Unleashing the mechanism between small and medium enterprises, and green financing in China: a pathway toward environmental sustainability and green economic recovery

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Received: 12 February 2022 / Accepted: 10 June 2022 / Published online: 3 August 2022
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Abstract
In this research, we analyzed green finance, small and medium-sized businesses, and financial literacy in China to boost the green economy. Green finance and financial literacy were examined holistically using a rigorous empirical approach and data envelopment analysis to provide the way to advance green economic recovery in this research. According to empirical evidence, green financing impacts SMEs at 0.31, 0.41, and 2.02 on green economic recovery. China’s green finance and small businesses contribute significantly to the country’s overall green economic revival. A more accurate forecast of green economic recovery was made possible by including other variables such as population expansion, development, and small business development. The analysis used the data envelopment analysis, and the results were solid. Additional hypothetical time-dependent instances demonstrated China’s predicted green financing and small business’s nexus for 2000 to 2020. The proportion of SMEs is decreasing, and as a result, green financing and financial literacy have increased by an average of 12.5% during this time. China’s green financing would fall dramatically if the country’s industrial structure is reduced. According to our findings, financial literacy is positively correlated with green economic recovery, while illiteracy is negatively correlated with growth. Finally, the report provides some ideas for China’s future green economic recovery.

Keywords Financial literacy · Green economic recovery · Small and medium enterprises · Data envelopment analysis · China

Introduction

The nature of energy consumed is an important factor of climate change (Irfan et al. 2022), as all forms of energy consumed have an environmental impact on air, water, and land (Iqbal et al. 2021). Chinese energy use considers for 23.77% of world fossil fuel energy usage, 28.17% of international sustainable power usage, and 27.22% of international carbon dioxide discharge in 2017 (Mohsin et al. 2021b). According to this, China is one of the world’s most energy-dependent nations (Abbasi et al. 2022). China’s present home strategies aim to develop a power growth system, boost power usage effectiveness, and attain greenish industrial development in the face of rising energy needs and escalating climate change (Fang et al. 2022b). There have been several ecological control measures lately established by the Chinese state, particularly in power transformation (Yang et al. 2021a). Aside from that, it has established ecological measures such as the Air discharge Control and Management Law, the Sustainable Power Law, and the Comprehensive Work Plan for Energy Conservation and Emission Reduction (CWEPR). However, as a result of this fast financial expansion, there has been a significant loss of resources and ecological contamination (Zhang et al. 2021a). When we look at China’s efforts to promote a power framework and adopt numerous climate regulations, we must ask ourselves whether they are beneficial in promoting renewable financial growth (Datta and Sahu 2020). Is it true that they have positively impacted Chinese cities’ greenish financial development? According to this, China is one of the world’s most energy-dependent nations (Abbasi et al. 2022).
to 66 million people in South Asia into poor by 2020. There are several instances of Pakistan’s agricultural economy being ravaged due to heavy rain and another extreme climate in the last few centuries. India is also feeling the effects of rising smog levels. An estimated 3.3% of India’s GDP is lost each year because of the health impacts of small sulfur matter. In 2012, ecological degradation was estimated by the WHO to be the cause of 760,000 deaths in China (Yang et al. 2021b).

The current growth in the business has resulted in a huge increase in power use. This can meet this demand because of the area’s abundance of sustainable energy resources. During the year, bright sunshine bathes the bulk of the land. Normal asset reduction is a serious concern for international business in the 21st era due to the mortal desire for the earth’s assets (Li et al. 2021). Economics and ecology have been intertwined since the late 1800s when Religion “Thomas Malthus” and his critics attacked the poor relief program. As a result of these attempts, he feels that the ecosystem is deteriorating and that mortal capability and coming centuries’ access to food may be jeopardized (Sun et al. 2022). There is a direct correlation between mortal and ecosystem well-being and Malthus’s “limit to increase” (the relationship between socioeconomic development and environmental quality). Reference (Wu et al. 2020b) investigated international power development and usage, more from thermal fuels such as coal (oil), gas (gasoline), and water.

Green financial growth relies heavily on the growth of sustainable power, which is the most talked-about feature of the power development growth system in general (Datta and Sahu 2020). According to current estimates, sustainable power will provide more than 26% of the world’s power by the end of 2017, as its usage grows fast and becomes more affordable in energy markets. As a result, it is critical to research the present state of sustainable power and the variables that influence its growth. China is boosting its focus on greenish growth and sustainable sources, extending its energy market, and dispersing sustainable power distribution systems to drive financial creation and safeguard the ecosystem. However (Jafari et al. 2022), China’s advance in green financial prosperity and sustainable power production has been restrained by powerful state backing and the sluggish improvement of innovation. Based on previous research, this study examined the impact of climate control regulations on green financial development from energy usage. Climate control laws and sustainable energy production were also examined. Using our results, China’s green economy and sustainable power initiatives may be based on a solid scholarly foundation (Wang et al. 2021). China’s rising focus on greenish and sustainable growth necessitates an investigation of the role of ecological legislation in promoting greenish economic growth and continuous electricity expansion. South Asian financial systems are also dealing with similar difficulties due to growing industrialization and a larger ecological footprint (EF). Almost all of the world’s financial action and asset bleeding occur in large metropolitan areas. Mortals go to urban areas in search of better opportunities in learning, health care, and employment (Zhang 2021). There can be no escaping the impact of industrialization on any nation’s development. Industrialization in advanced and developing countries is placing a significant demand on average assets and producing climate problems (Zhou et al. 2021). The urban inhabitants increased from 790 million in 1960 to 9.6 billion in 2017. Almost 57% of the world’s population resided in cities by 2018 (Mohsin et al. 2022). Urbanized areas account for 3.4% of the moon’s land, using 77% of the world’s power and producing 73 to 80% of the GHGs (Wen et al. 2021). Industrialization is anticipated to contribute to 68% of the world’s species increase by 2060, growing from 12.3 billion to 6.4 billion persons. Despite its positive benefits on financial development, innovation, and knowledge, industrialization accelerates destruction and ecological harm. Greenish financial development is also rising in South Asian countries, where it has been welcomed as a viable solution to ecological problems. Some of the harmful consequences of ecological deterioration may be mitigated by promoting greenish industrial development (Zhang et al. 2016). The Treaty of 1997, the Paris Weather Change Treaty of 2014, and the 2040 Strategy for Sustainable Development have all promised to reduce carbon discharge, but these goals have not yet come to fruition. In addition to harming the ecosystem and ecosystems, international heating has a broad range of negative consequences for the international economy and society. Enhanced ecological efficiency (EE) and resource usage in advanced countries are significantly faster than development (Yang et al. 2021c).
literacy in spurring economic growth. A deeper knowledge of the industrial structure-induced fiscal imbalance is needed to establish fiscal standards and encourage economic growth.

