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The Impact of Government Subsidies on the Renewable Energy Industry

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Abstract:

Since the implementation of reform and opening-up, China's economic development has achieved remarkable accomplishments. However, alongside rapid economic growth, fossil fuel consumption has surged significantly, exacerbating environmental challenges. Consequently, the government has introduced subsidies for the new energy sector—specifically renewable energy industries—to intervene in the market and optimise the energy structure. Existing research has primarily focused on identifying the direct impact of subsidies on the industry, such as their effect on industrial profits and changes in the share of renewable energy following subsidy provision. Therefore, the objective of this paper is to first establish the relationship between the proportion of industrial gross output value in total GDP and the elasticity of energy structure transformation. Subsequently, an assessment framework for policy exit timing will be constructed to determine the optimal moment for the government to phase out subsidies.

Keywords: Government subsidies, Renewable energy, Market intervention, Government withdrawal

1. Introduction

Energy, an indispensable element in contemporary society, has driven China's rapid economic growth. Yet excessive reliance on fossil fuels has precipitated severe environmental challenges, including excessive carbon emissions and global warming. As a rapidly developing nation, China remains heavily reliant on fossil fuels like petroleum. The China Energy Development Report 2018 indicates that China's total energy consumption reached 4.64 billion tonnes of coal in 2018, a 5% year-on-year increase marking a seven-year high. Concurrently, clean energy sources including natural gas, hydropower, nuclear power, and wind power accounted for 22.1% of total energy consumption [1], underscoring China's substantial dependence on traditional energy sources. This has significant environmental repercussions, generating numerous externalities. This represents a classic case of market failure, stemming from insufficient market investment where entrepreneurs lack adequate capital to invest in renewable energy industries. Consequently, government intervention through subsidies is necessary to address this market failure. Such subsidies may redirect capital towards green industries, thereby optimising the energy structure. Consequently, identifying new energy sources and enhancing the efficiency of renewable power generation have gained significant international traction in recent years. The MSCI Net-Zero Tracker report by Morgan Stanley Capital International (MSCI) reveals that by the end of 2021, 136 countries had established “zero-carbon” or “carbon neutrality” targets, covering 85% of the global population, 90% of GDP, and 88% of carbon emissions [2]. Existing research, however, has primarily focused on the direct impact of government subsidies on the new energy sector. This includes examining subsidies’ influence on corporate innovation and research investment, shifts in the total market value of the new energy industry, and changes in the proportion of renewable energy generation within total electricity production following subsidy provision. Consequently, this study explores the relationship between the share of industrial production value in total GDP and the elasticity of energy structure transformation. It then constructs an assessment framework for determining the optimal timing for government subsidy phase-out.

2. Materials and Methods

2.1 . Sample Data

In 2016, the Chinese government introduced the “Strategy for Revolutionising Energy Production and Consumption (2016-2030)” [3], vigorously supporting the renewable energy sector. This mandated that non-fossil energy sources account for 25% of primary energy consumption nationwide. Germany, meanwhile, enacted the Renewable Energy Sources Act [4] in 2000, mandating that renewable energy generation constitute 12.5% of Germany’s electricity supply by 2010. The seventh revision of the Renewable Energy Sources Act was enacted in July 2022, setting a target for renewable energy to account for 80% of electricity consumption by 2023, alongside coordinated amendments to relevant legislation to ensure the achievement of energy transition objectives. Therefore, comparing the evolution of renewable energy generation share in China from 2016 to 2023 with that in Germany from 2000 to 2023, with subsidies (as a percentage of GDP) as the variable, yields the following findings.

2.1.2 . China’s Photovoltaic Industry Policy Landscape

China commenced pilot photovoltaic industry projects in 1997, as illustrated in Table 1 [5].

Table 1: Summary of Key Photovoltaic Industry Policies in China

Time	Department	Policy
1997	National Development and Reform Commission (NDRC)	China Brightness Engineering
2002	National Development and Reform Commission (NDRC)	Township Electrification Programme
July 2008	National Development and Reform Commission (NDRC) and State Electricity Regulatory Commission (SERC)	Notice on the Renewable Energy Tariff Surcharge and Quota Trading Scheme for the Period July to December 2008
2009	Ministry of Finance of the People’s Republic of China and Ministry of Housing and Urban-Rural Development of the People’s Republic of China	Implementation Opinions on Accelerating the Application of Solar Photovoltaics in Buildings
September 2012	Ministry of Finance of the People’s Republic of China and Ministry of Housing and Urban-Rural Development of the People’s Republic of China	Implementation Opinions on Accelerating the Application of Solar Photovoltaics in Buildings
August 2013	State Council of the People’s Republic of China	Several Opinions on Promoting the Healthy Development of the Photovoltaic Industry
August 2013	National Development and Reform Commission (NDRC)	Notice on Leveraging Price Mechanisms to Promote the Healthy Development of the Photovoltaic Industry
November 2013	National Energy Administration (NEA)	Interim Measures for the Management of Distributed Photovoltaic Power Generation Projects

