VILNIUS TECH
Vilnius Gediminas Technical University

14th International Scientific Conference "Business and Management 2024"
May 16–17, 2024, Vilnius, Lithuania

NEW TRENDS IN CONTEMPORARY ECONOMICS, BUSINESS AND MANAGEMENT

ISSN 2029-4441 / eISSN 2029-929X
eISBN 978-609-476-363-2
Article Number: bm.2024.1204
https://doi.org/10.3846/bm.2024.1204

IMPACT OF GREEN ECONOMY EFFICIENCY ON SUSTAINABLE DEVELOPMENT: EVIDENCE FROM CHINA

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Received 1 February 2024; accepted 26 March 2024

Abstract. Increasing number of nations are moving to a green economy as a vital avenue to accomplish the objective of sustainable development, and China has made a mark among those countries. This study evaluated green economy efficiency (GEE) using the super slack-based measure (Super-SBM) model and empirically investigated the relationship between GEE and sustainable development (SD) using the mediation effect econometric model. The examination of this article led to the following results: (1) As China's growth method was completing the transition of old and new drivers, its GEE and SD were both demonstrating a fluctuating increasing trend. (2) The influence of GEE on SD was nonlinear and exhibited an inverted U-shape, with moderate GEE encouraging SD and excessive GEE limiting SD. (3) The industrial structure upgrading (ISU) indicator had a substantial mediating role in the process of GEE influencing SD, where an increase in GEE improved ISU, which in turn promoted SD. Therefore, for improved SD, we need to comprehend the scale not to mindlessly pursue GEE, and should stress the function of ISU. Our results give vital insight for understanding the link between GEE and SD.

Keywords: green economy efficiency, sustainable development, industrial upgrade, intermediary effect, influencing factors, China.

JEL Classification: O11, R11.

1. Introduction

Research from the 2023 Global Sustainable Development Report showed that the global sustainable development was much more worrisome and far off track owing to slow implementation and a confluence of crises. The report also stressed the creation of a green economy as an essential strategy to accomplish sustainable development objectives. The core of a green economy is green development, which has the immediate consequence of enhancing the efficiency of energy consumption, lowering carbon emissions, and supporting environmental protection (Kasztelan, 2017; Sun et al., 2024). Developing a green economy is acknowledged as a tool to encourage economic growth in ways consistent with the sustainable development objectives (Verma & Kandpal, 2021). Therefore, green economy may be considered as a new economic paradigm to cope with environmental shifting and ecological deterioration for all nations globally, especially emerging ones.

China has been paying significant attention to encouraging sustainable development via a greening transition and has achieved outstanding successes. China pledged to the world at the UN General Assembly in 2020 that it would strive to peak carbon dioxide emissions by 2030 and work towards carbon neutrality by 2060. To this objective, China is backed by green technological innovation, with conventional industry green transformation as a priority, optimize the industrial structure, enhance resource usage efficiency, improve the degree of clean production, and construct a green manufacturing system. China's green sector had been 7.5 trillion yuan by 2020, and would be predicted to reach 11.0 trillion yuan by 2050, an increase of 46.67%.

Nowadays, there is a broad consensus in most countries and regions of the world on the important role that a green economy plays in sustainable development. However, inequalities in economic growth patterns, government governance performance, resource empowerment and technological investment in nations throughout the

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globe have led to large discrepancies in the efficiency of green economies, consequently influencing the sustainable development processes of countries (Nahman et al., 2016). For the purpose of analyzing the issue, this paper explores the mechanisms by which a country's green economy efficiency (GEE) affects its sustainable development (SD). The research has two purposes: The first purpose was to quantify China's GEE between 2011 and 2021 by creating an indicator system of "input-expected output-unanticipated output" and using the Super-SBM model. The second purpose was to design an intermediate-effect economics model to explain how China's GEE influenced SD, while proving the intermediate function of industrial structure upgrading (ISU) in that effect.

