




Testing green fiscal policies for green investment, innovation and green productivity amid the COVID-19 era

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Abstract

This article measures renewable energy firm-level pure innovation efficiency, green productivity, technical efficiency, scale efficiency and total investment efficiency from micro input–output factors using Banker, Charnes and Cooper’s (BCC) data envelopment analysis (DEA) approach. Its main novelty is that it clearly explores the effective impacts of government subsidies and tax rebate policies on renewable energy firms’ investment efficiency using China’s renewable energy firm-level panel data. Our observational findings indicate that between 2001 and 2018, the aggregate degree of total investment performance from renewable energy firms rose steadily before declining. Renewable energy firms had larger ranges of total investment efficiency and size efficiency, and their levels of pure technological efficiency were both greater than 0.457%. At the 16% trust mark, current government subsidies and taxation rebates had dramatically positive effects on pure technological efficiency and total investment efficiency; additionally, government subsidies have a stronger positive impact on total investment efficiency and pure technical efficiency than taxation rebates. Furthermore, the ownership concentrations of renewable energy companies greatly encourage pure technological efficiency, size efficiency and total investment efficiency, and asset returns will significantly increase their average degree of total investment efficiency and pure technical efficiency.

Keywords Green fiscal policies · Economic change · Investment efficiency · Innovation efficiency · Green productivity · Restructuring

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1 Introduction

Countries around the world have a regional direction for clean energy (Barbier 2020). There has been an extraordinary amount of expenditure on renewable energy in response to global warming mitigation and environmental goals in the past few years, due to the exponential development of the greenhouse gas mitigation field (Mooij et al. 2020). A range of green fiscal policies has supported the exponential development of sustainable industries, including budget incentives and tax breaks. Currently, fiscal incentives, rigorous environmental regulations and improved investment knowledge of these industries all drive increasing renewable energy investment. China is in the process of assuming leadership in the global renewable energy sector (IMF 2020).

Using various methods, several researchers have shown that incentives and tax incentive programs will accelerate renewable energy investment from a macro viewpoint (Wu et al. 2021). The most important considerations in the decision-making phase for clean energy projects are higher construction rates, the availability of funding, subsidy prices and industry stability. Progress and integration of low-carbon electricity technologies, capacity consolidation, feed-in tariffs and regulatory growth help to make renewable energy investment feasible (He et al. 2021; Wang et al. 2021). Green investment subsidies enable free riders and developers to hurt the effectiveness of environmental programs (Zhang et al. 2020). Removing fossil fuel subsidies helps Middle Eastern and North African economies expand and open new job opportunities for people (Kennedy et al. 2020; Yu 2021). The nation's new energy vehicle (NEV) production was improved by including a subsidy for electric cars. International direct investment incentives and tax reductions should be defined through their growth rate rather than total investment, which make profits susceptible to large swings in uncertainty (Mi et al. 2021; Muposhi 2019). The fastest growing US solar photovoltaic and fuel cell sectors include tax credits to investors. Different policy tools, including tax and budgetary and financial benefits, along with business mechanisms, were found to speed up investments in solar energy and renewable energy adaptation (Tobias-Mamina and Maziriri 2020; Feng et al. 2020a, b).

As China has increased the application of its environmental and economic strategies and management schemes, the literature that blends the words “creativity” and “sustainability” has increased. Companies are expected to evolve to meet Porter's Green Economy Hypothesis's goal of improving green efficiency (del Rosal et al. 2019; Feng et al. 2020a, b). There are different directions in which SDG fulfillment is enhanced by innovation. Firstly, a responsive environmental policy, which focuses on maintaining growth while meeting sustainability targets, prompts companies to evolve because it relies on market-oriented instruments. Many businesses strive to satisfy technological, fiscal and environmental requirements (Albert and Gómez-Fernández 2020; Hu et al. 2020). Second, a well-designed environmental policy under SDG is an impetus it allows companies to carry out environmental creativity (Phan and Quang Thanh 2019). Nevertheless, the overall rewards of that outweigh its feedback to be obtained.

Clean companies should use environmental architecture, manufacturing and treatment advancement to reduce emissions (Matthews and Mokoena 2020; Zhao et al. 2020) based on the micro factors that govern investment in renewable energy (Athiyaman and Magapa 2019; Quan et al. 2021). If oil prices rise, spending in the automotive industry will shrink, which will consequently negatively affect employment in the field (Mhlanga and Moloi 2020; Yuan et al. 2021; Chien et al. 2021d). Rent and energy capacity determine the profit differentials of US, German, Mexican and Brazilian clean energy companies. Capital structure, company scale, knowledge funding, demand and preferences for socially conscious investments all back up. NEO firms' expenditure productivity is shaped by macroeconomic trends and firm-specific characteristics. Furthermore, the empirical findings reinforce the idea that clean energy companies will have a positive impact on the economy (Şanlısoy and Çiloğlu 2019; Li et al. 2021a, b, c, d). With unpredictable government regulations, the investment potential for renewable energy sources is restricted. The financial success of green energy firms depends on governmental incentives and political ties but is infrequently impacted by them (Chen et al. 2021; Han et al. 2021; Chien et al. 2021a). With regard to small- and medium-sized businesses, subsidy schemes like these can have a large impact on company spending, wages, production and productivity.

In addition, government incentives help companies conduct R&D, which influences expenditure volumes, forms of renewable energy buyers, output and energy production. These energy conservation and greenhouse reduction measures imposed by the nation serve to encourage carbon pollution and use. Higher feed-in tariffs and clean energy certificates will reduce profit margins. Applied and market measures such as electricity taxes and carbon taxes are generally well suited for intra-firm developments in energy-saving renewable technology. For the EU pollution trade plan, carbon dioxide (CO₂) tax does not have a big effect on electricity production even though energy tax would. Incentives for R&D including research and development (R&D credits) produce greater impacts on expenditure on R&D, on information spillover and even on the amount of spillover and knowledge acquired (Chien et al. 2021c). Tax and subsidy policies and regulation could discourage energy firms from competing in Germany, Switzerland and China and inhibit the growth of new technologies. Argentina, Russia and China are the same. Both Brazil and South Africa discovered many issues with the channels for funding innovation, as well as clean energies and poor policies in law. Thus, a reduction in the importance of fiscal benefits and public subsidies for clean energy is seen to be incorrect (Chien et al. 2020i; Sadiq et al. 2020).

The Chinese government has introduced subsidy and tax relief programs to encourage the renewable energy sector's growth with regard to energy reform, adaptation and stability in mind. Due to the rising role of government support and credits in renewable energy, there has been an increase in competition among industries, which has helped resolve investment issues and boost productivity. What kind of a difference does the point of market penetration make with regard to green investments? Is tax relief for wind and solar power companies a kind of investment motivation? We want to bridge the above information gaps through our study of business characteristics, energy costs and investors' expectations (Chien et al. 2021e)

in terms of the overall profitability of electricity production, as well as the effect of government tax breaks and subsidies on the productivity of investment in renewable energy firms. When the works of the literature examined previously showed a lack of awareness of government incentives and rebates for renewable industry companies' investment growth which weakens them at the small-scale stage, it results in investment shortages in the renewable industry (Mohsin et al. 2020, 2018b, 2021; Chien et al. 2021b). Both firm-specific considerations and market factors are expected to impact the financial performance of renewable energy companies, for instance, multiple government incentives and disincentives for investment. Renewable energy companies must decide if incentives and taxes encourage excessive growth and long-term development. In particular, government officials and company managers are interested in understanding the connection between green fiscal policy and the competitiveness of the market. Government incentives and tax breaks supplement private sector spending in developed and developing countries (Ikram et al. 2019a; Mohsin et al. 2018a, 2018b).