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Time	Department	Policy
September 2014	National Energy Administration (NEA)	Notice on Further Implementing Policies Related to Distributed Photovoltaic Power Generation
January 2015	Certification and Accreditation Administration of the People's Republic of China (CNCA) and National Energy Administration (NEA)	Photovoltaic Product Testing and Certification Technical Committee
March 2015	Ministry of Industry and Information Technology of the People's Republic of China (MIIT)	Regulatory Requirements for the Photovoltaic Manufacturing Industry
April 2015	National Energy Administration (NEA) and State Administration of Work Safety (SAWS)	Standardisation Specification for Work Safety in Photovoltaic Power Generation Enterprises
December 2015	National Development and Reform Commission (NDRC)	Notice on Improving the Onshore Wind Power and Photovoltaic Power Generation Benchmark Feed-in Tariff Policy
March 2016	Five Ministries and Commissions	Opinions on Implementing Poverty Alleviation Through Photovoltaic Power Generation Projects
May 2016	National Energy Administration (NEA) and State Council Poverty Alleviation and Development Office	Notice on Issuing the Outline for Formulating Photovoltaic Poverty Alleviation Implementation Plans
October 2016	National Energy Administration (NEA), State Council, and State Council Poverty Alleviation and Development Office	Notice on Issuing the First Batch of Photovoltaic Poverty Alleviation Projects
May 2017	National Energy Administration (NEA)	Notice on Submitting Annual Construction Scale Plans for the 13th Five-Year Renewable Energy Development Plan
October 2017	National Development and Reform Commission (NDRC) and National Energy Administration (NEA)	Notice on Launching Pilot Schemes for Market-Based Trading of Distributed Generation
December 2017	National Development and Reform Commission (NDRC)	Notice on the Pricing Policy for Photovoltaic Power Generation Projects in 2018
April 2018	National Energy Administration (NEA) and State Council Leading Group Office of Poverty Alleviation and Development	Measures for the Management of Photovoltaic Poverty Alleviation Power Stations
May 31,2018	National Development and Reform Commission (NDRC), Ministry of Finance (MOF), and National Energy Administration (NEA)	Notice on Matters Related to Photovoltaic Power Generation in 2018
November 2018	National Energy Administration (NEA)	Convening a Symposium on the Mid-Term Assessment Results of the "13th Five-Year Plan" for Solar Energy Development
January 2019	National Development and Reform Commission (NDRC) and National Energy Administration (NEA)	Notice on Promoting Grid-Parity Projects for Wind and Photovoltaic Power Generation Without Subsidies
April 2019	National Development and Reform Commission (NDRC)	Notice on Improving the Mechanism for Grid Feed-in Tariffs for Photovoltaic Power Generation
May 2019	National Energy Administration (NEA)	Notice on Matters Related to the Construction of Wind and Photovoltaic Power Generation Projects in 2019

Time	Department	Policy
April 2020	National Development and Reform Commission (NDRC)	Notice on Matters Related to the Grid Feed-in Tariff Policy for Photovoltaic Power Generation in 2020
June 2020	National Energy Administration (NEA)	Notice on Announcing the Results of the National Subsidy Bidding for Distributed Photovoltaic Power Generation Projects
June 2021	National Development and Reform Commission (NDRC)	Letter on Implementing the Policy Matters Regarding the 2021 Renewable Energy Feed-in Tariff

2.2 . Core Explanatory Variable: Government Subsidies

This paper examines the impact of government subsidies of varying proportions on new energy enterprises. Therefore, the magnitude of government subsidies serves as the variable. Data on China's subsidy levels and the proportion of renewable energy generation are sourced from Polaris Power News and annual China Energy Development Reports. Relevant German data can be obtained from the German Federal Network Agency (Bundesnetzagentur) and the German Federal Ministry for Economic Affairs and Climate Action for comparative analysis and research.

2.3 . Control Variables

Based on theoretical analysis and existing literature, and considering that the share of renewable energy generation and the magnitude of government subsidies may be influenced by other factors (such as the COVID-19 pandemic in 2018), data from years affected by such factors were removed to reduce model complexity and facilitate drawing conclusions.

