



Sustainability in the economic development of China's industrial cities: a case study with new energy industries in Yibin

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Abstract

Sustainable economic growth has become a global priority as governments implement green policies to balance economic development and environmental protection. China, the world's largest carbon emitter, has implemented national policies aiming to achieve carbon neutrality by 2060. However, resource-dependent cities face structural challenges in transitioning toward economic structures with green industries. Understanding how such cities can successfully transform is important for China's long-term economic and environmental goals. This study examines Yibin, a historically resource-dependent city in Sichuan province, as a case study of successful industrial transformation. Yibin has historically been reliant on baijiu production and coal industries, facing challenges including market plateau and severe pollution. Through targeted government policies, investments, and R&D aggregation, Yibin has established a strong power battery industry as its second major industry now. Using government data and policy documents, this study finds significant improvement in Yibin's economy and environment. However, Yibin's transformation was mainly caused by government intervention and sees potential challenges in the long term. The study identifies these risks and provides suggestions for Yibin; including a near-universal, city-agnostic pivot paradigm, to balance government intervention and market ecosystems and repurpose and/or re-engineer existing industries, resources and labor. This study suggests future paths for Yibin and provides insights for other resource-dependent cities in China aiming to achieve sustainable industrial development.

Keywords

Sustainable development, Resource-dependent cities, Industrial transformation, Green economy, Renewable energy, Yibin, Government intervention, Baijiu, Carbon neutrality, Resource curse

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1. Introduction

1.1 Research background

The need for sustainability in economic growth has become a priority in countries worldwide and has been discussed intensively regarding policymaking and innovations. The United Nations' Sustainable Development Goals (SDGs) highlight the importance of responsible industrialization, and many nations are implementing green policies to reduce carbon emissions and reliance on fossil fuels (1). China, the world's largest carbon emitter, has worked towards sustainable development as well. The government has set the "dual carbon goals" to reach peak carbon emissions by 2030 and achieve carbon neutrality by 2060 (2). Policies such as the "Made in China 2025" plan and the "14th Five-Year Plan" emphasize green technology, renewable energy, and the transition away from resource-intensive industries. Despite these efforts, many cities in China still face challenges in achieving sustainable development.

China's resource-dependent cities face significant structural challenges in achieving sustainable development and are trapped in the "resource curse" where overreliance on a single resource causes difficulty transitioning to higher-value industries (3). Cities reliant on natural resources and traditional manufacturing often face economic stagnation. This occurs when their primary industries decline due to policy shifts or market forces. The lack of economic diversification can also lead to technological constraints and underutilized industrial infrastructure, limiting their ability to make transformations and attract high-tech or sustainable industries.

Understanding how resource-reliant cities can successfully transition toward a greener and more sustainable economic model is crucial for China's long-term economic and environmental goals. This study uses Yibin, a historically resource-dependent city in Sichuan Province, as a case study. Yibin has faced industrial pollution and output contraction due to its dependence on baijiu production and a large coal industry. However, in recent years, it has strategically transformed into a hub for new energy industries, particularly in power battery production. Yibin has attracted major firms and product chain projects and become a major supplier of Tesla's batteries. Its trajectory offers insights into how other resource-dependent cities can navigate economic restructuring while improving sustainability under a similar national context in China.

This paper analyzes Yibin's transition quantitatively and qualitatively and provides suggestions for alternative trajectories in the long run. By analyzing Yibin's transition, this study aims to provide actionable insights for Yibin and other resource-dependent cities in China, contributing to the broader discourse on sustainable industrial transformation.

1.2 Literature review

Extensive research on the impact of government policies on resource-dependent cities has found government policy to be helpful in industrial transformations (4-6). Acemoglu et al. modeled the optimal strategy for transitioning to clean energy as a combined implementation of taxes and subsidies that encourage the production of clean energy (7). Still, the extent and effectiveness of government intervention industries remain debated (8). While it is common in China for

local governments to accelerate industrial transformation through tax incentives, fiscal subsidies, and infrastructure investments, such an approach can play a negative role in industry development in the long term (9). Inland cities often face additional challenges, including weaker market integration and higher logistical costs, on top of educated individuals migrating to coastal cities (10). Studies on sustainable industrial transitions in China have largely concluded policy efficiency through quantitative models, while there is limited analysis of the policies themselves (11). This paper addresses this gap by examining Yibin as a case study and understanding its policy effectiveness throughout the industrial transformation.