There are various investment holes in China's renewable energy companies owing to the country's peculiar and unstable economy (Chien et al. 2021f; He et al. 2020; Yang et al. 2021). Evaluating expenditure in green energy projects and assessing inefficiency in the sector are essential for government administrators to understand the economic impacts of their fiscal incentives (Chien et al. 2021g; Tiep et al. 2021). However, our key contribution furthers the current debates and elaborates on the current research by calculating firm-specific investment productivity using the DEA methodology and implementing it at the company level of business investments. This text contains three new facts. The first is to calculate the technological scale utility and expenditure and the overall variety of renewable energy firms' respective performance using a BCC model. The second item discusses the influences of government subsidies and levies on overall expenditure productivity, as well as technological effectiveness; the details on such subsidies and levies are also discussed in this report. Finally, this study explores how there are firm-specific fundamental factors that can account for different degrees of technological and complete productivity across companies, as well as company-specific factors that last across time.

This report is organized into the following subsections. This section summarizes the established theory and speculates its implications and implications. The green fiscal model established in Sect. 3 uses the clean energy panel data from the Econometric Economics program. The variable collection is given in Sect. 4, which explains the data source. Section 5 shows how various incentives and tax rebates impact the performance of clean energy firms' investments.

2 Literature review

The Chinese government adopted tax-rebate and subsidy programs to support accelerated development in the green sector and environment-altering technology, with the hope of meeting aggressive carbon reduction goals (Chien et al. 2021g). They have carried out various direct subsidies, such as research and growth, interest, program and on-grid as well as grid tariff subsidies for renewable energy (Chien et al.

2021h; Ikram et al. 2019a; Shah et al. 2019). Thus, China has adopted value-added tax, corporation taxes, profit taxes and several other industry tax policies. Direct and indirect participation in clean energy companies is aided by government incentives (Anh tu et al. 2021; Chien et al. 2021j). On the other hand, subsidies from the federal and state governments help renewable energy firms attract financial resources while enriching other streams of cash and creating financial capital gaps in project profitability, particularly where sources outside of the traditional banking system cannot be relied on (Ikram et al. 2019a, 2019b; Sun et al. 2019). Additionally, governmental subsidies for renewable energy firms serve as a market signal for financial institutions that indicate industrial investment opportunities, lower debt interest rates and show the operational and total efficiency of renewable energy firms (Chien et al. 2021b).

The Chinese government currently offers R&D tax rebates, VAT rebates, corporate tax breaks and expenditure breaks for clean energy production, among other current practices. Firms gain advantage from tax reduction because they will lower the cost of spending and make improvements in indirect investment sources, which improve their cash flow options. Discretionary funding is tied to cash flows, which enable renewable energy companies to manage their resource flows. A company that uses tax breaks to finance its green energy programs has more access to capital; this makes renewable energy technology efficient, which frees up money (Baloch et al. 2020; Sun et al. 2020a). Increased tax incentives mean companies will lower their borrowing costs and promote renewable energy procurement, encourage higher project profitability and lead to a more efficient renewable energy sector (Phan and Quang Thanh 2019). Capital-intensive technological advancement and research and development operations are a traditional public commodity that has a higher failure rate and a higher chance of losing the investment. Thus, business mistakes are compensated for by public funds, which corrects them with profits from R&D (Huang et al. 2020; Li et al. 2021d). One important effect of applying for grants is that it will promote the competitive advantages of technical R&D, causing renewable energy companies to strengthen their technical monopolies, motivating them to spend money on R&D and technology, thus enhancing unexpected profits and increasing performance (Baloch et al. 2020; Li et al. 2021a, 2021b, 2021c).

Though community efforts can be more successful or less effective depending on the approach taken, innovation quality should remain similar in all safe and emission categories. Alemzero et al. (2020a), Alemzero et al. (2020b) and Sun et al. (2020c) found that emerging developments can be further distinguished based on their emissions footprint. Newly emerging technologies can hurt the climate, but novel technology can counteract that. Firms in pollution-intensive sectors create more “compliance costs” and create fewer “value for clients” due to an invention offset. In addition, high-polluting businesses bear an extra financial burden because of financial limits (Chandio et al. 2020; Othman et al. 2020; Sun et al. 2020c). Research indicates that in the context of pollution abatement costs must be concurrent with the level of productivity in innovation systems; thus, companies working with pollutants face a dilemma in trying to enhance the latter. As a result, the net increase in efficiency may be reduced because of innovation in the environment. Pollution abatement is estimated to have a small

impact on green efficiency compared to conventional costs. Finally, the net benefit generated by the Porter hypothesis is more positive in clean industries. Accordingly, healthier sectors benefit greatly from creativity than those that generate emissions (Sun et al. 2020a, 2020b, 2020c).

In a way, such outcomes have been reached in the partnership between creativity and green productivity discussions. There are no standardized approaches to measure innovation; there is the risk that new conclusions will emerge based on the way different viewpoints are seen. Input is the amount of effort placed forward, and performance is the outcome. Feedback would normally incorporate human and R&D expenses. Previous studies demonstrate that invention inputs allow higher total factor productivity and business clout (Wang et al. 2021). However, because there are doubts that innovativeness is accompanied by uncertainty and failure, these projects will struggle. Additionally, employees could not be able to give their maximum efforts to creative ventures because of the insurance risk. Thus, we may be looking at the impact of progress on green productivity over-presumption (overestimating the benefits and underestimating the risks). A successful new product or new patent will tell us its consistency and efficiency. Thus, they enable firms to compete against one another and increase market share. However, patenting a business idea would not show the full benefit that they add to the company. There may be an attempt to steal the intellectual property and bring down the resulting competitive edge down in the industry (Sun et al. 2020a, 2020b).

An improved climate transparency strategy, while also putting in place a firm and transparent green growth strategy, would help investors gain understanding and knowledge to invest in healthy, inclusive and innovative growth. Thus, in this sense, there are new financial tools such as green bonds. However, due to the lack of well-defined data, their impact on the real economy and capital markets is not certain. In addition, their distributional impacts, as well as their trade-offs, have not been discussed (Jiang et al. 2021; Sadiq et al. 2021, 2020). Simulation methods such as the integrated assessment models (IAMs) are not capable of representing a complex system in which several sector-to-to-sector feedback mechanisms, as well as temporal lags, impact macroeconomic conditions and business strategy simultaneously (Agyekum et al. 2021; Xueying et al. 2021; Zhang et al. 2021).

Modern money philosophy does not have a credit and financial market (Wang et al. 2021). Since they are unable to portray the position of private debt in market risk formation or market risk diffusion, central banks are missing the overall picture. Therefore, analysts began to look at bottom-up and out-of-of-equilibrium models, which deal with diverse climate change sources of structural danger, including the economy and money. They suggest that a new kind of macroeconomic model could be developed that better considers feedback loops between ecosystems and the whole economy, while Chien et al. (2021b), Li et al. (2021b) and Iqbal et al. (2021) emphasized the need for a micro-level model in ecological models that is in line with financial systems.

3 Methodology

3.1 Econometric strategy

Data envelopment analysis (DEA) and stochastic frontier analysis (SFA) approaches from multi-dimensions of input and output parameters were used in the current investment productivity step. Centered on the principle of relative performance, the DEA system is extended to multidimensional input and output variables to calculate the investment efficiency of each decision-making unit (DMU). First, using a data envelopment analysis (DEA) model, this segment assesses the expenditure performance of renewable energy companies. Input variables include labor (payable employee salary) and capital inputs (operation and maintenance investment), while production factors include growth ratios of gross assets, returns of net assets and returns per share. Second, we use clean energy firm-level panel data to analyze the effects of subsidies and tax refund programs on overall expenditure effectiveness, pure technological performance and scale quality (Førsund 2018; Neralić and Kedžo 2019; Santos Arteaga et al. 2019).