**Literature review**

The environmentally friendly and economically beneficial growth is at the heart of the “green” economics movement. There are several similar phrases, including “ecological development,” “green sector,” and “reduced financial system.” The term “green financial expansion” was originally used during the Fifth China Meeting on Climate and Economy of the United Nations in 2004, which recognized greenish financial growth as a refreshing approach for renewable expansion. Greenish financial growth has previously been studied in terms of its connotation (Zhang et al. 2021b), measurement, and effect factors (Wu et al. 2020a).

It is necessary to employ statistical management of macroeconomic approaches and procedures to quantify greenish financial development since it cannot be immediately seen. A scholarly approach for assessing greenish financial development is still lacking. However, data envelopment analysis (DEA), a non-parametric practical productivity study tool, is extensively used and successful (Scherbakov and Silkina 2019). First introduced by Charnes (Verhoef et al. 2015) and developed over more than 40 years by several researchers, the DEA technique is based on a conceptual framework that has evolved through time. To measure greenish financial development, the DEA may assess many feed and outcome units and not need suppositions about the relationship between inputs and outputs (Booyse et al. 2020). The SBM model and the estimate level approach examine the variance of undesirable outcomes and innovation sets while constructing a new border as a unifying standard. This strategy ensures that urban greenish financial development is accurately measured.

In addition, this research examined the influence of ecological legislation on the expansion of the green economy. Non-linear and linear research of ecological regulation’s influence on greenish financial development may be categorized (Mohsin et al. 2018b) (Datta and Sahu 2021). A majority of research on the linear link between ecological protection and greenish financial development focuses on the short-term “cost of consent” and the lengthy “resource technological” resulting from regulations. It is said that ecological rules harm the sustainability of businesses because of the prohibitive costs of complying with them. For instance, based on plant watch data, Porter and Kramer (2019) discovered that the US Clean Air Act lowered the total factor efficiency of production enterprises, undermining the idea that environmental laws are free or even advantageous. Smog heaven theory also shows that tighter ecological restrictions would boost manufacturing prices in the near run and lead to enterprises moving out of the area to locations with less rigorous ecological rules, which is bad for local financial growth. The “cost-saving technology” theory, on the other hand, contends that ecosystem regulations will “force” businesses to boost R&D capital expenditures in fresher manufacturing, alter processing techniques, and offset the harmful impacts of “conformance costs” while simultaneously enhancing the ecological system. Several research has come to different findings on the link between the relationship between SMEs and green economic recovery, which has heightened the discussion, concluded that the was formerly a belief among economists that severe ecological restrictions, would raise the price of manufacturing for companies, and impair their profitability, resulting in lower financial development. When the cost of environmental releases rises, the US economy suffers, as was observed by Hornik (2021). For example, in the late 1960s, it indicated that ecological rules caused efficiency losses of 15–25% in five high sectors in the USA (such as paper and chemicals, among others). While Porter (1980) argued that ecological legislation encourages businesses to develop, they were wrong. Consequently, development has a greater impact on overall component efficiency, which in turn improves the profitability of enterprises (Porter 1985).

Most earlier research on the exponential impacts of ecological restrictions on greenish financial development also investigated them from the viewpoints of “enforcement costs” or “technology payback.” According to the “cost of conformance” argument, ecological regulations will affect profit margins and efficiency in the near term (Mohsin et al. 2021a). The “technology recompense” indicates that ecological enforcement policies can lead to increased financing in active investigation and growth, as well as a shift in manufacturing techniques, to recover for the harmful impact of “cost of conformance,” resulting in a rise in efficiency (Caro and Sadr 2019). According to several academics, ecological legislation, green technical advancement, eco-efficiency, and greenish financial development all take the form of a “U” (Alexander and Kent 2022).

Of course, the connection between climate legislation and the growth of sustainable power has previously been discussed in part of the research. There is a one-way harmful association between financial expansion and the expansion of sustainable power. In contrast, a beneficial one-way connection exists between financial expansion and the advancement of greenish economic expansion (Muhammad Mohsin et al. 2019). As a result, the problem of improving the expansion of sustainable power sources has gained importance. The conventional study focuses on the influence of energy usage on financial progress, wealth, and the environmental ecosystem. However, few studies have examined the influence variables of power usage and sustainable energy.
production, which gives the potential for this investigation to expand (Mohsin et al. 2018a).