3. Results and Discussion

3.1 . Research Data (Subsidy Magnitude)

The development of renewable energy in China relies heavily on government-provided generation subsidies, with funding sourced from the renewable energy surcharge levied on electricity consumption. As the installed capacity of new energy sources like wind and solar power expands rapidly, the subsidy gap has become increasingly severe, emerging as a significant constraint on renewable energy development [6]. According to the National Bureau of Statistics, China's renewable energy subsidy shortfall exceeded 70 billion yuan by the end of 2016 [7], with the gap between actual and theoretical subsidy disbursements reaching 67.8 billion yuan and 93.7 billion yuan in 2017 and 2018 respectively. By comparison, the German government provided total subsidies of 1.1 billion Deutschmarks (562 million euros) to its renewable energy sector in 2000 [8].

Table 2

Regarding subsidy policies	Specific Details	Notes/Source references
Feed-in Tariff for Photovoltaics	0.99 Deutsche Mark per kilowatt-hour For wind power, solar energy, hydropower and biomass energy, feed-in tariffs are set at 90% of the residential electricity retail price. Additionally, policies such as direct investment subsidies and low-interest loans are implemented. [9]	This feed-in tariff is valid for a period of 20 years

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Hundred Thousand Roofs Programme	The government provides subsidies totalling 1.1 billion German marks Offering zero-interest or low-interest loans to users installing photovoltaic systems[10], with a loan term of 10 years	The scheme was established in 1999 and commenced implementation in 2000
Cost-sharing mechanism	The subsidy costs exceeding conventional electricity tariffs are shared collectively by all electricity consumers[9]	Households are projected to incur an additional cost of approximately €1 on average

3.2 . Research Data (Renewable Energy Industry's Share of Electricity Generation)

With substantial support and generous subsidies from both the Chinese and German governments, the new and renewable energy sector has experienced rapid development, leading to a significant increase in its share of total energy production, as illustrated below:

Table 3

Indicator	China (Photovoltaic) [11]	Germany (Wind Power) [12]
Subsidy as a Percentage of GDP	0.3%	0.5%
Change in Energy Share	10%–40% (2015 to 2023)	6%–27% (2000–2023)
Electricity price change	+5%	+20%

3.3 . Government Subsidy Phase-Out Mechanism

Owing to the government's continuous provision of substantial subsidies to the renewable energy sector, the industry has developed a dependency on such support. This dependency may reduce efficiency and potentially lead to fraudulent claims for subsidies. In 2016 within China, 16 projects either failed to install equipment or falsely reported installed capacity, defrauding approximately ¥116 million in subsidies. Additionally, 15 projects were installed but failed to connect to the grid for power generation, involving subsidies of approximately ¥61.84 million [13]. Consequently, the Chinese and German governments introduced phase-out mechanisms in 2016 and 2000 respectively. This policy tool is typically employed in emerging industries or market sectors to guide enterprises towards gradually reducing dependence on government subsidies, enhancing their overall competitiveness, and ultimately achieving market-driven resource allocation and industrial development.

For China, the 2018 "531 New Policy" [14] stands as a landmark event. This policy signalled the Chinese government's intention to reduce subsidies for the renewable energy (new energy) sector and lower subsidy intensity, effectively marking the countdown to the end of the subsidy era. It caused significant upheaval within the photovoltaic industry at the time, abolishing the benchmark feed-in tariff and replacing it with a guidance price serving as the upper limit for competitive bidding. This laid the groundwork for subsequent cost reductions and the eventual achievement of grid parity. This was deemed the "strictest PV policy in history"[15]. In 2021, the state issued the "Notice on Matters Concerning the 2021 Feed-in Tariff Policy for New Energy", formally announcing the cessation of national subsidies for the new energy sector and the full implementation of grid parity[16]. Prior to this, Germany maintained fixed feed-in tariffs from 2000 to 2010, yielding substantial benefits. This stimulated entrepreneurial investment in the new energy sector, significantly accelerating its development. Photovoltaic and wind power installations surged rapidly, with cumulative photovoltaic capacity reaching 17,320 MW and cumulative wind power capacity reaching 27,214 MW [8] [17] [18][19], accounting for 17% of total electricity generation by 2010. From the mid-2010s to the present, fixed feed-in tariffs led to substantially increased costs, with the Renewable Energy Surcharge (EEG-Umlage) becoming a heavy burden on many households' electricity bills. To address this, the German government has repeatedly amended the Renewable Energy Sources Act (EEG), determining new installation volumes through developer bidding, with the lowest bid securing the contract. Furthermore, market competition determines subsidy levels, substantially reducing subsidy costs and decreasing the renewable energy sector's reliance on subsidies. Currently, onshore wind and photovoltaic power in Germany have largely achieved grid parity, while offshore wind has even reached "zero subsidy" status[20].

