inventory turnover of finished goods. To further control for the endogeneity of the variables taken by the firm's factors, we use the first-order lagged term of cost margin (L1_MP) and inventory turnover (L1_MD) as explanatory variables to represent the market factor.

(3) Control Variables. Referring to the relevant literature, the control variables selected in this paper are: government subsidies (Subsidy); enterprise size; age; asset-liability structure (Lev); research and development investment (RD); cashflow; profitability (ROA); growth; nature of the enterprise (Soe); and year dummy variables (Year)

to control the impact of changes in the macroeconomic environment in different years. The main variables and their definitions are shown in Table 1.

Table 1. Key Variables and Definitions

Type	Symbol	Meaning	Variable Description
Explained Variable	OC	Overcapacity	$LN(\hat{Y}-Y)$
	CU	Capacity Utilization	$Y/\hat{Y}$
Explanatory Variable	L1_MD	Market Demand Signal	Inventory turnover (prior year) = Operating costs/average inventory balance
	L1_MP	Market Price Signal	Cost margin (prior year) = (operating income - operating costs) / operating costs
Control Variable	Subsidy	Government Subsidy	LN (Government grants disclosed in the appendix to the annual financial statements of an enterprise)
	Size	Corporate Size	LN (total asset)
	Age	Corporate Age	LN (Year of survey - year of establishment of the enterprise)
	Lev	Financial Leverage	Total liability/total assets
	RD	R&D Investment	Total R&D investment/revenue
	Cashflow	Corporate Cash Flow	Net cash flow TTM/total assets
	Roa	Corporate Profitability	Return on assets = net profit/total assets
	Growth	Corporate Growth Potential	Growth rate of annual business income of the enterprise = [business income in period t - (business income in period t-1)]/(business income in period t-1)
	Year	Year Dummy Variable	Year 2008-2023
Moderator Variable	Soe	Ownership of Corporate	Dummy variable, state-owned enterprises = 1, non-state-owned enterprises = 0
	Ind	Industry Segment	Dummy variable, upstream industry = 1, midstream and downstream industry = 2
Variables needed to calculate overcapacity	K	Capital Input	Average Net Fixed Assets
	L	Labor Input	Total number of employees
	Y	Actual Output	Gross Operating Revenues

Overcapacity Measurement Model

There is no clear standard for measuring overcapacity, and a variety of methods are commonly used to address this challenge. These include the production function method, cost function method, peak method, stochastic production frontier (SPF), data envelopment analysis (DEA), financial index method, and others. Morrison (1985) employed the cost function method to assess the capacity utilization of the U.S. automobile industry. This approach allows for the incorporation of a range of input variables influencing output capacity. However, the form of the cost function is challenging to ascertain, the heterogeneity of input factors is difficult to differentiate, and the quality of the data is a significant consideration. The peak method was initially proposed by Klein in 1960. It reflects the utilization of industrial capacity by comparing the highest output and the actual output during the peak period within a specified time frame. The peak method is applicable to situations involving a single input and a single output. Its advantages include wide applicability and low data requirements. However, a disadvantage is that it assumes that capital in the measured year does not change, which is inconsistent with reality. The data envelopment analysis (DEA) method is a measure of relative effectiveness and is generally more suitable for multi-output situations. However, it does not account for data variability and is prone to high capacity utilization rates. The stochastic production frontier method necessitates the identification of the precise form of the production function.

Klein and Preston (1967) pointed out that the production function method can be used to measure potential output and capacity utilization, which is currently the most used method to estimate potential output internationally. In this paper, the production function method is selected for the following reasons: (1) the production function method is based on the economic growth theory, which has a strong theoretical basis; (2) it takes into account the role of capital inputs, labor inputs, and technological progress factors in capacity output, so we can effectively analyze the contribution of different factors; and (3) it has an obvious advantage in terms of data availability.

The main steps are: First, determine the basic form of the boundary production function, and estimate the specific form of the average production function by using the appropriate regression model. Second, calculate the difference between the observed value of the output in the sample interval and the corresponding estimate of the average production function, and take the maximum value of the difference and add it to the constant term of the average production function, so as to obtain the specific form of the boundary production function. Finally, based on the specific form of the bounded production function, the potential output is calculated, and the potential output is compared with the actual output to obtain the capacity utilization rate.