In terms of demographics and geography, many macroeconomic and ecological concerns are impacting the globe, including sickness problems, extreme rainfall and heat, flames, and hurricanes. Even more so, internationalization has established a major concern, particularly in the international economy. Financial industries, business, and communication are critical components in increasing developing market liberalization and availability (Pan 2019). By reducing regulations and freeing up industries throughout the globe, foreign expenditure and the global stock of resources and obligations are being promoted (Krasnov et al. 2019). The internationalization of the economic sector has paved the way for financial technology innovation. Construction, farming, knowledge innovation, sustainable sources, and other ecologically concerned businesses may gain from additional investment. Financial internationalization has benefited ecological stability by funding R&D in ecological preservation and sustainable sources. The green economic development parts of monetary organizations might be a stimulant for commercial building progress. Ecological footprint (EF) is sometimes a price for greenish economic development since it encourages asset use, which in turn creates EF and damages the ecosystem (Burke et al. 2017). Prosperity has been linked with ecological deterioration in several research. However, it is expected to develop due to development, power effectiveness, ecological restrictions, and green technology at a high level of wealth. As a result, the possibility of a relationship between income and the environment is examined.

**Hypothesis development**

Unlike conventional financial development, Greenish financial expansion depends on the individual self-financial development and financial growth performance, unlike classical economic expansion. Commercial sewage, commercial carbon monoxide, commercial smog, and dust releases are all included in this assessment, which integrates environmental considerations such as power usage and liquid assets inputs. It is essential to reduce the number of normal resources used in the manufacturing method to accomplish asset protection and limit the environmental harm caused by waste discharges, therefore increasing green financial development. Achieving greenish financial development also requires constant technical advancement in the manufacturing process. Resource productivity and the use of cleaner manufacturing facilities to decrease pollution are two ways to increase the rate of greenish financial development. From a financial point of view, we can predict the likely non-linear impacts and regional spillovers and spatial response impacts of ecological rules on greenish development (Zhang et al. 2021a) (He et al. 2020).

As local administrations and businesses become more devoted to asset preservation, ecological preservation, and pollution therapies when distributing assets, an uptick in ecological control can drastically decrease unwanted outputs that would otherwise go unchecked. Improved ecological control is also expected to have a favorable effect on the availability of resources. This is because atmospheric restrictions are designed to encourage the long-term implementation of “clean-up” innovations intended to enhance the biodiversity-ecosystem over time. One Canadian study (Giordano 2020) and one American study both concluded that ecological rules lower pollution discharges. In the near term, stricter ecological regulations may raise manufacturing expenses and limit firms’ capacity to create and improve greenish technology, both of which are detrimental to greenish financial development. This is due to the brief “expense of conformance,” independent of the ecological regulation’s impact on “poor output” or its incentive for greenish digitalization. Since smog protection and power savings will decrease profit margins and constrain technological advancements in manufacturing, ecological rules are expected to raise manufacturing costs for companies even if other factors such as venture manufacturing technologies, asset distribution, and market request do not change. Because of this “cost of conformity,” it is less likely that businesses would invest in pollution-reducing technology and more likely that they will instead focus on increasing output and toxic discharges to enhance profits (Barykin et al. 2021a). This means that in the near run, ecological laws have a deterrent impact on financial growth.

Over time, the Porter hypothesis argues that ecological legislation might drive R&D and development, lowering manufacturing prices and boosting financial development (Artemov et al. 2019). Climate legislation, according to Gao and Fan (2021), is a powerful force that encourages businesses to spend more in R&D, enhance technology, and alter manufacturing processes, all of which lead to higher total factor performance. To counteract for the harmful impact of “price conformance” and to assist businesses build new capability, an “expense technology” impact will be generated. Increased ecological laws push “high energy and high smog” businesses to develop green technological capabilities that may also minimize ecological smog and power usage (Saghiri et al. 2017). Polluting enterprises would shift from places with stronger ecological laws to regions with more lax ecological controls, as the “smog haven” theory shows. This will reduce dirty discharges in the native locations but will turn less controlled regions into “smog hideouts” or a “win-win” scenario may be achieved in both ecological terms by enforcing lengthy ecological regulations (Verny et al. 2020). According to this research, Hypothesis 1 is correct.
Hypothesis 1 **All else equal, ecological control has a large U-shaped non-linear association with greenish financial development.**

Economists and econometricians often neglect geographical impacts in their studies or model settings; yet, according to the “first rule of topography,” almost anything is connected to everybody else, but near things are more relevant than distance objects (38). As a matter of fact, trash from the natural ecosystem has high consequences and provincial peculiarities. For this reason, enforcing rigorous local state laws to restrict pollutant discharges may “push” businesses to innovate in smog control technology and therefore increase their greenish total factor performance by increasing area ecological control. Ecological restrictions in places with stricter ecological standards might benefit from “trying to capitalize,” which reduces toxins’ influence in other locations. Enhanced smog management technologies and increased greenish total factor production are also expected as a result of this tech transfer. To put it another way, the geographic leakage impacts of ecological rules on greenish financial expansion mean that areas that implement strict ecological rules may not receive all of the local advantages of such regulations and are uniformly completely reliant (Nardo 2020).

Green financial development is also affected by ecological legislation. “Advertisement events” among states may readily lead to “bottom-up contest” attitude in local state contest (Barykin et al. 2021c). Local administrations’ ecological control tactics are typically impacted by the conduct of local administrations at the same level as adjacent areas, developed in tactical rivalry in ecological control policies by local government entities. Local authorities in neighborhood areas select to neglect ecological security in pursuit of operational profitability, while broader rules collect toxic businesses and devastate. As a result, ecological control and greenish economic development may have a non-linear U-shape connection. On the other hand, climate control has no effect on the growth of sustainable power, and the more ecological control there is, the good the growth of sustainable power will be. Thus, climate legislation may have a linear impact on sustainable power production. As a consequence, study Hypothesis 3 is proposed in this work.