Efficiency in renewable energy investment relates to the production for which investments are made as well as the inputs. The performance of renewable energy technology is shown by renewable energy firms' performance. For accurate measurement of sustainable energy production, picking the right model is key. The evaluation of green energy potential usage can be done using two methods: non-specific approaches and parametric. Overall evolution of data envelopment analysis (DE) models and other works within the clean energy sector is given in Table 1. Nonparametric linear programming was used to measure inter-oriented decision processes (DMUs). Instead of the DEA model that uses fixed returns to scale, a new model was proposed, which distinguishes between technical and pure utility with fixed returns. Rusydiana et al. (2019) designed highly efficient models that are infeasible, which provide solutions to the infeasibility problem (Athanasoglou 2016).

Prior studies feature a semi-parametric three-stage procedure that takes into account environmental influences and randomness that are introduced into the control parameters (input and output). Chen and Han (2012) show that the productivity of green energy companies in China is influenced by both macroeconomic trends and firm-specific characteristics in a new approach. They claim that green finance will make China less responsive to alternative energy investments by reducing credit availability through the Richardson model. Furthermore, in 2019, Zhao and Zhen affirm that China's wind industry is already quite productive. To examine the net efficiency of invested capital, scaling efficiency and pure technical efficiency related to renewable firms of energy sectors were considered and the study supposed n energy organization to compute investment efficiency as a technical unit, using pragmatic DMUs,

Where

$$\{DMU_j : j = 1, 2, 3, \dots, n\}.$$

Using these, every energy-related firm using m dimension is an input function with $W_{ij}(i = 1, 2 \dots \dots n)$. Here, the output function is denominated with s with

Table 1 Investment efficiency of energy organizations

Years	$CRSTE_{j,t}$	$VRSTE_{j,t}$	$Scale_{j,t}$
2000	0.111134	0.046685	0.080272
2001	0.191726	0.05331	0.080008
2002	0.110889	0.047291	0.034767
2003	0.132011	0.071782	0.047337
2004	0.084414	0.073249	0.039217
2005	0.082166	0.037056	0.07402
2006	0.081394	0.040166	0.059956
2007	0.048106	0.011942	0.089337
2008	0.051904	0.030139	0.06952
2009	0.061916	0.037813	0.059197
2010	0.076793	0.051704	0.075852
2011	0.101175	0.049611	0.088347
2012	0.172021	0.046896	0.113259
2013	0.202588	0.028935	0.108618
2014	0.162495	0.114982	0.071403
2015	0.079922	0.060778	0.114728
2016	0.066242	0.065862	0.096005
2017	0.038541	0.06394	0.063795
2018	0.020618	0.044312	0.086839

$Z_{ij}(r = 1, 2 \dots \dots m)$ of j th DMUs. Thus, the linear function for study econometric unit is given as follows:

$$\begin{aligned} \sum_{j=1}^n u_j Z_{rj} &\geq \quad i = 1, 2, \dots s \\ \sum_{j=1}^n u_j W_{ij} &\leq W_i, \quad i = 1, 2, \dots n \end{aligned} \tag{1}$$

However, the BCC DEA prototypical with variable returns of scale is elaborated as follows:

$$\max E_j = u_r y_{ro} - u_0 \tag{2}$$

where

$$\begin{aligned} \sum_{r=1}^s w_r x_{jo} &= 1 \\ \sum_{r=1}^s u_r y_{rj} - u_0 \sum_{i=1}^m w_i Z_{ij} &\leq 0 \quad j = 1, 2, \dots n \\ w_i &\geq \epsilon \quad i = 1, 2, \dots, m \end{aligned}$$

$$u_i \geq \epsilon r = 1, 2, \dots, s$$

Here the research attempts to quantify the impact of government subsidies and tax incentives on overall spending, production, pure technological creativity and green growth, among others, by employing econometric modeling. Eq. 2 is converted into the following form:

$$P = \left\{ (L, M, N, W, S) : \sum_{i=1}^m \sum_{i=1}^t y_{j,t} w_{j,t} \leq W \sum_{i=1}^s \sum_{i=1}^n T_{j,t} y_{j,t} \leq S \dots \right\}. \quad (3)$$

A zero-cost renewable energy source chosen according to the above DEA model has a total investment efficiency of 10%, a scaling efficiency of 100% and a pure technological efficiency of 10%. We use the incentives and tax rebates of chosen clean energy developers to help explain their resulting financial performance (Ben Doudou et al. 2020). The scale of the renewable energy firms, their equity allocation and returns on their investments are crucial to the future of the sector. When we examine the relationship between government incentives and tax credits and total spending, we analyze the impact on total production, overall technological efficiency and total size (Ehsanullah et al. 2021; Hsu et al. 2021; Zhang et al. 2021).

$$CRSTE_{j,t} = \alpha + \beta 1SUB_{j,t} + \beta 2INE_{j,t} + \beta 3TE_{j,t} + \beta 3GRP_{j,t} + \beta 4ROA_{j,t} + \beta 5SIZE_{j,t} + \beta 6LEV_{j,t} + \beta 7IE_{j,t} + \epsilon_{j,t} \quad (4)$$

$$VRSTE_{j,t} = \alpha + \beta 1SUB_{j,t} + \beta 2INE_{j,t} + \beta 3TE_{j,t} + \beta 3GRP_{j,t} + \beta 4ROA_{j,t} + \beta 5SIZE_{j,t} + \beta 6LEV_{j,t} + \beta 7IE_{j,t} + \epsilon_{j,t} \quad (5)$$

$$Scale_{j,t} = \alpha + \beta 1SUB_{j,t} + \beta 2INE_{j,t} + \beta 3TE_{j,t} + \beta 3GRP_{j,t} + \beta 4ROA_{j,t} + \beta 5SIZE_{j,t} + \beta 6LEV_{j,t} + \beta 7IE_{j,t} + \epsilon_{j,t}. \quad (6)$$

In Eqs. (4)–(6), c is the intercept term, a and b are the estimated coefficients of explanatory variables, respectively, $d1, d2, d3$ and $d4$ are the evaluated coefficients of controlling variables, x is the residual error, j refers to the j th renewable energy firms and t refers to the t th year in the study period.

3.2 Data collection and sources

Investing in listed companies in China’s clean energy sector on the Shanghai and Shenzhen Exchange requires looking at the government’s incentives and tax breaks. To guarantee that the sample time series can maintain their temporal stability and accuracy, this article looks at the following procedures. First, this paper includes all firms in the renewables industry from 2000 to 2018 in its analysis; second, it leaves out firms that are solely in the clean-tech sector due to its too broad definition of the sample; and third, this paper only takes companies mentioned as clean in future

with extensive use of wind power as a sample. Following the above screening methods, a research sample of 40 identified renewable energy companies was chosen to measure company investment performance, with both input and output variables sourced from the wind database. This article selects certain publicly traded renewable energy companies that reported government incentives and tax rebates in their annual financial results during the study period based on the above investment performance. Finally, as a research sample, this report selects 38 publicly traded clean energy companies to explore the effects of green government incentives and rebate taxes on company expenditure performance. The accounting evidence comes from the wind archive as well as the annual financial statement of publicly traded clean energy companies.