In this paper, the boundary production function is set to be the most widely used Cobb-Douglas (C-D) production function, which has the following basic form:

$$Y = f(K, L, A)e^{-\mu} = AK^{\alpha}L^{\beta}e^{-\mu} \qquad (1)$$

In the model, Y represents real output, K represents capital inputs, L represents labor inputs, and α and β represent the output elasticities of capital and labor, respectively, with α > 0 and β > 0. By taking logarithms on both sides of equation (1), we obtain:

$$\ln Y = \alpha \ln K + \beta \ln L + \ln A - \mu \qquad (2)$$

Thus, the boundary production function takes the form:

$$\ln Y^{*} = \alpha \ln K + \beta \ln L + \ln A \qquad (3)$$

Y^{*}denotes the potential maximum level of output. Let $\ln A = \delta, E(\mu) = \varepsilon$, and rewrite equation (2) as:

$$\ln Y = \alpha \ln K + \beta \ln L + (\delta - \varepsilon) - (\mu - \varepsilon) \qquad (4)$$

By $E(\mu - \varepsilon) = 0$, using regression to obtain:

$$\ln \overline{Y} = \overline{\alpha} \ln K + \overline{\beta} \ln L + (\delta - \overline{\varepsilon}) \qquad (5)$$

Eq. (5) is the average production function. From the nature of the boundary production function, we get: :

$$\max(\ln Y - \ln \overline{Y}) = \underset{\wedge}{\max}\left\{\ln Y - \left[\overline{\alpha} \ln K + \overline{\beta} \ln L + (\delta - \overline{\varepsilon})\right]\right\} \qquad (6)$$

Eq. (6) is the value of $\overline{\varepsilon}$, and the value of δ can be obtained by substituting $\overline{\varepsilon}$ into Eq. (5). The estimated boundary production function is:

$$\hat{Y} = e^{\hat{\delta}} K^{\overline{\alpha}} L^{\overline{\beta}} \qquad (7)$$

CU (Capacity Utilization) can be expressed as:

$$CU = Y/\hat{Y} \qquad (8)$$

Fixed Effects Regression Model

To investigate the effect of market factors on overcapacity, the following model is constructed:

$$OC_{it} = \alpha_0 + \alpha_1 L1\_MD_{it} + \alpha_2 L1\_MP_{it} + \beta X + \delta_i + \gamma_t + \varepsilon_{it} \qquad (9)$$

Among them, L1_MD and L1_MP are the main explanatory variables, X are the control variables, δ is the individual fixed effect, and γ is the time-fixed effect. Before running the model regression, the variance inflation factor test is performed on the full sample. The results in Table 2 show that the VIF values between the explanatory variables are less than 10, and the average value is 1.63, which means that there is basically no possibility of multicollinearity. In this paper, firm-fixed effects and year-fixed effects are added to control for individual differences and time trends, while Driscoll-Kraay standard errors are used for regression estimation to eliminate further heteroskedasticity, auto-correlation, and cross-sectional correlation problems of the model.

Table 2. VIF Detection Results

	L1_MD	L1_MP	Subsidy	Size	Age	Lev	RD	Cashflow	Roa	Growth	Mean VIF
VIF	1.21	1.47	2.72	3.08	1.07	1.62	1.48	1.04	1.40	1.17	1.63

Data Source and Processing

This paper selects A-share listed companies whose main business belongs to new energy from 2008 to 2023 as the research sample. The reason for choosing 2008 as the starting year is that Chinese listed companies started to implement the new accounting standard in 2007, and there were a lot of corporate reconciliations in 2007, which confused the reporting data. In determining whether a company is a new energy listed company, we reviewed the information in the annual reports of the past years and classified the listed companies whose disclosed main business and main products were in the fields of solar energy, wind energy, nuclear energy, photovoltaic energy, lithium batteries, and new energy automobiles as new energy companies, and approved the node of the year in which each company entered the new energy industry. In order to increase the stability of the samples and reduce the impact of outliers, we perform the following data processing: eliminating samples with a large number of missing data and winsorising all continuous variables at the 1% quantile. All data come from iFinD and CSMAR. Finally, we obtain the unbalanced panel data of 216 pairs of listed companies, for a total of 2111 sample observations.