1.3 Research framework

This study first describes the case of Yibin, then analyzes Yibin's transition policies through government documents and news articles, and then evaluates its economic and environmental impact using company reports and yearbook data from Yibin Municipal Bureau of Statistics. Finally, the study identifies potential challenges, provides actionable suggestions for Yibin, and concludes.

1.4 Case description

Yibin has historically been the "liquor capital" of China, with its long-developed distillation industry and home to the famous baijiu brand Wuliangye. In 2020, Yibin's baijiu production ranked second in the country in terms of output, operating income, and total profit. The total income and profit of the baijiu industry accounted for 41.0% and 68.3%, respectively, of all Yibin's industries, playing a critical role in the city's economic development.

Yibin's economy also heavily depended on the coal industry, which accounted for nearly 50% of the city's increase in industry values and 15-20% of GDP, according to data from the Yibin Municipal Bureau of Statistics. This reliance on coal has led to serious carbon emission and air pollution problems, as Yibin had the highest pollution in Sichuan province, with an annual average PM2.5 concentration of 44 $\mu\text{g}/\text{m}^3$ and 17,220 million tons of CO₂ in 2021 (12).

At the same time, traditional baijiu industries in Sichuan have encountered weakening expectations and demand contraction. Lin highlights a 31.49% decrease in the revenue growth rate of the Sichuan baijiu industry in 2013, driven by areas including Yibin facing barriers in liquor sales (13). The potential environmental and economic issues from the coal and liquor industries have prompted Yibin to seek sustainable development strategies and diversify its economic structure.

2. Analysis of the problem

2.1 Current policies

Since 2019, Yibin City has established the "1+N" clean energy strategy with power batteries as the core, photovoltaics, energy storage, and new energy vehicles as extensions. The main measures taken to promote industrial upgrading and transformation centered on clean energy actively are discussed below.

2.1.1 Industrial planning and investment

The Yibin government has centered its efforts around the Sichuan Times Power Battery project, forming a "1+N" power battery industry ecosystem with the Sanjiang New District as the core and adjacent industrial

parks as support. A series of supportive policies, including the “Action Plan for Accelerating the Establishment of a World-Class Power Battery Industry Cluster,” have been introduced. These policies aggregated 90 projects across the entire industry chain, from battery cells to positive and negative electrode materials and separators, with total investments exceeding 210 billion yuan.

2.1.2 Tax incentive and reduction policies

To stimulate the technological innovation drive of the power battery industry, the Yibin tax department provides tax incentives concerning export tax rebates, consumption tax, and urban maintenance and construction tax. In 2023, Sichuan Times Company received a total of about 2.5 billion yuan in tax incentives, including export tax rebates, consumption tax, and urban maintenance and construction tax (14). According to Sichuan Times’ production capacity in Yibin’s power battery industry (approximately 75%) and the total output value of the power battery industry from 2020 to 2023 (20, 16, 88.9, and 100 billion yuan, respectively), it can be inferred that from 2020 to 2023 the government’s tax incentive reduction for the power battery industry was approximately 7 billion yuan.

2.1.3 Direct subsidies

The Yibin government, with Sichuan Times as the “chain leader,” is continuously increasing the attraction of the industry. By consistently introducing new battery projects such as sodium-ion batteries, solid-state batteries, energy storage batteries, and innovative materials like silicon-carbon anode materials and solid-state electrolytes, Yibin expands and improves the ecosystem of the power battery industry chain (15). Yibin has also established

numerous support policies for the downstream industries of power batteries, from research and development to sales, including subsidizing the development of new car models up to 50% of interest, giving one-time subsidies of 10 million yuan and 5 million yuan, respectively, to newly recognized national and provincial manufacturing innovation centers in the new energy field, and policies improving accessibility and establishing amenities for electric vehicles.

2.1.4 Government-strengthened specialist aggregation

The Yibin government has intensified efforts to attract talent to ensure high-quality development resources. It is one of the 21 national pilot cities for the integration of industry and education in China for more efficient R&D (16). The utilization of educational projects such as Yibin University Town, Science and Technology Innovation City, and Yibin Higher Vocational Education Park provides abundant resources for high-end R&D training and supports service facilities for the industry. The government also established plans to add human resources to fields where Yibin is vigorously developing or urgently needs to make up for shortcomings. The “Yibin Talent Plan” was started in 2019 to attract high-level talents by providing wage subsidies and has recruited 159 experts from the technology, education, and agriculture fields by the end of 2024 (17).