3.3 Empirical explanation of study constructs

Results show the average value of absolute, technological and scaled efficiency. A total productivity calculation and assessment of capability and use of renewable energy companies are critical for decision making. If renewable energy companies are near to the output boundary, gross expenditure productivity would be very close to it. Over the time frame from 2010 to 2017, the amount of expenditure in green energy companies rose and then decreased to the point of being identical to their cumulative investment in 2010, which is at 99.7%. Concerning renewable technology companies, only performance, management practices and the firm's technological capacities are critical, as well as the total installed capacity for renewable energy which will achieve full output capability. Clean energy technological performance is only greater than nine thousandths of one percent, showing that clean energy methods are more technologically sophisticated than chosen clean energy technologies. Thus, the question of "At what scale does green energy companies become more efficient?" is answered by effective scaling, whereby the scale utility must be around 1 to be viable, but may increase or decrease to match supply and demand.

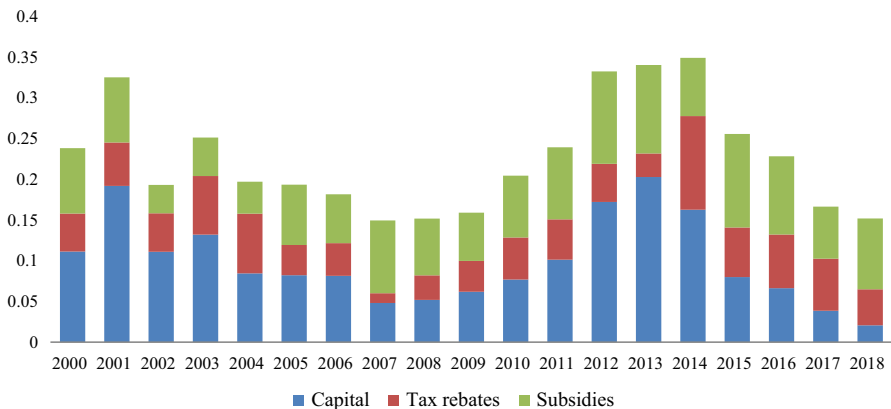
4 Results and discussion

The analysis showed that the means of scale reflected a growing trend in green energy firms from 0.53% to 0.98%. Renewable electricity was spent more in 2014 as their best method for energy conservation. At a larger scale, China's power supply had become even less reliable. Generally speaking, overall energy spending shows a wider range, but green companies strive to narrow the total spread.

Table 2 provides all the necessary benefits with the options presented by selected clean energies, tax credits and public resources. The above illustration (Fig. 1) shows the changes in the Federal government's money, business backing and personal taxes and credits over time. Compared to Table 3, government renewable energy subsidies increased from 2015 (3.74 billion yuan) to 2019 (3.78 billion yuan) (1.113 billion). Without federal grants and state aid, states would not be able to support students with a free college education. Subsidy development will slow due to recent

Table 2 Estimated outputs of innovation efficiency and green productivity of energy organizations

Years	Innovation efficiency			Green productivity		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
2000	2.43	3.21	2.54	3.34	2.34	2.34
2001	2.48	3.04	3.15	2.11	2.56	2.56
2002	2.38	2.77	3.37	2.01	2.22	2.22
2003	2.21	2.56	3.33	2.00	2.14	2.14
2004	1.17	2.33	3.01	3.00	2.33	2.33
2005	2.34	2.98	3.75	2.77	2.00	2.00
2006	1.19	3.44	2.75	1.19	2.00	2.00
2007	2.76	3.67	3.99	1.76	2.19	2.10
2008	3.34	3.91	2.97	2.60	1.18	3.12
2009	1.04	3.34	3.45	3.14	1.09	3.44
2010	1.07	3.45	2.65	2.33	1.00	2.17
2011	1.67	3.21	3.67	1.11	1.67	3.12
2012	0.99	3.45	1.11	1.07	1.56	3.14
2013	1.54	1.98	1.56	0.67	1.78	3.17
2014	2.34	1.77	3.56	0.76	2.11	3.17
2015	2.54	1.89	0.61	0.83	2.03	2.00
2016	2.56	2.11	3.41	2.33	2.67	2.99
2017	0.50	3.11	2.33	4.56	2.87	2.89
2018	0.56	1.06	1.77	1.17	2.34	3.00

**Fig. 1** Green financial support for investment efficiency

government subsidy cuts in China. In the alternative energy market, in 2007, 2008, 2009 and 2010, the taxes were much lower, and in 2012, 2014, 2016 and 2017, the tax cuts were much higher. An impressive number of government subsidies as well as 684 billion in subsidies have been raised by renewable energy firms in 2010.

Table 3 Nexus between main constructs and control variables of study

	$SUB_{j,t}$	$INE_{j,t}$	$TE_{j,t}$	$GRP_{j,t}$	$ROA_{j,t}$	$SIZE_{j,t}$	LEV	$IE_{j,t}$
$SUB_{j,t}$	1.0000							
$INE_{j,t}$	0.1709*	1.0000						
$TE_{j,t}$	0.1058*	0.0892*	1.0000					
$GRP_{j,t}$	0.1583*	0.0840*	0.1438*	1.0000				
$ROA_{j,t}$	0.2336*	0.1054*	0.0955	0.2980*	1.0000			
$SIZE_{j,t}$	0.2052*	0.0856*	0.0614*	0.3413*	0.2468	1.0000		
LEV	0.1840*	0.0906*	0.0572*	0.3515*	0.3110*	0.2969*	1.0000	
$IE_{j,t}$	0.1525*	0.1397*	0.0742*	0.3772	0.5025*	0.2714*	0.2828*	1.0000

*Means level of significance at 5% confidence interval

When controlling for collinearity, we begin to explore the relationships. When it comes to explaining and monitoring factors, Table 3 presents the relationship between the highest correlation (real) between tax credits and firm size has a value of 0.691%, whereas the smallest correlation (relative) between taxes and net renewable energy size has a coefficient (the inverse of absolute correlation) of a minimum of 0.0061% (Table 4).

Using Hausman's testable approach, we first decide if firm-level data on investment performance, government incentives and taxes are subjected to a set or random processing before creating our model. Results of Hausman rejected the null hypothesis; otherwise, the results are interpreted using a random-effects technique. Table 5 provides predicted results: If we assume that the evidence on green energy is flawed and companies are wrong, the odds of overall expenditure, pure technological performance and scalability are both greater than 0.05%; if we assume it is right, the resulting efficiencies are not always the same; if we assume it is nice, the chances of profitable operation might be lower.

Using green energy firm-level panel info, Table 3 shows the empirical findings of the effects of subsidies and tax rebates on overall expenditure performance, pure technological efficiency and scale efficiency. The government subsidies concept has a coefficient of 0.0182%, and government subsidies earned by renewable energy companies are positively linked to total investment efficiency at the 10% confidence stage. The rebate taxes term has a coefficient of 0.0149%, and rebate taxations received by renewable energy firms are positively related to total investment efficiency at the 10% confidence level. These projected findings show that both government subsidies and tax rebates can have a substantial positive effect on renewable energy firms' total investment performance, with government subsidies driving total investment efficiency marginally and considerably more than taxation rebates. At the 5% trust mark, higher asset yields and ownership concentration will greatly increase the overall investment performance of renewable energy companies (Figs. 2, 3).