Results and Analysis

Descriptive Statistics of Data

Figure 1 shows the change in the number of new energy listed companies obtained from the screening. Divided into solar, nuclear, wind and photovoltaic industries as the upstream, and lithium battery and new energy automobile as the mid and downstream, it can be seen that the number of companies in the upstream industry is significantly higher than that in the mid and downstream. In addition, the CAGR of the number of new energy enterprises from 2008 to 2023 is 9.8%, with 9.2% in the upstream, which is lower than the 11.2% in the middle and downstream, indicating that the expansion of the middle and downstream enterprises is faster than that of the whole. The growth rate of the number of new energy listed companies fluctuates during 2008-2023, with an overall trend of slowing growth.

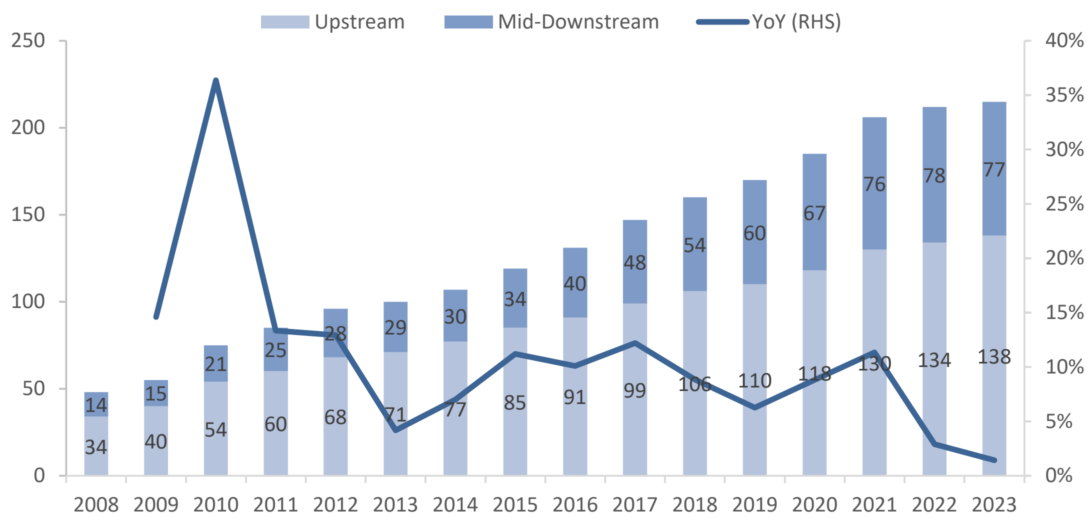

Figure 1. Statistics on the number of new energy listed companies (2008-2023)

Table 3 displays the basic descriptive statistics of the variables in the regression model. According to the table, the average capacity utilization rate in China's new energy industry is 24.9%, which is significantly lower than the standard capacity utilization rate. This indicates a serious overcapacity issue in China's new energy industry. In addition, the maximum and minimum values of the capacity utilization rate of enterprises have a large difference with a standard deviation of 0.15, indicating that even in the same industry, the capacity utilization rate of different enterprises varies widely. The mean value of the inventory turnover ratio of the sampled enterprises is 6.09 with a standard deviation of 10.35, indicating that the inventory management efficiency and market demand of different enterprises vary widely. The average value of the cost margin of the sample enterprises is 38.12%, indicating that the operating profit of new energy enterprises is still at a high level. The average asset liability ratio and R&D investment ratio of the sample firms are 46.41% and 4.29%, respectively. Finally, the proportion of state-owned enterprises in the total number of enterprises is about 23.5%. China's new energy industry is dominated by non-state-owned enterprises, and many leading new energy enterprises, such as BYD and Ningde Times, are non-state-owned enterprises.

Table 3. Descriptive Statistics

	Whole Industry					Upstream	Mid-Down stream
Variable	N	Mean	Min	Max	SD	Mean	Mean
CU	2110	0.249	0.026	1	0.154	0.258	0.228
OC	2109	22.854	19.130	26.819	1.482	22.683	23.203
MD	2111	6.094	0.436	83.576	10.350	6.602	5.060
MP	2111	0.381	-0.027	1.625	0.278	0.389	0.365
Subsidy	1358	16.643	12.332	20.971	1.557	16.471	16.996
Size	2111	22.343	19.435	26.386	1.359	22.273	22.487
Age	2111	2.822	1.792	3.664	0.367	2.818	2.831
Lev	2111	0.464	0.079	0.898	0.189	0.465	0.463
RD	2111	0.043	0	0.175	0.031	0.039	0.052