2.2 Positive influence in Yibin

2.2.1 Industrial integration and transition

Yibin introduced China’s largest power battery manufacturer, Contemporary Amperex Technology Co., Limited (CATL), in 2019 and

aggregated upstream and downstream enterprises to form a full-chain layout, attracting 90 supporting projects with a total investment exceeding 210 billion yuan (18). By 2024, Yibin's power battery production capacity has reached 180GWh, accounting for roughly 20% of the global market share. In 2022, Yibin's power battery industry achieved an output value of 88.9 billion yuan, a year-on-year increase of 4.5 times. This increased the city's above-scale industrial added value by 11.9% and contributed to 56.5% of Yibin's GDP, replacing liquor with the power battery industry. Beyond industrial integration, the power battery industry has also driven

significant economic growth in Yibin.

2.2.2 Economic growth

Besides industrial integration, the power battery industry has also driven significant economic growth in Yibin. Yibin has doubled its GDP from 2017 to 2023, as shown in Figure 1, ranking record high at 86th in China's cities with 380.66 billion yuan in 2023. The proportion of power battery industries in Yibin's production value has increased from 0.6% in 2020 to 25.3% in 2024, replacing coal and becoming the second largest industry in Yibin. The clean energy industry has created 120,000 new jobs in the city, of which 30% are high-end technical jobs.

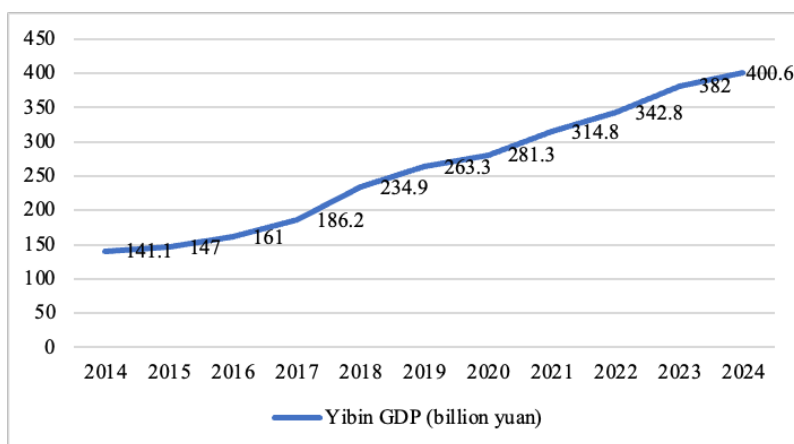


Figure 1. Significant GDP growth in Yibin from 2014-2024

2.2.3 Environmental improvement

The development of the clean energy industry has not only boosted Yibin's economy but also significantly improved its environmental performance. As an important industrial city in Sichuan Province, Yibin had high energy consumption and carbon emissions, posing pollution problems. The development of the clean energy industry has significantly improved Yibin's green development through

various ways, including new energy vehicles and increasing clean energy applications. As of 2024, carbon emissions in Yibin have been reduced by approximately 2.63 million tons from new energy vehicles, approximately 3.75 million tons through photovoltaic power, and approximately 120,000 tons through energy storage technologies. A total of 3.75 million tons of CO₂ was reduced, and the economic value would reach 3.86 billion yuan after

converting with the average national carbon market price (102.98 yuan/ton), equivalent to 1.2% of Yibin's GDP in 2023.

2.3 Potential problems

Yibin's clean energy transition was heavily dependent on the government's aggregation of resources and acceleration of industry formation. This approach can lead to several risks that must be addressed to ensure long-term market momentum and city development.

2.3.1 Risk of market distortion

Excessive government subsidies leading to an excessive amount of industry output can cause market distortion. Yibin's power battery industry has seen rapid expansion, with planned production capacity reaching 300GWh in 2024, accounting for 30% of the global demand (19). As demand growth slows down, partly due to demand shifts to hybrids that use less electricity, battery makers, including CATL, have dropped capacity utilization rates in 2023.