Table 4 Estimated output of Hausman' test

Constructs	Investment efficiency	Technical efficiency	Scale efficiency	Green productivity	Innovative efficiency
Probability > χ^2	0.4571	0.3331	0.2489	0.4026	0.3963
Model selection	RE model	RE model	RE model	RE model	RE model

*RE means random effect modeling

Table 5 Robustness of study findings

	Investment efficiency	Technical efficiency	Scale efficiency	Green productivity	Innovative efficiency
$SUB_{j,t}$	0.7804*	0.1033*	0.8291*	0.7257*	0.7709*
$INE_{j,t}$	0.1146*	0.9750*	0.3383*	0.7613*	0.2957*
$TE_{j,t}$	0.2933*	0.6277*	0.0132*	0.4563*	0.7669*
$GRP_{j,t}$	0.2857*	0.8230*	0.2126*	0.73185	0.9473*
$ROA_{j,t}$	0.4339*	0.1568*	0.9616*	0.7787*	0.2425*
$SIZE_{j,t}$	0.4001	0.1543*	0.6599*	0.3724*	0.3424*
LEV	0.7776*	0.0871*	0.0365	0.5838*	0.1494*
$IE_{j,t}$	0.5815*	0.8715*	0.6487*	0.7528*	0.6309*
F-Stats	0.2897	0.5621	0.5071*	0.03644	0.6829*

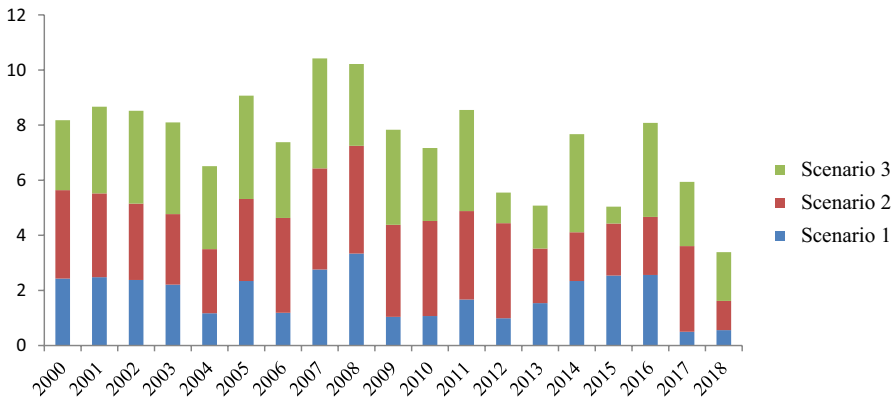


Fig. 2 Role of green fiscal policy in innovation efficiency

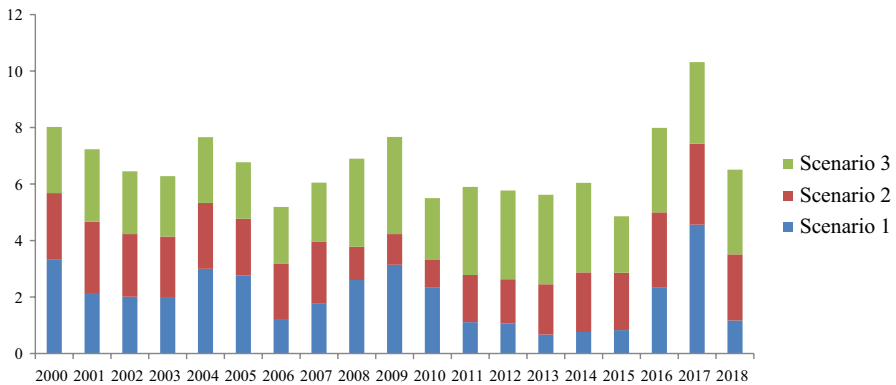


Fig. 3 Role of green fiscal policy in green productivity

4.1 Discussion

These estimated results show that the relationships between the pure and received investment coefficients of the financial assistance, and between financial assistance and received investment, are both positive and significant at the 5% level. The existence of greater firm's asset liability and ownership concentration levels are adversely linked to the relative technological performance of green energy companies, although higher asset has little relevance concerning this fact at the 1% stage. The rate of government discounts and taxes is 0.07%, and the scale of government rebates is zero. Tax breaks and discounts do not greatly improve the performance of green companies. However, at the 5% mark, the greater return on assets and higher ownership concentrations will improve the size of renewable energy companies Chien et al. 2021g).

When government subsidies are applied, absolute and pure economic productivity are the only characteristics that can be improved on the improvement of green energy companies, but not technological. Renewable energy production is a process and a learning-intensive business (Chien et al. 2021b). This set of government support policies acts to enhance and support the incorporation of R&D in green energy, as well as foster creative innovation (Wu et al. 2021), and they support businesses in using advanced renewable technologies by advancing their productivity and elevating technological capabilities (Chien et al. 2021e). Investment subsidies will currently enhance the performance of renewable energy businesses in terms of both overall sustainability and technological efficiency (Mohsin et al. 2021). The incentive of rebates could lead to a rise in the operating and capital costs of renewable energy firms (Taghizadeh-Hesary and Yoshino 2020).

For further cash flow, renewable energy researchers and developers are needed to create innovative methods and technologies, control costs effectively and encourage the advancement of renewable quality. Additionally, companies in the clean energy sector have incentives that can often have broader output scales and a stronger impact on the technological performance of companies (Mohsin et al. 2020). While existing subsidies and tax breaks may not help clarify the long-term technological and financial causes, they may indicate such influences that increase or decrease the financial and operating performance, which can be useful in the short term (Chien et al. 2021g). Pure technological performance positively correlates with firm size and is prohibited by the exuberance of Chinese clean energy investment. At a higher level of focus, the change in pure technological performance, scalability and overall efficiency would have a greater impact on renewable energy companies. These findings show that aggregate capital ownership will strengthen management power, as is shown by firms' structures and technological improvements (Iqbal et al. 2021; Zhang et al. 2021).

4.1.1 Green fiscal policies and green investment efficiency for economic recovery

Most countries have found it difficult to schedule an account for income and expenses because earnings are unpredictable as costs are rising (Taghizadeh-Hesary and Yoshino 2019). Indirect taxes have especially hurt developed countries such as

those that depend on consumption while consumption and economic growth have slowed. Government revenues are severely hampered by the decrease in oil rates, along with an ongoing decrease in the nation's industry. In addition, coronavirus-related costs on child-care facilities, supplies, community care and the cost of utilities have doubled, simultaneously increasing overall government spending. Countries around the world, including China, are looking to control their budget deficits (Taghizadeh-Hesary and Yoshino 2019; Taghizadeh-Hesary and Yoshino 2020).

The threat of these budget cuts could present in a major obstacle to long-term economic development but in developing countries, is due to capital expenditures and the development of jobs which are also encouraging progress. Instead of cutting the education expenditure to get rid of shortages, they should instead seek ways to lower the running costs of the administration. More importantly, expenditure that is extra-budgetary or non-approved must be tracked and monitored for proper oversight and accountability (Othman et al. 2020). This has to be done as a long-term approach to the coronavirus problem as opposed to a short-term solution on the taxation side, but they can prepare for longer-term changes in the tax processes. Relevant long-term results, such as the national debt and projected revenues and expenditures, can be managed (Taghizadeh-Hesary and Yoshino 2019) and (Taghizadeh-Hesary and Yoshino 2020).

As a result of the recent coronavirus pandemic, early and widespread shutdowns caused widespread financial disruptions as well as well as human hardships. This is especially true for the low- and middle-income countries of Africa where the coronavirus pandemic has been less lethal, as of yet (Taghizadeh-Hesary and Yoshino 2015), (Taghizadeh-Hesary et al. 2021). Already curfews and shutdowns have caused decades of economic and social change to be erased in these nations. The disrupted global supply chains, demand fall in high-income economies and developing countries, as well as falling product prices have resulted in the worsening of financial issues in China.