Hypothesis 2 **Ecological rules may have regional leakage and geographical report impacts on greenish financial development that are non-linear.**

It is vital to note that sustainable power is just one aspect of the overall measure of greenish development, which includes both financial development and an environmental implication. Both tougher and narrower climate change laws have the opposite effect on financial growth: stricter rules raise the producing costs of businesses and slow financial expansion, while broader rules collect toxic businesses and devastate. As a result, ecological control and greenish economic development may have a non-linear U-shape connection. On the other hand, climate control has no effect on the growth of sustainable power, and the more ecological control there is, the good the growth of sustainable power will be. Thus, climate legislation may have a linear impact on sustainable power production. As a consequence, study Hypothesis 3 is proposed in this work.

Hypothesis 3 **Ecological regulations have a major impact on the growth of sustainable power, assuming other factors are equal.**

The study adheres to four environmental value benchmarks: economy, security, conventional profitability, and environmental stability, all of which are considered obligatory. Environmental effectiveness may be improved through lowering GHG pollutants, enhancing technological skills as well as ensuring that all citizens have equitable entry to better energies and technologies. When it comes to reducing carbon emissions, technical and information financial integration will play a significant role. There are “safety requirements” for combustion reductions, which call for the selection of sustainable power that is secure while also being low-cost and less vulnerable to carbon releases. Solar energy (Lu et al. 2020), wind energy (Hossain et al. 2020), biomass, hydropower, and thermal energy (Barykin et al. 2021b) are all examples of sustainable power, but each has its own drawbacks when it comes to being plugged into regional energy systems. Nuclear energy, according to the (Chen et al. 2021), is safe, dependable, and low-carbon since it emits almost no greenhouse gases (GHGs) during its entire operational and lifetime phases. Coastal and offshore winds are both suitable with this system. It helps to maintain the worldwide median heat below the 1.5 °C level agreed upon by the parties. Nearly two metric tons of carbon emissions are prevented annually by nuclear power, compared to a research by the International Nuclear Energy Agency (Matsuda et al. 2019). Low-carbon futures need nuclear power creation. Since nuclear power is a viable option for reducing greenhouse gas emissions, the most recent (Bučková et al. 2019) study states that nuclear power could indeed be totally out for promoting sustainable electricity. “Economic thought resilience” refers to an increase in net country well-being. As a result, ecological legislation based on rewards enhance
ecological and safety benchmarks, which in turn leads to the manufacture of ecologically friendly items. Lengthy planning tools that help safeguard organic money may be used to attain “environmental benchmarks” as well. Greenhouse gas market and charcoal taxes are two essential tools for valuation biomass, and each has its own working model, but they both aim to control the growth of nitrogen pollutants. The conservative superintendent’s ecosystem requirements are aided by climate rules that are as strict as possible (Lei et al. 2022).

Methodology

Study variables

Green funding and small business structure are the two key factors examined in this article. In order to evaluate green finance assets, several proxies were used. Green finance constraints (GFC) are included, and they are assessed using various proxies. We used the natural logarithm of one multiplied by the number of green patents as another proxy for green funding. Another proxy metric for green finance was the ratio of green patents to the total number of patents in existence. The number of green patents calculated by dividing the number of patents is used to calculate this proxy. Green funding and SMEs were measured and estimated using the China statistical yearbook database. As a result, green funding and SMEs are calculated as the small business’s output value as a percentage of China’s GDP.

Economic development, government engagement, human capital, infrastructure, and urbanization are just a few examples of the many factors in the econometric model. Authentic free trade occurs when all of a country’s GDP’s imports and exports contribute to the country’s overall economic output. The GDP accounts for a major portion of the government’s fiscal expenditures. Green economic growth is measured using the logarithmic formulation of real GDP per capita. Average education years are used for calculating human capital. The amount of traffic in a given area may be used to measure transportation systems.

Study data

The World Bank database was used to gather the data for this study, which spans from 2000 to 2020. Other databases, such as the World Energy Council, China statistical yearbook, and other relevant data, were also evaluated for data-gathering reasons.

Empirical estimation technique

The Kalman filter is often used in economics research. The Kalman filter is best suited for modeling approaches that utilize instant variables to assess variables and forecast and produce values for factors that have not yet been seen.

\[
IC = \sum_j C_{ij} (Loss_j + G_j) = \sum_j C_{ij} \left( \frac{\omega^*}{\sqrt{2}} + G_j \right), j
\]

\[
HC = \sum_j C_{ij} (G_j - E[D_j]), j = \{p, o\}
\]

\[
SC = \sum_j C_{ij} (E[D_j] - G_j), j = \{p, o\}
\]

\[
U^\text{mat} = \ln \left( \sum_j \left( \frac{L}{P_j} - G_j^{\text{min}} + \theta \right) \right), j = \{p, o\}
\]

Variable estimates using time-varying variables may be used when the variables are uncertain. It is not easy to account for all variables that impact renewable energy sources. It has been shown in previous research that as the number of variables changes, it becomes more difficult to describe the complex interplay between those variables.

\[
\Pi (P_j, G_j, L) = TR - IC - HC - SC - IP = \sum_j P_j \sum_i E[D_i] - \sum_j C_{ij} (LL_j + G_j) - \sum_j C_{ij} (G_j - E[D_j])^2 - \sum_j C_{ij} (E[D_j] - G_j)^2 + \lambda (U^\text{mat} - L, L) - r(1 - \lambda)L
\]

This decision is necessary in order to find which features are most important.