Cashflow	2111	0.019	-0.225	0.467	0.098	0.016	0.024
Roa	2111	0.041	-0.223	0.196	0.065	0.036	0.051
Growth	2111	0.208	-0.518	1.905	0.373	0.180	0.263
Soe	2111	0.235	0	1	0.424	0.314	0.075

Empirical Measurement and Analysis of Overcapacity

As the sample is panel data, the Hausman test is performed first. According to the result, P is significantly 0, so the initial hypothesis is rejected and the regression is performed using the fixed effects model. The regression yields the average production function of the following form:

$$\ln Y = 0.376\ln K + 0.749\ln L + 7.972 \qquad (10)$$

Both coefficients are significant at the 1% level. Based on the above computations, the boundary production function required in this paper is obtained as:

$$Y = e^{9.525} K^{0.376} L^{0.749} \qquad (11)$$

From Eq. (11), we can see that the capital output elasticity of China's new energy industry $\alpha = 0.376$, is significantly lower than the labor output elasticity $\beta = 0.749$, which probably reflects an important fact about the development of China's new energy industry: although China is a large country with new energy resources, the majority of new energy enterprises are still concentrated in low-tech and labor-intensive production, and the development of the industry has become low-end. In addition, we find that the returns to scale in the new energy industry are greater than 1 ($\alpha + \beta > 1$), i.e. the returns to scale are increasing, suggesting that firms can achieve higher output growth by expanding their scale, which a reduction in unit costs may accompany. This situation may encourage firms to further expand their scale and increase their inputs, leading to overcapacity.

In this paper, the normal range of capacity utilization is set at 80-90%, where capacity utilization above 90% is considered insufficient capacity and capacity utilisation below 80% is considered overcapacity. Table 4 shows the general situation of capacity utilization in China's new energy industry from 2008 to 2023.

Table 4. Capacity Utilization in China's New Energy Industry (2008-2023)

	Overcapacity (<80%)			Normal Capacity (80%-90%)			Insufficient Capacity (>90%)			Total
	Min (%)	Max (%)	Mean (%)	Min (%)	Max (%)	Mean (%)	Min (%)	Max (%)	Mean (%)	Mean (%)
Upstream	3.83	79.45	25.12	-	-	-	90.63	100.00	94.51	25.95
Mid-Downstream	2.64	73.72	22.67	80.86	88.74	84.73	90.92	90.92	90.92	22.76
State Enterprise	4.71	78.89	26.35	-	-	-	90.92	97.45	93.51	26.76
Non-State Enterprise	2.64	79.45	23.67	80.86	88.74	84.73	90.63	100.00	94.44	24.33

Total	2.64	79.45	24.31	80.86	88.74	84.73	90.63	100.00	94.19	24.90

Capacity utilization and overcapacity in China's new energy industry are further analyzed. As shown in Figure 2, the overall capacity utilization rate of China's new energy industry shows an increasing trend, and the capacity utilization rate of mid- and downstream enterprises is lower than that of upstream enterprises. Table 4 shows that the capacity utilization rate of all segments of China's new energy industry is generally lower than the normal level, and all of them have serious overcapacity. The overall capacity utilization rate of the new energy industry in 2008-2023 is 24.9%, and the overcapacity sample accounts for as much as 99.05% of the total sample. The reason is that as one of the national strategic emerging industries, new energy has always been the object of strong government support, with high return on investment, high subsidy intensity, and low entry barriers, which in turn attracted a large amount of capital inflow, and the current lack of demand in China makes the production capacity cannot be fully released. The downstream industry is represented by new energy vehicles, China's subsidies for new energy vehicles are extremely huge, while China's new energy vehicle market has a low degree of scale, with a large number of small and medium-sized enterprises (SMEs), and the phenomenon of dispersal is serious, which makes it difficult to improve the efficiency of the overall capacity utilization. In addition, the capacity utilization rate of state-owned new energy enterprises is higher than that of non-state-owned enterprises. Huang Yiping[1] pointed out in the Economic Observer that China's past overcapacity mainly occurred in traditional industries and is now beginning to appear in some emerging industries. While in the past overcapacity conflicts were mainly concentrated in state-owned enterprises, they may now be more concentrated in private enterprises. This may indicate that the mechanism causing the new round of overcapacity problems is different from the previous one. We then analyze the factors affecting the new round of overcapacity that new energy represents.