5 Conclusion and policy implications

This study has provided arguments about the pure technological size, scale, the gross and total performance of renewable energy businesses using a BE model and discusses the effects of government subsidy and tax policies on BE level expenditure and efficiency. During the span from 2010 to 2018, pure technological firm-level disparities, size performance and overall energy efficiency increased. Over the study duration from 2010 to 2017, levels of total efficiency of Chinese renewable energy companies rose from 0.97% to 0.52% to 0.16%, but then declined from 0.66% to 0.20%. In reality, it can be concluded that the average level of technological performance for all green energy firms is around 0.92% and that for all energy firms in China, varieties in size and style are higher. In other words, for pure technological and absolute quality, the subsidies received by the government have a bigger impact on expenditure.

Furthermore, at the 5% confidence level, firm ownership concentration is positively related to pure technical efficiency, scale efficiency and total investment efficiency of renewable energy firms, and at the 1% confidence level, asset returns have significantly positive impacts on total investment efficiency and scale efficiency of renewable energy firms. These findings show that existing government incentives and tax rebate policies will improve the pure technological performance and overall expenditure efficiency of chosen renewable energy companies in contrast to subsidies and tax policies for renewable energy industry investment. The key innovation of this report is that it tests the efficacy of government incentives and tax rebates in terms of clean energy firms' expenditure performance, despite different information differences from a microeconomic viewpoint. Furthermore, government incentives have a stronger beneficial impact on overall spending productivity and pure technological efficiency than tax refund programs.

Our empirical findings have regulatory consequences for government policymakers and business executives. First, our findings demonstrate several firm-specific considerations, such as the following:

- Government incentives and tax rebates earned, as well as ownership concentration, have substantial impacts on investment performance, with renewable energy firms' managers having the most influence over these variables.
- Our study offers useful insights to firm managers about how to improve investment performance by influencing green energy firm-level variables.
- Our research shows that government subsidies and tax rebate policies have a significant positive impact on renewable energy firms' pure technical efficiency and total investment efficiency and that government policymakers should identify sources of investment efficiency, optimize fiscal policies and formulate effective renewable energy industrial strategies to promote them.
- Government subsidy policies may have a more active impact on firms' pure technical efficiency and total investment efficiency, and our findings provide Chinese policymakers useful information on how to assess the investment efficiency of annual subsidies and tax rebate policies on a timely basis, as well as to promote the collective effects of green fiscal policies.

There are several proposals for future study. The first expansion of this research is to see how government incentives and tax reimbursement programs result in political rent costs and inefficient spending by green energy companies. The effect of government incentives and tax refund programs on the innovation performance of green energy companies is the subject of the second expansion of this research. The spatial spillover impact of government incentives and tax refund programs on clean energy companies is a third extension of the report.

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References


- Agyekum EB, Amjad F, Mohsin M, Ansah MNS (2021) A bird's eye view of Ghana's renewable energy sector environment: a multi-criteria decision-making approach. *Util Policy* <https://doi.org/10.1016/j.jup.2021.101219>
- Albert JF, Gómez-Fernández N (2020) ¿ Es la Eurozona un área óptima para suprimir el efectivo? Un análisis sobre la inclusión financiera y el uso de efectivo. *Cuadernos De Economía-Spanish Journal of Economics and Finance* 43(121):1–16
- Alemzero DA, Iqbal N, Iqbal S, Mohsin M, Chukwuma NJ, Shah BA (2020a) Assessing the perceived impact of exploration and production of hydrocarbons on households perspective of environmental regulation in Ghana. *Environ Sci Pollut Res*. <https://doi.org/10.1007/s11356-020-10880-3>
- Alemzero DA, Sun H, Mohsin M, Iqbal N, Nadeem M, Vo XV (2020b) Assessing energy security in Africa based on multi-dimensional approach of principal composite analysis. *Environ Sci Pollut Res*. <https://doi.org/10.1007/s11356-020-10554-0>
- Anh Tu C, Chien F, Hussein MA, Ramli MM, Psi MM, Iqbal S, Bilal AR (2021) Estimating role of green financing on energy security, economic and environmental integration of BRI member countries. *Singap Econ Rev*. <https://doi.org/10.1142/S0217590821500193>
- Athanassoglou S (2016) Revisiting worst-case DEA for composite indicators. *Soc Indic Res*. <https://doi.org/10.1007/s11205-015-1078-3>
- Athiyaman A, Magapa T (2019) Market intelligence from the internet: an illustration using the bio-mass heating industry. *Int J Econ Finance Stud* 11(1):1–16
- Baloch ZA, Tan Q, Iqbal N, Mohsin M, Abbas Q, Iqbal W, Chaudhry IS (2020) Trilemma assessment of energy intensity, efficiency, and environmental index: evidence from BRICS countries. *Environ Sci Pollut Res*. <https://doi.org/10.1007/s11356-020-09578-3>
- Barbier EB (2020) Greening the post-pandemic recovery in the G20. *Environ Resour Econ*. <https://doi.org/10.1007/s10640-020-00437-w>
- Ben Doudou M, Nouira R, Saafi S, Belhadj A (2020) Correction to: Do exchange rate changes have threshold effects on the trade balance? Evidence from Tunisia (*Economic Change and Restructuring*, (2020), <https://doi.org/10.1007/s10644-020-09306-4>). *Econ Change Restruct* <https://doi.org/10.1007/s10644-020-09309-1>
- Chandio AA, Jiang Y, Rehman A, Twumasi MA, Pathan AG, Mohsin M (2020) Determinants of demand for credit by smallholder farmers: a farm level analysis based on survey in Sindh, Pakistan. *J Asian Bus Econ Stud*. <https://doi.org/10.1108/jabes-01-2020-0004>
- Chen Y, Han B (2012) Regional public transportation scheduling model based on welfare economics and DEA. *Int J Model Identif Control*. <https://doi.org/10.1504/IJMIC.2012.047738>
- Chen X, Huang C, Wang H, Wang W, Ni X, Li Y (2021) Negative emotion arousal and altruism promoting of online public stigmatization on COVID-19 pandemic. *Front Psychol*. <https://doi.org/10.3389/fpsyg.2021.652140>
- Chien F, Wang CN, Nguyen VT, Nguyen VT, Chau KY (2020) An evaluation model of quantitative and qualitative fuzzy multi-criteria decision-making approach for hydroelectric plant location selection. *Energies*. <https://doi.org/10.3390/en13112783>
- Chien F, Anwar A, Hsu CC, Sharif A, Razzaq A, Sinha A (2021a) The role of information and communication technology in encountering environmental degradation: proposing an SDG framework for the BRICS countries. *Technol Soc*. <https://doi.org/10.1016/j.techsoc.2021.101587>
- Chien F, Ajaz T, Andlib Z, Chau KY, Ahmad P, Sharif A (2021b) The role of technology innovation, renewable energy and globalization in reducing environmental degradation in Pakistan: a step towards sustainable environment. *Renew Energy*. <https://doi.org/10.1016/j.renene.2021.05.101>
- Chien F, Chau KY, Ady SU, Zhang Y, Tran QH, Aldeehani TM (2021c) Does the combining effects of energy and consideration of financial development lead to environmental burden: Social perspective of energy finance? *Environ Sci Pollut Res*. <https://doi.org/10.1007/s11356-021-13423-6>
- Chien FS, Kamran HW, Albashar G, Iqbal W (2021d) Dynamic planning, conversion, and management strategy of different renewable energy sources: a sustainable solution for severe energy