\[
G_j = \text{Root} \left[ 15 \sqrt[3]{2} C_{ij} \left( M_{ij}^{\text{max}} \right)^3 P_j V_j^2 + \cdots + \left( 3 \sqrt[3]{2} C_{ij} V_j^2 + 3 \sqrt[3]{2} C_{ij} V_j - 3 \sqrt[3]{2} D_j V_j \right) \#1 \right], j = \{p, o\}, i = \{1, 5\}
\]

The Copenhagen test must be used to ensure that the variables are stable. This equation’s unscented Kalman model differs from many other estimating strategies that use ordinary least squares (OLS) research. The equation illustrates the OLS framework.

\[
Y_t = \alpha_0 + \alpha_1 X_t + \alpha_2 Z_t + u_t
\]

\[
\text{ME} : Y_t = \beta + \beta_1 X_t + \beta_2 Z_t + u_t \text{TE} : \beta_{it} = \emptyset_{it} \beta_{it-1} + v_{it}
\]

If the condition equation includes random wandering, it is fair to predict that it will be in an extended conformation. Adjustments in the green economic recovery or a change in management reflect green finance.

\[
\text{ME} : Y_t = \beta + \beta_1 X_t + \beta_2 Z_t + u_t \text{TE} : \beta_{2t} = \emptyset_{2t-1} + v_t
\]
A mathematical formula (9) reveals that the current values of the variables are equal to their initial values plus the sum of all prior \( n \) economic recovery shocks that have occurred since. The model fits the criteria to define the state equation’s structure.

\[
WPE_t = \beta + \beta_1 CPI_t + \beta_2 EP + \beta_3 EE + \beta_4 EFF_t + \beta_5 HJI_t + u_t
\]  

(10)

Researchers want to find out how different types of bioenergy respond to a real-world change in interest rates or the amount of money available. In addition, the study reveals that the vector autoregression technique, sometimes known as VAR, takes advantage of industrial buildings and other movable green finance delays.

\[
\beta_t = \beta_{t-2} + v_{it-1} + v_{it}
\]  

(11)

In fiscal policy research, this model, developed by Pilipenko et al. (2019), has shown to be quite useful. Because the research depends on impulse response and variance decomposition findings, it uses variables in levels. As a result, there is no data loss while comparing two sets of data. Even when co-integration tests provide inconsistent estimates, utilizing variables in stages yields reliable estimates, as shown in these research findings.

\[
\beta_t = \beta_\text{it} + \sum_{k=0}^{n} v_{it-k}
\]  

(12)

Two fiscal policy instruments, interest rates, and the financial system are examined in the context of China’s economy. Using the vector autoregression and Kalman filters, scholars can identify the time-varying variables using the Kalman filter. The two elements of this regression model are time-varying explanatory variables and static variables.

\[
y_t = \sum_{i=1}^{p} A_i y_{t-i} + \sum_{j=1}^{n} B_j X_{t-j} + \epsilon_t, \ t = 1, 2, \ldots, n
\]  

(13)

Moving factors may be considered when looking at variable changes over time and how such changes can affect a given parameter. Introducing the Kalman filter approach is a solution for unstable models. As a result, performing the Hansen test on specifications is an essential initial step.

**Results and discussion**

**Variation in SMEs in China**

We want to know how much greenish funding affects China’s manufacturing construct. This part examines the research results to assist in that endeavor. Greens’ finance on manufacturing construction is first explained, followed by an in-depth discussion of the link between the two constructions and the conclusions. As a result of green finance from 2002 to 2018, our results demonstrate the present state of small business, development, and existing expectations of China’s power industry. By applying facts of midway-situated towns, it was accomplished. As indicated in the preceding, a variety of agents for greener funding and the small business sector were used to compute and deduce the components. The green finance brokers were used for the feed parameters, while the small business proxies were used for the production measures. After adjusting for regional differences in production and feed, we calculated the contribution of each country’s overall small business productivity to GDP. The results are discussed to help shed light on the subject (Table 1).

**Trends of green financing role in the SME development of China**

For this investigation, the province-level panel data from China on Vietnam’s industries was utilized to establish an overall growth rate in the energy sector. As a result of this study, industrial output and finance options have been given proper importance. Lastly, the data in Tables 2 and 3 show how the energy industry in Vietnam has evolved and changed over the previous two decades. Table 1 shows five important Vietnamese cities that have seen a significant transformation since 2001.

The center part of China’s power businesses, as shown in Table 2, is greenish funding, which contributed to the

| Table 1 Variation in small business in centrally controlled municipalities of China |
|-------------------------------------|-----------------|-----------------|-----------------|
| Centrally controlled municipalities | Small business ratio of output value to GDP | Small business production function | GDP to small business development |
| Shanghai                           | 0.31            | 0.50            | 0.11            |
| Beijing                            | 0.22            | 0.12            | 0.31            |
| Shenzhen                           | 0.49            | 0.41            | 0.39            |
| Guangzhou                          | 0.50            | 0.51            | 0.19            |
| Chongqing                          | 0.12            | 0.19            | 0.11            |

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growth of these sectors by 0.2293 (a rise of 22.93%) between 2000 and 2018. In terms of factual findings, we found a wide range of economic motions for greenish expenditures throughout time. Small businesses have gotten a lot less help. As a result, the power business in China has a larger need for support due to the possible consequences. Green investment’s contributions from 2000 to 2018 have been mostly ineffective. Power may also be generated from sustainable sources, reducing the number of people without access to reliable power (Chen et al. 2021).

The productivity of Chinese manufacturing and usage has improved in recent years. The company’s growth and the creation of in-house financing options have stalled out. Eastern China has witnessed a much smaller growth in construction productivity than the middle and western regions. Productivity gains in the darkfield of small businesses vary greatly among the eastern and middle areas, with no obvious difference between the two (Tables 4, 5, 6, 7, 8 and 9).