The phase-out is not merely a simplistic reduction or removal of subsidies, but rather a strategic process of smooth transition from "policy-driven" to "market-driven" development [21]. It necessitates corresponding strategic adjustments based on multiple factors, including industry maturity, market conditions, and the sector's dependence on subsidies. Drawing upon historical data from China and Germany regarding the impact of renewable energy subsidy increases and reductions on government expenditure, household costs, and power generation share, this paper explores when governments should implement subsidy phase-out policies. The following conditions serve as key criteria for such decisions:

(1) When technological costs decline significantly and economic competitiveness approaches that of conventional energy sources (such as petroleum), it indicates the local renewable energy sector has established a complete, core-competitive industrial chain. Most enterprises no longer rely on government subsidies, instead sustaining normal profits* and achieving sustainable development through technological innovation, consumer loyalty, and market competitiveness (where price and quality competitiveness approach or exceed those of traditional energy sources like petroleum). This signifies the renewable market has developed preliminary self-sustaining capabilities.

(2) When subsidies for the renewable energy sector become excessively burdensome, creating a heavy fiscal strain that impedes government provision of other vital subsidies – such as unemployment benefits and pensions that directly impact citizens' living standards – subsidy phase-out becomes inevitable.

(3) As electricity markets mature, fostering fair competition alongside grid infrastructure upgrades or energy storage advancements, China's renewable generation will fully integrate into the power market.

(4) Public acceptance of renewable energy is high, extending beyond recognition of its environmental benefits as a "green" industry to encompass understanding of its systemic value and potential impact on electricity pricing.

In summary, subsidy phase-out constitutes a critical component of support mechanisms. Even when timing is meticulously chosen, the process demands careful design. Germany, for instance, has repeatedly amended its Renewable Energy Sources Act, each time providing the market with clear and predictable expectations years in advance to mitigate the shock of abrupt policy changes. Crucially, "phasing out" does not equate to "withdrawing oversight." The government's role should transition from "price-setter" to "market rule-maker and regulator." The emphasis lies in establishing a level playing field for market competition, enhancing grid infrastructure, and incentivising technological innovation.

*Normal profit: This denotes the profit an enterprise achieves through long-term operations, sufficient to cover all costs—including labour wages and opportunity costs—and sustain enduring development.

4. Conclusion

4.1 . Limitations

Firstly, there are currently few examples of subsidy phase-out mechanisms for renewable energy, making it exceedingly difficult to formulate a relatively objective assessment. The primary examples are limited to developed nations such as China and Germany, with few instances from developing countries possessing comparatively weaker economic capabilities. Moreover, the renewable energy sectors in most nations remain at a stage requiring subsidy provision and government leadership, lacking a fully developed industrial chain with core competitiveness and an established electricity market. They possess virtually no capacity to compete fairly with traditional energy markets and require substantial time to develop such capabilities, alongside conducting long-term tracking and evaluation.

Secondly, current research and literature on subsidy phase-out mechanisms for the renewable energy sector often lack a dynamic perspective, frequently overlooking consumers' anticipatory behaviour. Some consumers opt for 'front-loading purchases' in anticipation of future subsidy reductions or technological advancements, explaining the surge in sales observed prior to subsidy phase-outs. This phenomenon is termed intertemporal price elasticity [23].

Concurrently, most renewable energy research currently emphasises economic outcomes while undervaluing environmental benefits. Numerous studies focus solely on the impact of subsidy reductions on installed capacity, electricity costs, and corporate profits, with scant evaluation of changes in lifecycle environmental benefits.

The current subsidy mechanism also exhibits certain shortcomings. The basis for reductions is highly singular, with many reduction mechanisms (such as China's new energy vehicle subsidies) simply lowering subsidy amounts at predetermined time points [24]. This approach is divorced from the actual development of market scale. It places unnecessary pressure on enterprises or leaves policies in a state of constant, reactive adjustment.

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4.2 . Directions for Further Research

Given these limitations, future research should deepen investigations into dynamic mechanisms and heterogeneity by constructing more complex dynamic structural models. These should incorporate consumer expectations, corporate strategies, and market evolution. Studies should also strengthen analyses of how regions with differing economies and enterprises of varying scales respond to subsidy phase-out policies. Furthermore, a more comprehensive benefit assessment framework could be introduced, integrating the environmental impacts of phase-outs into policy evaluations to pursue a win-win outcome for both economic and environmental benefits.

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