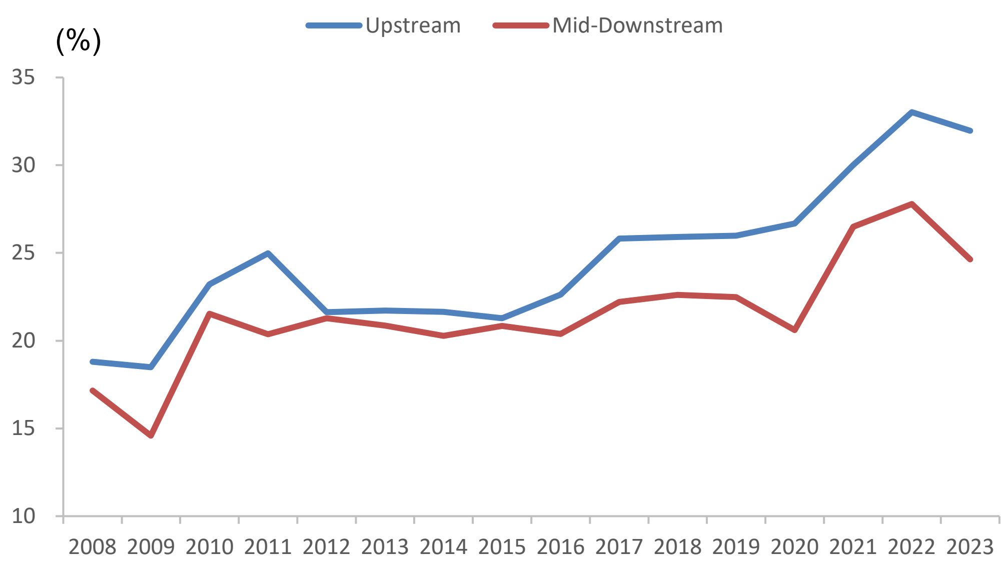

Figure 2. Capacity Utilization in China's New Energy Industry (2008-2023)

[1] https://jg-mvvm.eeo.com.cn/article/info?id=3319f2125bdb4d42a1f50a1db2f3aaa1

Regression Analysis of Factors Affecting Overcapacity

Table 5 shows the regression results of equation (9), where column (1) shows the univariate regression results and the coefficient of the market demand explanatory variable is -0.00434, suggesting that the lack of market demand will lead to overcapacity in China's new energy. If the growth of market demand slows down or declines and production capacity does not adjust in time, overcapacity may occur. The coefficient of the market price explanatory variable is -0.191, indicating that the decline in market price will exacerbate the problem of overcapacity in China's new energy. The sustained decline in prices is indicative of an overcapacity situation. In the event of an excess of products on the market, companies will typically reduce their prices to compete for a limited market share. A decline in prices not only diminishes the profit margins of individual companies but can also precipitate a price war, resulting in a reduction in the profitability of the entire industry. Furthermore, a decline in prices may intensify the issue of overcapacity. This can be attributed to a distortion of demand signals, whereby a reduction in prices may convey inaccurate information to market participants, leading to an overestimation of demand. This, in turn, may prompt the entry of new firms or the expansion of existing firms' production capacity, ultimately leading to oversupply. Column (2) presents the regression results after adding the control variables, where the coefficients of the explanatory variables L1_MD and L1_MP are significantly negative at the 5% and 1% statistical levels, respectively, indicating that the conclusions remain robust even when other factors are taken into account.

Table 5. Baseline Regression Results

	(1) Whole Industry	(2) Whole Industry	(3) Upstream	(4) Mid-Downstream
L1_MD	-0.00434^{**}	-0.00545^{**}	-0.00784^{***}	0.0546^{***}
	(0.00186)	(0.00276)	(0.00287)	(0.0135)
L1_MP	-0.191^{**}	-0.404^{***}	-0.435^{***}	-0.376^{**}
	(0.0738)	(0.0826)	(0.101)	(0.151)
Subsidy		0.0483^{***}	0.0604^{***}	0.00495
		(0.0153)	(0.0174)	(0.0337)
Size		0.787^{***}	0.816^{***}	0.770^{***}
		(0.0298)	(0.0387)	(0.0522)
Age		0.498^{**}	0.145	2.161^{***}
		(0.234)	(0.269)	(0.474)
Lev		0.164	0.319^{**}	-0.507^{**}
		(0.122)	(0.142)	(0.237)
RD		2.792^{***}	2.260^{**}	5.478^{***}
		(0.794)	(0.919)	(1.620)
Cashflow		-0.248^{*}	-0.383^{**}	0.0972
		(0.131)	(0.160)	(0.224)
Roa		-0.824^{***}	-0.688^{**}	-1.641^{***}
		(0.276)	(0.327)	(0.509)
Growth		0.0137	-0.0655	0.244^{***}
		(0.0400)	(0.0501)	(0.0681)
Cons	22.37^{***}	3.781^{***}	3.649^{***}	1.105
	(0.0606)	(0.787)	(0.974)	(1.470)
Individual fixed effects	Yes	Yes	Yes	Yes