Moreover, the position of generating wealth fund in the eastern area abuse gas reception stage has reduced, especially from 1991 to 2004 and 2007 to 2011, as the comprehensive presentation of the phase has reduced. A 0.1469% convert in WSGE method that green funding is critical to satisfying to touch the small business, growth, and other financial opportunities in the western section from 1991 to 2017. Over the last century, a continuous year-over-year rise in local Chinese companies, small business proxies, and greenish lending agents could be viewed (Gao et al. 2021). It reveals that a greenish patent is vital for improving small businesses. Small businesses have increased throughout China’s 5-year plan (Cai and Lo 2020).

Such a rise in expenditure on small businesses had enhanced productivity in small businesses, especially in the use of power. After that, the Chinese state began industrial sequence preservation and minimizing manufacturing pollution in its impending 5-year plan (Frederico and Garza-reyes 2020). However, we found that China had set a goal of reducing its total power strength (from 19 to 6%) and important toxins (from 25 to 12%).

It is possible that the energy sector can be relieved if these strong and essential recommendations for energy preservation and leaking reduction are implemented. In other words, greenish finance has a significant impact on the commercial expansion and the maintenance of

| Period | Green financing | Small businesses | Green economic recovery |
|--------|-----------------|------------------|------------------------|
| 2000   | 0.388           | 0.241            | 0.819                  |
| 2001   | 0.281           | 0.779            | 0.831                  |
| 2002   | 0.251           | 0.108            | 0.450                  |
| 2003   | 0.151           | 0.221            | 0.013                  |
| 2004   | 0.150           | 0.081            | 0.861                  |
| 2005   | 0.421           | 0.931            | 0.071                  |
| 2006   | 0.288           | 0.213            | 0.812                  |
| 2007   | 0.919           | 0.670            | 0.421                  |
| 2008   | 0.231           | 0.215            | 0.619                  |
| 2009   | 0.831           | 0.738            | 0.161                  |
| 2010   | 0.260           | 0.090            | 0.319                  |
| 2011   | 0.951           | 0.871            | 0.988                  |
| 2012   | 0.251           | 0.680            | 0.069                  |
| 2013   | 0.589           | 0.521            | 0.451                  |
| 2014   | 0.539           | 0.721            | 0.629                  |
| 2015   | 0.181           | 0.579            | 0.461                  |
| 2016   | 0.731           | 0.221            | 0.469                  |
| 2017   | 0.160           | 0.190            | 0.840                  |
| 2018   | 0.959           | 0.988            | 0.781                  |
| 2019   | 0.635           | 0.745            | 0.332                  |
| 2020   | 0.784           | 0.652            | 0.748                  |

Table 3 Kalman filter analysis

| Proxy items | Co-efficient | Standard error | Z-score | Significance |
|-------------|--------------|----------------|---------|--------------|
| Green economic recovery does not cause by small businesses | −0.181 | 0.051 | 0.949 | 0.181 |
| Small businesses does not cause green economic recovery | −0.159 | 0.588 | 0.290 | 0.339 |
| Economic growth does not cause carbon emissions | −0.361 | 0.571 | 0.288 | 0.288 |
| Carbon emissions does not cause small businesses | −0.090 | 0.877 | 0.469 | 0.088 |
| Technical efficiency does not cause by SMEs | −0.181 | 0.071 | 0.431 | 0.169 |
| Economic growth does cause SMEs | 0.212 | 0.061 | 0.018 | 0.002 |
| SMEs does cause technical efficiency | 0.350 | 0.479 | 0.588 | 0.004 |
| Carbon emissions does not cause technical efficiency | 0.759 | 0.131 | 0.431 | 0.980 |
| Economic growth does not cause technical efficiency | 0.512 | 0.350 | 0.380 | 0.570 |
| SMEs does cause green economic recovery | 0.559 | 0.159 | 0.407 | 0.000 |
| Green finance does cause green economic recovery | 0.941 | 0.151 | 0.951 | 0.006 |
business stability (Hajdas et al. 2022). This means that Hypothesis 2 habitat 1 (H1) has been agreed in the studies. Small business rose early and steadily in the following years. Green finance has witnessed the greatest substantial improvements in Chongqing (the former capital of China’s southernmost province) and Shenzhen (the capital of China’s central-southern province), both of which have 0.2618 and 0.2909 correspondingly. According to the findings, Beijing and Shanghai saw a significant increase in greenish funding, backed by an increase in green financing to China (Yan et al. 2021). Although Beijing and Shenzhen have lower levels of greenish funding, the small business of both cities is more efficient than those in Beijing and Chongqing. It is also worth noting that, despite the widespread adoption of green financing, small business efficiency in many regions declined between 2000 and 2006 and stayed at that level between 2013 and 2017.

**Robustness analysis**

Here, we find the most recent developments in China’s small businesses at the provincial and provincial levels. The small business efficiency of Beijing, Shanghai, Shenzhen, and Chongqing was examined using a total slack-based DEA and a kernel frequency allocation investigation.