- crises in emerging economies. *Int J Hydrogen Energy*. <https://doi.org/10.1016/j.ijhydene.2020.12.004>
- Chien F, Pantamee AA, Hussain MS, Chupradit S, Nawaz MA, Mohsin M (2021e) Nexus between financial innovation and bankruptcy: evidence from information, communication and technology (ict) sector. *Singap Econ Rev*. <https://doi.org/10.1142/S0217590821500181>
- Chien F, Sadiq M, Kamran HW, Nawaz MA, Hussain MS, Raza M (2021f) Co-movement of energy prices and stock market return: environmental wavelet nexus of COVID-19 pandemic from the USA, Europe, and China. *Environ Sci Pollut Res*. <https://doi.org/10.1007/s11356-021-12938-2>
- Chien F, Sadiq M, Nawaz MA, Hussain MS, Tran TD, Le Thanh T (2021g) A step toward reducing air pollution in top Asian economies: the role of green energy, eco-innovation, and environmental taxes. *J Environ Manag*. <https://doi.org/10.1016/j.jenvman.2021.113420>
- Chien F, Ngo QT, Hsu CC et al (2021h) Assessing the mechanism of barriers towards green finance and public spending in small and medium enterprises from developed countries. *Environ Sci Pollut Res*. <https://doi.org/10.1007/s11356-021-14907-1>
- Chien F, Zhang Y, Sadiq M, Hsu CC (2021i) Financing for energy efficiency solutions to mitigate opportunity cost of coal consumption: an empirical analysis of Chinese industries. *Environ Sci Pollut Res*. <https://doi.org/10.1007/s11356-021-15701-9>
- del Rosal JCC, del Rosal DEC, Ocerin JMC, Tabales JN (2019) Spanish real estate market: a tool for supply analysis. *Cuadernos de Economía* 42(120):207–218. <https://doi.org/10.32826/cude.v42i120.82>
- Ehsanullah S, Tran QH, Sadiq M, Bashir S, Mohsin M, Iram R (2021) How energy insecurity leads to energy poverty? Do environmental consideration and climate change concerns matters. *Environ Sci Pollut Res*. <https://doi.org/10.1007/s11356-021-14415-2>
- Feng S, Lu H, Tian P, Xue Y, Lu J, Tang M, Feng W (2020a) Analysis of microplastics in a remote region of the Tibetan Plateau: implications for natural environmental response to human activities. *Sci Total Environ*. <https://doi.org/10.1016/j.scitotenv.2020.140087>
- Feng W, Lu H, Yao T, Yu Q (2020b) Drought characteristics and its elevation dependence in the Qinghai-Tibet plateau during the last half-century. *Sci Rep*. <https://doi.org/10.1038/s41598-020-71295-1>
- Førsund FR (2018) Economic interpretations of DEA. *Socioecon Plann Sci*. <https://doi.org/10.1016/j.seps.2017.03.004>
- Han X, Wei Z, Zhang B, Li Y, Du T, Chen H (2021) Crop evapotranspiration prediction by considering dynamic change of crop coefficient and the precipitation effect in back-propagation neural network model. *J Hydrol*. <https://doi.org/10.1016/j.jhydrol.2021.126104>
- He W, Abbas Q, Alharthi M, Mohsin M, Hanif I, Vinh Vo X (2020) Integration of renewable hydrogen in light-duty vehicle: Nexus between energy security and low carbon emission resources. *Int J Hydrogen Energy*. <https://doi.org/10.1016/j.ijhydene.2020.06.177>
- He X, Zhang T, Xue Q, Zhou Y, Wang H, Bolan NS, Jiang R, Tsang DCW (2021) Enhanced adsorption of Cu(II) and Zn(II) from aqueous solution by polyethyleneimine modified straw hydrochar. *Sci Total Environ*. <https://doi.org/10.1016/j.scitotenv.2021.146116>
- Hsu CC, Quang-Thanh N, Chien FS, Li L, Mohsin M (2021) Evaluating green innovation and performance of financial development: mediating concerns of environmental regulation. *Environ Sci Pollut Res*. <https://doi.org/10.1007/s11356-021-14499-w>
- Hu P, Cao L, Su J, Li Q, Li Y (2020) Distribution characteristics of salt-out particles in steam turbine stage. *Energy*. <https://doi.org/10.1016/j.energy.2019.116626>
- Huang SZ, Chau KY, Chien F, Shen H (2020) The Impact of Startups' dual learning on their green innovation capability: the effects of business executives' environmental awareness and environmental regulations. *Sustainability* 12(16):1–17
- Ikram M, Mahmoudi A, Shah SZA, Mohsin M (2019a) Forecasting number of ISO 14001 certifications of selected countries: application of even GM (1,1), DGM, and NDGM models. *Environ Sci Pollut Res*. <https://doi.org/10.1007/s11356-019-04534-2>
- Ikram M, Sroufe R, Mohsin M, Solangi YA, Shah SZA, Shahzad F (2019b) Does CSR influence firm performance? A longitudinal study of SME sectors of Pakistan. *J Glob Responsib* 11:27–53. <https://doi.org/10.1108/jgr-12-2018-0088>
- IMF (2020) Greening the recovery, Special Series on COVID-19
- Iqbal W, Tang YM, Chau KY, Irfan M, Mohsin M (2021) Nexus between air pollution and NCOV-2019 in China: application of negative binomial regression analysis. *Process Saf Environ Prot*. <https://doi.org/10.1016/j.psep.2021.04.039>