Overcapacity can lead to instability and regressing consequences in Yibin's power battery industry. The market expectations brought by industrial transformation will attract a large amount of external investment, create a large number of jobs, and help the local economy to thrive quickly. The market itself has strong regulatory capabilities for possible overcapacity, overheating investment, and declining efficiency. However, suppose the driving force of industrial transformation mainly comes from non-market factors, such as government subsidies, policy financing, and tax incentives. In that case, changes in these factors often cannot be reflected in the market instantly and effectively. The greater impact of such

drivers will lead to greater economic disorder, such as short-term irrational prosperity, rapid recession after policy changes, waste of resources caused by excessive infrastructure investment, etc.

2.3.2 Fiscal sustainability

The long-term fiscal sustainability of Yibin's tax incentive policies is also a major concern. In 2023, Yibin's local tax revenue was 16.2 billion yuan. The total tax reduction of the power battery industry in 2023 can be estimated, with the data from the Sichuan Times, to be 20.5% of the tax revenue. Prolonged reliance on such measures can strain public finances, potentially reducing funds available for essential services such as education, healthcare, and infrastructure. As China's fiscal capacity consistently decreases, it is unsustainable to execute such large-scale interventions that drive regional transformations, and this is harmful to market competitiveness (20).

2.3.3 Increased inequality

While the rapid transition towards the clean energy sector created new jobs, including high-tech positions, the workforce adaptation in other industries may be overlooked. Traditional industries such as coal mining and liquor production have seen higher job displacement. Many workers face difficulties in transitioning to the new economy due to skill mismatches and insufficient retraining programs. If such disparities are not adequately addressed, they may exacerbate regional inequalities.

3. Suggestions

Historically, many local governments in China have played a crucial role in driving industrial

transformations through tax incentives, subsidies, and direct interventions. While government interventions can yield positive short-term outcomes—much like Yibin’s recent success—the sustainability of such transitions is complex in different city contexts (21).

It is essential for Yibin to ensure the continuous development of the clean energy industry along with the whole economy by addressing the identified risks. Policymakers must proactively explore strategies to gradually balance government interventions and market ecosystems, and the study provides the following suggestions to achieve this.

3.1 Optimize the role of government

Instead of being the direct driving force, shift the government’s role to a “designer of systems” by enhancing the carbon trading market and green financial instruments. Specific actions include 1] integrating Yibin’s carbon emission reductions into the national carbon market, 2] exploring regional carbon trading mechanisms to promote cross-regional carbon quota trading and green project collaborations, 3] introducing a carbon tax on high-emission enterprises, with revenues allocated to support clean energy technology R&D and infrastructure development, and 4] developing green financial tools such as green bonds, green industrial funds, and green credit. These measures help balance environmental protection with economic growth while avoiding excessive government interventions and allowing market-driven self-regulation.

3.2 Drive technological innovation

Enhance industrial policies to shift focus from encouraging enterprises to increase capital

investments and productions to R&D investments in areas like solid-state batteries and hydrogen energy. This can increase competitiveness within the industrial ecosystem and prevent redundant low-end capacity construction.

3.3 Inclusive transformation

Industrial transformation inevitably impacts workers in traditional sectors, like coal miners in Yibin’s case. To mitigate social inequality conflicts and ensure that the benefits of transformation are widely shared, Yibin should implement inclusive policies such as 1] retraining funds for workers transitioning from traditional industries and 2] improving social security systems through joint efforts of the government and enterprises.

3.4 Promote regional collaborative development

Yibin can collaborate with the Chengdu-Chongqing economic circle to jointly develop the clean energy industry chain and enhance the overall regional competitiveness. First, Yibin’s leading enterprises, such as CATL, can create synergies with Chongqing’s intelligent automotive industry and Chengdu’s electronic information industry to form an integrated “power battery–new energy vehicle–intelligent connectivity” industrial chain. Second, infrastructure sharing between cities, such as integrating transportation systems and establishing a clean energy resource network between Yibin and adjacent cities, can reduce logistics costs and increase resource efficiency. Third, interconnecting carbon trading markets in the Chengdu-Chongqing region and building joint R&D centers can be beneficial to Yibin’s new energy market and development in the long run.

Implementing the above strategies requires careful planning and coordination to ensure that interventions are effective and do not lead to unintended consequences such as market distortions or fiscal imbalances.