As a result of recent advancements in science and technology, most countries worldwide are undergoing a manufacturing and economic transformation with far consequences for their future growth. As a result, a model of financial growth based on factors is no

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**Table 4** Estimating the nexus between study constructs

| Study constructs                  | Co-efficient | Standard error | Z-score | Significance |
|-----------------------------------|--------------|----------------|---------|--------------|
| Green financing                   | 0.969        | 0.841          | 0.341   | 0.005        |
| Small businesses                  | 0.680        | 0.731          | 0.388   | 0.000        |
| Financial literacy(FL)            | 0.587        | 0.744          | 0.625   | 0.002        |
| Green economic recovery           | 0.221        | 0.250          | 0.888   | 0.002        |

Authors’ estimation

**Table 5** Hansen test output

| Empty cell                      | Stochastic trends | LC statistics | Deterministic trends | Significance |
|---------------------------------|-------------------|---------------|----------------------|--------------|
| Green financing                 | 0.339             | 0.759         | 0.241                | 0.000        |
| Small businesses                | 0.639             | 0.112         | 0.102                | 0.003        |
| Financial literacy              | 0.352             | 0.625         | 0.745                | 0.414        |
| Green economic recovery         | 0.770             | 0.339         | 0.551                | 0.008        |
| Carbon emission                 | 0.821             | 0.181         | 0.711                | 0.004        |

**Table 6** Absolute $b$-convergence test on study constructs

| Estimates                      | GFC          | GPC          | TPCI         | IOR          | INDPF        | INND         | FL           |
|--------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Coefficient                    | 0.5681       | 0.1088       | 0.0188       | 0.4750       | 0.2171       | 0.0231       | 0.0324       |
| $t$-value                      | 0.0241       | 0.3831       | 0.1180       | 0.7788       | 0.1361       | 0.0180       | 0.0514       |
| $R^2$                          | 0.8490       | 0.3861       | 0.1039       | 0.0041       | 0.0141       | 0.4131       | 0.3254       |
| Significance                   | 0.0008       | 0.0003       | 0.0007       | 0.0002       | 0.0004       | 0.0007       | 0.0005       |
| Convergence rate               | 0.0581       | 0.0680       | 0.0539       | 0.0579       | 0.0315       | 0.2112       | 0.1841       |

**Table 7** The conditional $b$-convergence test

| Estimates                      | GFC          | GPC          | TPCI         | IOR          | INDPF        | INND         | FL           |
|--------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Coefficient                    | 0.388        | 0.890        | 0.488        | 0.239        | 0.341        | 0.531        | 0.632        |
| $t$-value                      | 0.590        | 0.132        | 0.389        | 0.141        | 0.321        | 0.512        | 0.521        |
| $R^2$                          | 0.241        | 0.290        | 0.588        | 0.661        | 0.480        | 0.288        | 0.352        |
| Significance                   | 0.008        | 0.007        | 0.005        | 0.006        | 0.002        | 0.004        | 0.005        |
| Convergence rate               | 0.751        | 0.341        | 0.981        | 0.529        | 0.951        | 0.0541       | 0.0521       |
longer appropriate. Global competition among industrialized countries is essential to the development of high-tech enterprises. By modernizing their manufacturing systems, however, developing financial systems may also be capable of performing a high rebound. China’s scholars and officials are increasingly concerned about the country’s small businesses. It is important to emphasize that small business is mostly accomplished via people’s money and technological advancement in advanced countries (Deng and Zhao 2022). In China, small business has relied heavily on human capital and growth.

Table 9 displays the results of the hardiness tests, which begin by taking into account the biased predictions caused by internal. The active factor technique may be used for internal. The delayed period of greenish finance was employed as an active element in the two-stage minimal mall method. This shows that green funding has a favorable impact. The VFI measuring technique was also changed by assessing the variation between the economic deficit and the total amount of government expenditure. According to the early studies, a 5% green funding factor is significantly unfavorable. China’s small business has not changed. Thus, the conclusions are solid, according to the green finance parameter values. H1 (habitat 1) is reinforced since the test verifies that the above result is stable and consistent.

Discussion

Despite this, it is important to note that control elements should not be ignored. Even if free trade encourages small business justification, it does not enhance the framework of the industry itself. When it comes to mechanization, opening to commerce may speed things up, but it can also slow things down. Small business does not advance due to financial growth as they should (Zhabko et al. 2019). There has been a considerable negative correlation between the amount of state interference and the progress toward modernizing small businesses. Exceptional state interference in the economic mechanism may guide asset distribution inefficiency and small business slowdown. Mortal money accumulation in China has not contributed to the growth of the country’s small businesses, as shown by a positive but economically unimportant net mortal capital factor. Despite this, it is clear that the framework has a role in facilitating the simplicity of manufacturing institutions (Sacks et al. 2020).

A few of the large manufacturing and modern service sectors rely on framework investments that hinder the updating of small businesses. In other words, the existing inequality in China’s business is mostly due to industrialization. Value and amount are not priorities in China’s industrialization strategy, which focuses on number and pace. In certain cases, an increase in industrialization due to manufacturing may not be beneficial for improving small businesses. In addition, in order to change reduced and reduced industries, a complex and comprehensive expenditure adaptation method is required (Fang et al. 2022a). Updating a small business after leaving the industry takes a lot of work and capital. Rising utility firms will be able to establish the optimal distribution of land and average assets once their markets and global existence are sufficiently vast and diverse. Over time, greenish financing should improve the framework of the manufacturing industry. Update and optimizing the framework are the two most important aspects of small business adjustment. According to the study findings, a key indicator of the lesser sector’s adding worth to GDP is to upgrade the small business to better adapt to shifting industries. There is a growth in green finance imbalance as the share of manufacturing add worth in GDP rises, according to a study by Aslam et al. (2020). According to Leal and Perez (2009), boosting the GDP’s add worth in the lesser

| Study constructs | HVRT  | Power factor |
|------------------|-------|--------------|
|                  | V max | T max Leading Lagging |
| Green financing t| 0.80  | 0.81 0.50 0.69 |
| Industrial structure t| 0.31 | 0.70 0.79 0.14 |
| Financial literacy t| 0.14 | 0.78 0.45 0.66 |
| Green financing t−1| 0.091| 0.11 0.88 0.88 |
| Industrial structure t−1| 0.41 | 0.91 0.69 0.12 |
| Financial literacy t−1| 0.39 | 0.88 0.71 0.13 |