Time fixed effects	Yes	Yes	Yes	Yes
Regression method	FE	FE	FE	FE
N	1894	1184	807	377
R^2	0.270	0.697	0.643	0.820

Notes: Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Column (3) presents the regression results for China's new energy upstream industry. The coefficients of the explanatory variables L1_MD and L1_MP are both significantly negative at the 1% statistical level, which is consistent with the aforementioned conclusion. Column (4) presents the regression results for China's new energy midstream and downstream industries. The explanatory variable L1_MP is significantly negative, while the explanatory variable L1_MD is significantly positive. These findings indicate that market demand has a positive effect on China's new energy midstream and downstream industries. The market demand for China's new energy upstream, midstream and downstream industries exerts opposing effects on overcapacity, reflecting the disparate characteristics of the industry's development stage. China's new energy vehicle production and sales are experiencing a period of substantial growth. This growth, as observed by Dong Kaiqiang and Su Wei (2022), is accompanied by a notable increase in market expansion signals, which in turn induce firms to invest. On the one hand, market expansion signals raise firms' expectations of future profits, thereby motivating firms to invest more. On the other hand, during a period of market expansion, firms may improve their competitiveness by investing more in order to maintain or increase their market share. Consequently, China's new energy midstream and downstream industries are more susceptible to the "surge phenomenon" (Lin et al., 2010), whereby firms exhibit a uniform improvement in expectations for the lithium battery and new energy vehicle industries, resulting in a substantial influx of firms and capital into the industry within a brief period. This, in turn, gives rise to overcapacity. Conversely, the photovoltaic market and other industries commenced development at an earlier stage and are now in a relatively mature phase. Consequently, a deceleration in market demand growth is more likely to result in overcapacity.

Analysis of Control Variables

Some factors have a positive impact on overcapacity: (1) Government subsidy. Government subsidies exacerbate overcapacity in China's new energy sector, which is consistent with the findings of previous studies. In response, the Chinese government has implemented a subsidy rollback policy in recent years to mitigate the negative impact of government intervention on the market imbalance between supply and demand. Additionally, the coefficient of the government subsidy variable for midstream and downstream enterprises is found to be positive but not statistically significant. This may be because the term "government subsidies" encompasses both producer and consumer levels, whereas this paper analyses them solely from the former. Furthermore, the subsidies provided to producers encompass a range of forms, including direct government subsidies, indirect tax rebates, financial support, and others. It can thus be surmised that midstream and downstream enterprises are more likely to be influenced by other forms of policy support than by direct government subsidies. (2) Firm size and firm age. Firstly, this paper uses the natural logarithm of total assets to measure firm size, which is highly positively correlated with potential capacity itself. Secondly, there is a general tendency for established firms to be larger, and larger firms often have more capital and may overinvest in pursuit of market share. Thirdly, firms with substantial fixed assets and considerable investment in equipment are more likely to experience exit barriers, which can result in overcapacity. (3) Research and development investment (RD). An increase in research and development investment does not contribute to an improvement in capacity utilization and thus a reduction in overcapacity. This is likely due to the fact that R&D investment results in technological innovation that enhances production efficiency. However, product mix transformation is a gradual process, which, in market conditions where supply exceeds demand, will further exacerbate the level of overcapacity.

Some other factors have a negative impact on overcapacity: (1) Cash flow. When an enterprise has sufficient cash flow, it is able to provide financial and human resources support for innovation and equipment upgrading, thereby creating conditions conducive to improving capacity utilization. Enterprises with higher levels of cash flow tend to have higher efficiency in the linkage and feedback between production, operation, sales, and othes and thus are less likely to have overcapacity. (2) Corporate profitability (Roa). The greater the return on assets, the higher the capacity utilization and the less overcapacity, indicating that the key to corporate profit growth lies in the full use of existing assets rather than the blind expansion of production scale.