4. Pivot existing industries to emerging/green technology

While new energy industries, developed from the ground-up, have helped Yibin achieve green transformation, alternative trajectories that make use of existing industries and infrastructure can be as sustainable and significantly less distortive. Existing industries should be remodeled, repurposed and/or re-engineered, instead of being abandoned. This paradigm has the potential to be universally applicable across cities, save costs, retain labor, retain supply chains and resources, cause minimum disruptions and distortions to the local economies, require minimum government intervention and boost Research and Development (R&D) with long-term implications.

Firms can pivot both upstream and downstream, using existing resources and infrastructure to develop green products and technologies. In doing so, existing core manufacturing operations can continue largely unchanged, and environmental innovation at the beginning and end of the production chain can achieve multiple sustainable goals; which, in the case of Yibin; can encompass 1] increased carbon sequestration using new Sorghum cultivars, 2] keeping existing coal mines open and using the coal input for fermentation into ethanol, biofuel and biogas, in turn by using a sub-consortium of micro-organisms derived from the Jiuqu starter, 3] modernizing Baijiu manufacturing by the

production of value-added micronutrient containing Baijiu that can subsequently be upsold as a Health-liquor when consumed moderately. In the process, R&D on the – as yet sparsely researched – Jiuqu starter can yield new uses for sub-consortia of bacteria and fungi. Figure 2 shows a flowchart such a pivot both upstream and downstream of core-existing industry and infrastructure. The utility and near-universal applicability of this approach means that it is city-agnostic and can be applied with equal ease across diverse geographical regions and resources with minimal disruptions to existing local economies.

4.1 Reusing microbial culture for coal fermentation

Baijiu fermentation relies on jiuqu, a complex microbial starter. The rich microbial diversity within different strains of jiuqu contributes to the fermentation and saccharification in baijiu production and could be reused for sustainable purposes (22). Research on fermentation of coal into biogas suggests the potential of using anaerobic organisms – such as those found in jiuqu - for this bioconversion (23). Biogas, or methane, can be reused for electricity or as transportation fuel, and the solid residue from the fermentation is less harmful than coal combustion waste.

Jiuqu also produces a diverse enzyme system that could enhance lipid extraction by breaking down cell walls (24). Microalgae, sorghum bagasse, and biochar are all promising feedstocks for biofuel due to their high lipid content, but efficient lipid extraction is hindered by robust cell walls. Using jiuqu in enzymatic pretreatments for lipid extraction can lower industrial production costs for

biofuel and form a circular bioeconomy in baijiu production.

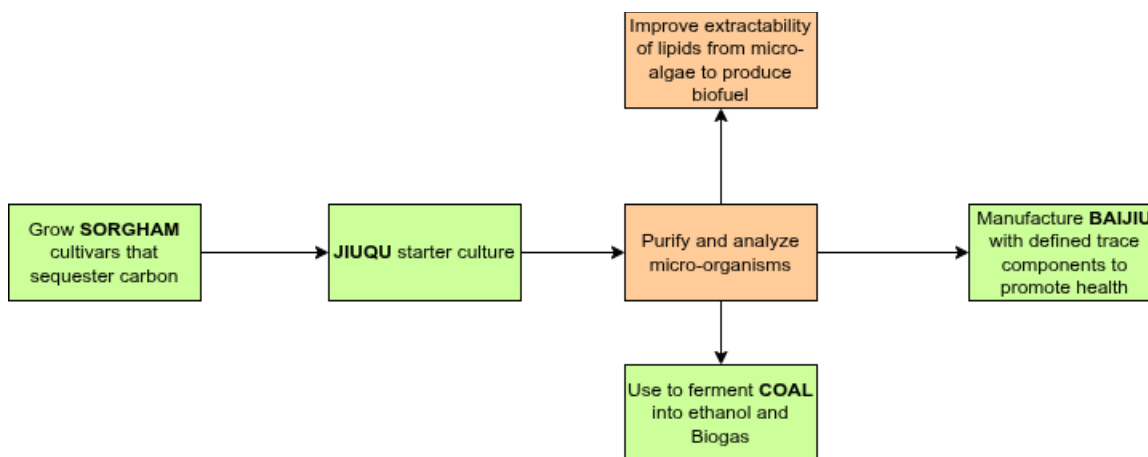


Figure 2. Existing industries and/or materials and processes (green and BOLD) can be used with new and emerging technologies (red) to drive both upstream and downstream innovations. Sorgham, Coal, Baijiu and Jiuqu were already existing industries and processes, which are now re-engineered to pivot to carbon sequestration, the manufacture of biofuel and biogas, fermentation products and the upselling of a healthier version of Baijiu.