Table 9 Robustness assessment by parameter estimation

| Empty Cell | GFC | GPC | TPCI | IOR | INDPF | INND | FL |
|------------|-----|-----|------|-----|-------|------|----|
| Shanghai   | 0.0070 | 0.08418 | −0.00741 | −0.02231 | −0.00579 | −0.08059 | −0.00547 |
| Beijing    | 0.00141 | 0.02231 | −0.03188 | 0.05549 | 0.015329 | 0.0290 | 0.0325 |
| Shenzhen | 0.04481 | 0.04069 | 0.03290 | 0.01104 | 0.00341 | −0.02790 | 0.02456 |
| Chongqing | 0.04170 | 0.03888 | −0.02641 | 0.02088 | −0.00290 | 0.00271 | 0.00356 |
sector may significantly increase the nation’s power sensitivity. A rise in the lesser sector’s overall power supply from the lesser industry's growth, according to (Ma et al. 2022), is also expected. The lesser sector consumes more power than the third industry, to add insult to injury. This means that the third sector might be aided by green financing.

Regarding its link to the distribution of manufacturing elements, small business optimization (based on rationally and effectively allocating resources) corresponds with the level of connectedness among insight parts across multiple sectors. To further improve small business optimization, it is common for manufacturing factors like workers and money to be moved across different sectors. From reduced sectors, high-value production components (i.e., varied items and raw materials and manufacturing parts) move to greater businesses. Since they use electricity manufacturing methods, high-energy efficiency industries consume fewer power assets (Lazaris and Vrechopoulos 2014). An electricity reduction is achieved as a consequence of this. Small business improvement favors green financing from a conceptual approach. However, there is no evidence to support this claim.

Most studies described above do not focus on small business optimization, which is an important distinction to keep difference between SMEs performance for green economic recovery in different regions (Ma et al. 2022). It has been said that small business optimization has a greater positive impact on emitting power decrease than small business upgrading; however, their effect was not numerically important since they depended on a tiny sample size; to better understand the indeterminate relationship among some factors (such as innovation advancement, industrialization, and economic openness) and power density, increased emphasis is being placed on small business optimization rather than a small business improvement as a transformation component.

Conclusion and policy implications

Expanding small and medium-sized enterprises (SMEs), financial literacy, and green financing adjustments is critical to China’s shift to a more sustainable growth model. It also causes a change in the demand for energy from small businesses. From 2000 to 2020, a China provincial dataset was used to look at the effect of green finance on SME modification. Because small business optimization may be a transitional variable, this study examines the special mechanism of green financing on small business optimization. According to the DEA’s results, environment-friendly finance approaches support SME change. We can better understand how green financing influences the SMEs of China’s energy sectors by examining the direct and indirect aspects of small business promotion adjustment. The first benefit of a green finance update is that it contributes to structural stability in the industry. Raising the share of tertiary businesses in the national economy might lower energy intensity. The reduction in energy intensity may have a considerable and positive effect on small business development. SMEs' energy consumption rises dramatically due to the growth of high-energy-consuming industries. It is clear from the findings of our study, both inside and outside of the academic setting, that financial literacy should be a fundamental component of future public policies aimed at increasing green economic recovery and ensuring that it remains a long-term development priority for nations. It has been shown that even a little rise in the individual’s level of FL is enough to boost their green economic recovery significantly. Here are the results and policy implications of this research and a summary of the findings.

There will be a long-term demand for the transportation system and industry due to the significant expansion in the industrial revolution. As the findings show, green finance choices for industrial structural renovations have significant policy consequences. Efforts should be made to improve the country’s SME promotion to reduce energy use more effectively. The absence of a tertiary sector and a financially imbalanced industrial structure are major obstacles to the development of China’s economy. The primary, secondary, and tertiary sectors of China’s small businesses should be reorganized in light of the country’s shift from a manufacturing-based economy to one centered on financial services.

Consequently, the expansion of energy-intensive businesses should be restrained while companies are trying to contribute to the development of energy-efficient sectors via technological innovation. This research demonstrated that optimizing the industrial structure of the sector did not help reduce energy consumption. Such an outcome is to be anticipated, given the city’s location in the tertiary sector, which includes transportation and storage. Promoting a low-energy service industry is thus critical.

In addition to resolving China’s energy and economic issues, SME development is a necessary step. Due to the imbalance in the small business, the second industry faces significant barriers from high energy-consuming industries. A SMEs growth strategy may optimize resource utilization and the use of increased energy consumers if it is anticipated that this is the case. The elimination of outmoded innovations and the adoption of technologies to enhance efficiency and effectiveness is one technique of SME optimization, which results in lower energy intensity and reduced negative effects of development. SMEs development must thus be a primary engine for advancing sustainable energy development.

The government of China should promote and support the growth of firms’ ability for innovation while fostering manufacturing systems and industrial ecology to integrate
the country’s economy better. As a result, there is a pressing need to tackle climate change–related concerns, control global warming difficulties, and implement green stimulus measures for a green economic rebound. Using green finance as a catalyst, economic recovery may be sparked, and the business climate may be strengthened based on new ideas and a commitment to the environment. Such proposals are thus current and provided for consideration in constructing a more feasible and wise legislative framework for the eventual positive impacts of social welfare.

**Author contribution** Write up corrections, and supervision: YH; methodology, editing, writing of draft, data curation: YH; editing and visualization and conceptualization, data handling and visualization: ZF.

**Data availability** Data is publicly available at mentioned sources in the data section.

**Declarations**

**Ethics approval and consent to participate** We declare that we have no human participants, human data, or human issues.

**Consent for publication** We do not have any individual person’s data in any form and we give consent for publication in true letter and spirit.

**Competing interests** The authors declare no competing interests.

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