- Kennedy PL, Schmitz A, DeLong KL (2020) Biotechnology and demand concerns: the case of genetically modified US sugar beets. *AgBioforum* 22(1):49–60
- Li W, Chien F, Hsu CC, Zhang YQ, Nawaz MA, Iqbal S, Mohsin M (2021a) Nexus between energy poverty and energy efficiency: estimating the long-run dynamics. *Resour Policy*. <https://doi.org/10.1016/j.resourpol.2021.102063>
- Li W, Chien F, Kamran HW, Aldeehani TM, Sadiq M, Nguyen VC, Taghizadeh-Hesary F (2021b) The nexus between COVID-19 fear and stock market volatility. *Econ Res-Ekonomska Istraživanja*. <https://doi.org/10.1080/1331677X.2021.1914125>
- Li W, Chien F, Ngo QT, Nguyen TD, Iqbal S, Bilal AR (2021c) Vertical financial disparity, energy prices and emission reduction: empirical insights from Pakistan. *J Environ Manag*. <https://doi.org/10.1016/j.jenvman.2021.112946>
- Li X, Li Z, Jia T, Yan P, Wang D, Liu G (2021d) The sense of community revisited in Hankow, China: combining the impacts of perceptual factors and built environment attributes. *Cities*. <https://doi.org/10.1016/j.cities.2021.103108>
- Matthews M, Mokoena BA (2020) The influence of service quality dimensions on customer satisfaction within visa facilitation centres in South Africa. *Int J eBusiness eGov Stud* 12(2):122–135. <https://doi.org/10.34111/ijepeg.202012203>
- Mhlanga D, Moloi T (2020) The stakeholder theory in the fourth industrial revolution. *Int J Econ Finance Stud* 12(2):352–368. <https://doi.org/10.34109/ijefs.20201220>
- Mi C, Huang Y, Fu C, Zhang Z, Postolache O (2021) Vision-based measurement: actualities and developing trends in automated container terminals. *IEEE Instrum Meas Mag*. <https://doi.org/10.1109/mim.2021.9448257>
- Mohsin M, Rasheed AK, Saidur R (2018a) Economic viability and production capacity of wind generated renewable hydrogen. *Int J Hydrogen Energy*. <https://doi.org/10.1016/j.ijhydene.2017.12.113>
- Mohsin M, Zhou P, Iqbal N, Shah SAA (2018b) Assessing oil supply security of South Asia. *Energy* 155:438–447. <https://doi.org/10.1016/j.ENERGY.2018.04.116>
- Mohsin M, Taghizadeh-Hesary F, Panthamit N, Anwar S, Abbas Q, Vo XV (2020) Developing low carbon finance index: evidence from developed and developing economies. *Finance Res Lett*. <https://doi.org/10.1016/j.frl.2020.101520>
- Mohsin M, Hanif I, Taghizadeh-Hesary F, Abbas Q, Iqbal W (2021) Nexus between energy efficiency and electricity reforms: a DEA-Based way forward for clean power development. *Energy Policy*. <https://doi.org/10.1016/j.enpol.2020.112052>
- Mooij R, de Fenochietto R, Hebous S, Leduc S, Osorio-Buitron1 C (2020e) Tax policy for inclusive growth after the pandemic. *Int Monet Fund*
- Muposhi A (2019) Emergence of Green marketing capitalism in South Africa: implications for green economy agenda. *Int J Bus Manag Stud* 11(1):1–15
- Neralić L, Kedžo MG (2019) A survey and analysis of scholarly literature in DEA published by Croatian researchers: 1978–2018. *Zagreb Int Rev Econ Bus*. <https://doi.org/10.2478/zireb-2019-0014>
- Othman Z, Nordin MFF, Sadiq M (2020) GST fraud prevention to ensure business sustainability: a Malaysian case study. *J Asian Bus Econ Stud* 27(3):245–265
- Phan LTC, Quang Thanh N (2019) Influence of new countryside construction program on household welfare: evidence from the Mekong River Delta of Vietnam. *AgBioforum* 21(3):1–14
- Quan Q, Gao S, Shang Y, Wang B (2021) Assessment of the sustainability of *Gymnocypris eckloni* habitat under river damming in the source region of the Yellow River. *Sci Total Environ*. <https://doi.org/10.1016/j.scitotenv.2021.146312>
- Rusydiana AS, Marlina L, Rani LN (2019) Malmquist productivity index on islamic economics and finance research. *Shirkah J Econ Bus*. <https://doi.org/10.22515/shirkah.v4i1.261>
- Sadiq M, Singh J, Raza M, Mohamad S (2020) The impact of environmental, social and governance index on firm value: evidence from Malaysia. *Int J Energy Econ Policy*. <https://doi.org/10.32479/ijeep.10217>
- Sadiq M, Hsu CC, Zhang Y, Chien FS (2021) COVID-19 fear and volatility index movements: empirical insights from ASEAN stock markets. *Environ Sci Pollut Res*. <https://doi.org/10.1007/s11356-021-15064-1>
- Şanlısoy S, Çiloğlu T (2019) An investigation on the crypto currencies and its future. *Int J eBus eGov Stud* 11(1):69–88. <https://doi.org/10.34111/ijepeg.20191115>
- Santos Arteaga FJ, Tavana M, Di Caprio D, Toloo M (2019) A dynamic multi-stage slacks-based measure data envelopment analysis model with knowledge accumulation and technological evolution. *Eur J Oper Res*. <https://doi.org/10.1016/j.ejor.2018.09.008>

- Shah SAA, Zhou P, Walasai GD, Mohsin M (2019) Energy security and environmental sustainability index of South Asian countries: a composite index approach. *Ecol Indic* 106:105507. <https://doi.org/10.1016/j.ecolind.2019.105507>
- Sun H, Tariq G, Haris M, Mohsin M (2019) Evaluating the environmental effects of economic openness: evidence from SAARC countries. *Environ Sci Pollut Res*. <https://doi.org/10.1007/s11356-019-05750-6>
- Sun H, Awan RU, Nawaz MA, Mohsin M, Rasheed AK, Iqbal N (2020a) Assessing the socio-economic viability of solar commercialization and electrification in south Asian countries. *Environ Dev Sustain*. <https://doi.org/10.1007/s10668-020-01038-9>
- Sun H, Jiang J, Mohsin M, Zhang J, Solangi YA (2020b) Forecasting Nitrous Oxide emissions based on grey system models. *Environ Geochem Health*. <https://doi.org/10.1007/s10653-019-00398-0>
- Sun H, Pofoura AK, Adjei Mensah I, Li L, Mohsin M (2020c) The role of environmental entrepreneurship for sustainable development: evidence from 35 countries in Sub-Saharan Africa. *Sci Total Environ*. <https://doi.org/10.1016/j.scitotenv.2020.140132>
- Taghizadeh-Hesary F, Yoshino N (2015) Macroeconomic effects of oil price fluctuations on emerging and developed economies in a model incorporating monetary variables. *Econ Policy Energy Environ*. <https://doi.org/10.3280/EFE2015-002005>
- Taghizadeh-Hesary F, Yoshino N (2019) The way to induce private participation in green finance and investment. *Financial Res Lett*. <https://doi.org/10.1016/j.frl.2019.04.016>
- Taghizadeh-Hesary F, Yoshino N (2020) Sustainable solutions for green financing and investment in renewable energy projects. *Energies*. <https://doi.org/10.3390/en13040788>
- Taghizadeh-Hesary F, Rasoulinezhad E, Yoshino N, Chang Y, Taghizadeh-Hesary F, Morgan PJ (2021) The energy-pollution-health nexus: a panel data analysis of low-and middle-income Asian countries. *Singap Econ Rev*. <https://doi.org/10.1142/S0217590820430043>
- Tiep NC, Wang M, Mohsin M, Kamran HW, Yazdi FA (2021) An assessment of power sector reforms and utility performance to strengthen consumer self-confidence towards private investment. *Econ Anal Policy*. <https://doi.org/10.1016/j.eap.2021.01.005>
- Tobias-Mamina R, Maziriri ET (2020) modelling consumers' willingness to use card-less banking services: an integration of TAM and TPB. *Int J Bus Manag Stud* 12(1):241–257
- Wang H, Han Y, Fidrmuc J, Wei D (2021) Confucius Institute, belt and road initiative and internationalization. *Int Rev Econ Finance*. <https://doi.org/10.1016/j.iref.2020.09.011>
- Wu B, Jin C, Monfort A, Hua D (2021) Generous charity to preserve green image? Exploring linkage between strategic donations and environmental misconduct. *J Bus Res*. <https://doi.org/10.1016/j.jbusres.2020.10.040>
- Xueying W, Sadiq M, Chien F, Ngo TQ, Nguyen AT (2021) Testing role of green financing on climate change mitigation: evidences from G7 and E7 countries. *Environ Sci Pollut Res*. <https://doi.org/10.1007/s11356-021-15023-w>
- Yang Z, Abbas Q, Hanif I, Alharthi M, Taghizadeh-Hesary F, Aziz B, Mohsin M (2021) Short- and long-run influence of energy utilization and economic growth on carbon discharge in emerging SREB economies. *Renew Energy*. <https://doi.org/10.1016/j.renene.2020.10.141>
- Yu B (2021) Urban spatial structure and total-factor energy efficiency in Chinese provinces. *Ecol Indic*. <https://doi.org/10.1016/j.ecolind.2021.107662>
- Yuan H, Wang Z, Shi Y, Hao J (2021) A dissipative structure theory-based investigation of a construction and demolition waste minimization system in China. *J Environ Plan Manag*. <https://doi.org/10.1080/09640568.2021.1889484>
- Zhang Z, Liu S, Niu B (2020) Coordination mechanism of dual-channel closed-loop supply chains considering product quality and return. *J Clean Prod*. <https://doi.org/10.1016/j.jclepro.2019.119273>
- Zhang D, Mohsin M, Rasheed AK, Chang Y, Taghizadeh-Hesary F (2021) Public spending and green economic growth in BRI region: mediating role of green finance. *Energy Policy*. <https://doi.org/10.1016/j.enpol.2021.112256>
- Zhao X, Gu B, Gao F, Chen S (2020) Matching model of energy supply and demand of the integrated energy system in coastal areas. *J Coast Res*. <https://doi.org/10.2112/S1103-205.1>

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