4.2 Utilizing fermentation byproducts

Baijiu production generates substantial by-products, notably spent grains and wastewater, which have traditionally posed environmental challenges. Recent research indicates that these by-products can be transformed into value-added, sustainable products. The fermented grains from baijiu production are rich in lactic acid bacteria (LAB), which are found to prevent drunkenness and alcoholic liver injury (25). Huangshui, the wastewater from baijiu fermentation, is highly polluting in untreated form. However, it contains valuable ingredients that can be extracted and used for medicine, fertilizer, and functional food products (26). By properly utilizing these residues from baijiu production, the industry can achieve diversification including health-oriented products like probiotic beverages and fermented grain pastes and bio-based products converted from huangshui (27).

4.3 Carbon-sequestering sorghum cultivars

Sorghum (*Sorghum bicolor*), the foundational grain in Baijiu production, can be specifically bred for carbon sequestration, the process of capturing atmospheric CO₂. Research has shown that certain rhizomatous sorghum lines exhibit high heritability for rhizome biomass, contributing significantly to belowground carbon storage without compromising grain yield (28). Bioenergy sorghum hybrids develop unusually deep root systems that enhance biomass accumulation, manage nutrient runoff, and help restore soil organic carbon level (29). By optimizing carbon-sequestration through sorghum breeding, Baijiu producers can improve environmental sustainability while preserving traditional crops.

5. Conclusion

5.1 Key findings

The case study of Yibin finds significant

positive outcomes of the city's transitional strategies, including full integration of new energy industries, economic diversification and growth, and carbon emission reduction. However, there are potential issues that need to be addressed for the long-term development of Yibin. Excessive government intervention is unsustainable in the long run and can cause over-capacities and increase inequality between workforces of industries. When investments from such policies start to decrease, the new energy industry and production are at risk of becoming unstable and regressing. To balance government interventions with market ecosystems, this study suggests shifting the government's role to design systems in which regulations and incentives are market-driven, implementing inclusive policies and R&D, and promoting Yibin's integration into regional new energy ecosystems. Implementing these suggestions can be facilitated by adopting another trajectory that is near-universal in application and causes minimum disruptions to existing industries, infrastructures and local economies. Rather than building or transplanting brand-new industries, policies and local economies, that cause significant disruptions; existing core industry can pivot toward sustainable upstream inputs, as well as toward downstream sustainable processes and products. In the case of Yibin, this would have implied re-engineering, repurposing and diversifying the existing Sorghum, Coal and Baijiu manufacturing and processing industries into a sustainable and circular economy.

5.2 Research significance

This study provides important insights into how Yibin can avoid potential pitfalls and achieve stable economic development and suggests an alternative trajectory for future

implementation. The implications of this study, including common problems of transforming resource reliant cities and resolutions, can be adapted for other developing cities in China.

5.3 Limitations

Although this study utilized comprehensive data and qualitative analysis, some limitations must be addressed and considered in the implications of the study. First, China's new energy industry is still in the period of rapid development and has not yet experienced a complete economic cycle. Therefore, the study's evaluation depends on sources of Yibin within 5 years, and the analysis lacks the long-term perspective needed to assess the stability of Yibin's policies. Second, while this study directly uses post-policy data to show the policy impact on Yibin, a more accurate assessment would require quantitative modeling. Without such analysis, it is difficult to isolate the direct impact of specific policies from broader economic trends, which may lead to an inaccurate estimation of their effectiveness. Finally, information transparency is a significant constraint to the thorough understanding of Yibin's transition. Many government industrial policies, in this case, are not fully accessible through public information channels. The lack of complete and accurate policy data makes it difficult to assess the policy measures and their actual impact thoroughly. This limitation introduces potential bias, as the analysis may rely on partial information. Additionally, the study's evaluation of green reinvention in traditional industries relies on emerging research and pilot applications that have yet to be tested at scale. Further study is needed to understand the feasibility and long-term impact of these initiatives.

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