The influence of specific factors on overcapacity varies across different industry segments: (1) Asset Liability Ratio (Lev). The level of assets and liabilities of upstream enterprises will exacerbate overcapacity, reflecting their inappropriate use of financial leverage and overinvestment behavior through increased liabilities, while the level of financial utilization of midstream and downstream enterprises is higher. (2) Potential for enterprise growth (Growth). The growth of upstream enterprises' operating income will enhance their operational efficiency and mitigate the prevalence of overcapacity. Conversely, the expansion of mid- and downstream enterprises' operating income will exacerbate overcapacity, which may be attributed to the fact that the faster the growth of enterprises, the more optimistic the economic returns brought by the production and operation of existing products. Consequently, enterprises are readily motivated by the prospect of short-term economic benefits, leading them to allocate funds toward the expansion of existing product capacity.

Further Analysis

Robustness Tests

(1) Add lagged first-order explanatory variables. Considering that excess capacity is not quickly absorbed in the short run, the excess capacity accumulated in the previous period is directly reflected in the level of excess capacity in the current period. In addition, since producers cannot adjust their inputs in time before the beginning of each production year based on their past experience, there is an obvious "inertia" characteristic of the overcapacity situation. By adding the first-order lag of overcapacity (L1_OC) to the regression, we expect a positive relationship between OC and L1_OC. The regression results are shown in column (1) of Table 6, where L1_OC is significantly positive at the 1% level, indicating that overcapacity is indeed affected by the previous period. After controlling for this effect, the effect of market demand and market prices on overcapacity is significantly negative and the conclusions of this paper remain robust.

(2) Substitute explanatory variables. Following Li, Bo et al. (2017), the natural logarithm of aggregate input redundancy (OCre) is used to measure overcapacity. The sum of input redundancy = total inputs - total outputs = (operating expenses + financial expenses + selling expenses + administrative expenses + total assets) - operating income. The regression results, as shown in column (1) of Table 6, indicate that market demand and market prices have a significant negative impact on excess capacity, in line with the findings above.

Heterogeneity Analysis

Subgroup regressions are run for state-owned and non-state-owned new energy enterprises to explore the heterogeneity of the impact of market factors on overcapacity across enterprises of different types. Table 6, column (3) shows the regression results for SOEs, and column (4) shows the regression results for non-SOEs. We can see that market demand and market price have a negative impact on overcapacity in both SOEs and non-SOEs. In addition, the sensitivity of the effect of market factors on overcapacity is higher for SOEs, indicating that SOEs are more affected by market cycles. Overcapacity in SOEs is more serious when market demand or market prices fall, probably because SOEs pursue not only economic benefits but also multiple government objectives, such as improving employment and stabilizing the social environment, which makes it difficult for SOEs to fully and timely adjust their capacity inputs in line with market supply and demand, thus exacerbating overcapacity.

In addition, the positive effect of government subsidies on overcapacity is more pronounced in state-owned enterprises. As can be seen from the results in Table 6, the coefficient of government subsidies is significantly positive at the 5% level for SOEs, while the positive effect becomes insignificant for non-SOEs. It is more difficult for non-SOEs to receive government subsidies than for SOEs, so once they receive government subsidies, non-SOEs tend to be cautious and avoid a certain amount of waste in order to continue to receive government subsidies.

Table 6. Further Analysis of Regression Results

	Robustness Test		Subgroup Regression	
	(1)	(2)	(3)	(4)
	OC	OCre	SOEs	NON-SOEs
L1_OC	0.396***			
	(0.0560)			
L1_MD	-0.00331**	-0.000437**	-0.00728**	-0.00550*
	(0.00113)	(0.000191)	(0.00359)	(0.00331)
L1_MP	-0.234***	-0.0377**	-0.480***	-0.460***
	(0.0289)	(0.0145)	(0.125)	(0.0984)
Subsidy	0.0115	0.00295**	0.0547**	0.00668
	(0.0101)	(0.00101)	(0.0223)	(0.0185)
Size	0.527***	0.994***	0.684***	0.842***
	(0.0559)	(0.00335)	(0.0412)	(0.0335)
Age	-0.551***	-0.00609	-0.297**	-0.295***
	(0.0990)	(0.00869)	(0.121)	(0.0924)
Lev	0.186*	0.0290**	0.560***	-0.0211
	(0.0991)	(0.0113)	(0.192)	(0.146)
RD	2.088**	-0.0168	-0.338	1.024
	(0.778)	(0.0852)	(1.437)	(0.864)
Cashflow	-0.0848	0.00494	-0.542*	-0.217
	(0.140)	(0.00513)	(0.311)	(0.144)
Roa	-0.209	-0.535***	-1.948***	0.384
	(0.287)	(0.116)	(0.462)	(0.340)
Growth	0.0828	-0.0180**	0.0159	-0.0498
	(0.0497)	(0.00653)	(0.0688)	(0.0455)
Cons	3.449***	0.0679	7.515***	4.906***
	(0.416)	(0.0503)	(0.693)	(0.473)
N	1183	1185	336	848
R^2	0.762	0.998	0.605	0.719

Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Policy Proposal and Discussion

Main Conclusions

This paper takes new energy A-share listed companies as sample data from 2008-2023 and divides them into solar, nuclear, wind and photovoltaic industries as upstream; lithium battery and new energy vehicles as mid-downstream. We measure capacity utilization in China's new energy industry by the production function method, and construct a fixed-effect model to empirically analyze the impact of market factors on overcapacity. The main conclusions are as follows:

The overall capacity utilization rate of China's new energy industry in 2008-2023 is 24.9%, with serious overcapacity. In terms of industry segments, the capacity utilization of mid-downstream enterprises, represented by new energy vehicles, is lower than that of upstream enterprises. In terms of enterprise type, China's new energy industry is dominated by non-state-owned enterprises, and the capacity utilization rate of non-state-owned enterprises is lower than that of state-owned enterprises.

Market demand and market prices exert a negative influence on China's new energy overcapacity. Declining market demand and prices will serve to exacerbate overcapacity. Specifically, the upstream industry of new energy is affected by this trend, while the mid and downstream industries show the opposite effect. This implies that an increase in market demand in the mid and downstream industries will exacerbate the overcapacity issue, reflecting the disparate characteristics of the industry's development stage.

The market demand and market prices have a negative influence on overcapacity in both state-owned and non-state-owned enterprises. Market factors are more sensitive to the impact of overcapacity in SOEs, indicating that overcapacity in SOEs is more severe when market demand decreases or market prices fall.

Government subsidies exert a favorable influence on the overcapacity of new energy industry in China, with a discernible impact on upstream industries and state-owned enterprises.

Policy Recommendations

In light of the aforementioned research findings, to effectively manage the overcapacity problem in China's new energy industry, this paper puts forward the following policy recommendations:

Expand demand. Expanding the domestic market demand is the fundamental way to resolve China's new energy overcapacity issue. Furthermore, give full play to the role of the market competition mechanism to eliminate backward excess capacity.

The government should develop rational and scientific support policies for the new energy industry. It should endeavour to cultivate a favorable investment climate, ensuring the availability of comprehensive market intelligence, mitigating the potential risks associated with excessive optimism-driven investments, and optimizing the efficiency of resource allocation. Furthermore, the government should consider implementing targeted financial subsidy policies tailored to the unique characteristics and development stages of different sub-sectors within the new energy industry, departing from the traditional uniform subsidy model.

Promote the transfer of excess capacity to the middle and high-end segments of the industrial chain. At present, the capital output elasticity of China's new energy industry is significantly lower than the labor output elasticity, and the majority of new energy enterprises are still concentrated in low-technology and labor-intensive production segments, requiring further industrial upgrading.

Further Discussion

It must be acknowledged that the research presented in this paper is not without certain shortcomings and that there is scope for further analysis. Firstly, the term 'true overcapacity' is used to describe a situation whereby exports from China are produced over global demand, thereby placing significant pressure on global industry competitors. In order to gain a deeper understanding of the extent of this phenomenon, it would be beneficial to conduct a comparative analysis of China's new energy output with global new energy demand and the output of new energy in other countries. However, there are challenges associated with the collection of comprehensive and comparable data. Secondly, in response to the conclusion that market demand in China's new energy upstream and mid-downstream sectors play an opposite role to overcapacity, the impact of market factors on overcapacity can be further explored by quantifying the stage of development of the market at which different industry segments are situated, for example, by dividing the market into periods of expansion and stabilization based on the rate of demand growth. Thirdly, the issue of overcapacity is a global phenomenon, with different countries facing this challenge in varying industries. It would be beneficial to examine the solutions implemented by other countries, such as Japan and Germany, to gain insight into how they have addressed their respective overcapacity issues.

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