To achieve the aforementioned aims, the following parts were designed: Part 1 was a summary of current research results on GEE and SD, establishing the framework for this article. Part 2 was a technique that explained the design of the Super-SBM model for assessing the GEE, as well as the intermediate-effect econometrics model for testing the mechanisms for GEE's influence on SD. Part 3 was an empirical study, which examined the changing patterns of China's GEE and SD, and studied the link among GEE, ISU and SD. Part 4 presented the research conclusions and disclosures of this work.

2. Literature review

2.1. Green economy efficiency

How to boost the green economy efficiency growth and make it play a bigger role in fostering sustainable development was an important study path of academic interest. As a consequence, more and more experts were beginning to concentrate on the effect elements of green economy efficiency. First, as one of the important elements determining the efficiency of the green economy, many academics had examined the impact mechanisms and geographical consequences of technological innovation (Duan et al., 2022; Liu & Dong, 2021; Liu et al., 2023; Ma et al., 2022). Second, green economy efficiency advances were controlled by capital inputs, and the amount of effect was modified by the magnitude of energy consumption (Li et al., 2020). Third, the geographical spill effect of the expansion of the digital economy might contribute to an overall rise in the efficiency of the green economy in the area (Kong & Li, 2022). Forth, environmental regulatory considerations set by the government first restricted green economic efficiency, but, once at a certain level, enhanced green economy efficiency (Shuai & Fan, 2020).

Furthermore, how to quantify green economy efficiency was another key topic of interest among researchers, and a more consistent method had recently arisen, employing the Super-SBM model for evaluating green economy efficiency. The Super-SBM model was based on the data envelopment analysis approach, but had two major improvements compared to the regular model: on the one hand, while determining the input and output variables for the development of a green economy, it was sometimes required to take into consideration unexpected outputs, while the Super-SBM model compensated for the inadequacy of the classic BCC model to assess unintended output. On the other side, compared to the SBM model, the Super-SBM model compared effective decision-making units (DMUs) with efficiencies larger than 1, which in turn promoted comparability between DMUs (Chen et al., 2019; Li & Ouyang, 2020; Wu et al., 2020).

Based on the findings of the research, this article employed the Super-SBM model to compute the value of green economy efficiency in China's provinces, and the resultant green economic efficiency would be utilized as a primary interpretive variable to examine its influence on sustainable development. This is one of the minor additions that separates the study from existing material.

2.2. Sustainable development

While the concept of sustainable development continued to vary, its essential, the harmonization of economic growth, ecological balance and social development, remained unaltered (Tomislav, 2018). Economic growth improved per capita national income, so reducing poverty and supporting sustainable development (Dalevska et al., 2019). However, excessive pursuit of economic expansion would ultimately destroy the link between economic growth and ecological and social harmony, hence damaging to sustainable development. Therefore, there were experts who advised from a microscopic point of view that to prevent excessive economic expansion, it was important to concentrate on the sustainable development of firms, so that they maintained a condition of "compliance safety" (Pererva et al., 2021). Studies by other experts suggested that creative measures such as establishing new company models, extending new markets, and opening up new trade partners might progressively minimize the detrimental effect of economic expansion and social development on ecological balance, and thus promoted sustainable development (Broman & Robèrt, 2017; Xu et al., 2020). Furthermore, research on the social development component revealed that, on the one hand, human actions and conduct had a variety of consequences for sustainable development (Monkelbaan, 2019). On the other side, social movements, public action and advocacy encouraged sustainable development (Sachs et al., 2019).

Although there was a large number of studies on assessing sustainable development, many of the metrics that had been established tend to stay at the theoretical level and difficult to implement in reality (Hak et al., 2015). Thus, the article created a tangible, quantifiable system of sustainable development indicators from the three elements of economic growth, ecological balance and social development, and assessed China's sustainable development. Subsequently, an intermediate effect econometric model, including industry structure upgrading factor, was established to examine the mechanism of green economy efficiency influence on sustainable development. This is another marginal addition that is distinct from prior studies.

3. Method

3.1. Super-SBM model

In the paper, each province in China was treated as a decision-making unit (DMU). Let supposed a term input $X_j=(x_{1j},x_{2j},\cdots,x_{aj})$, b term desired output $Y_j=(y_{1j},y_{2j},\cdots,y_{bj})$, and c term non-desired output $Z_j=(z_{1j},z_{2j},\cdots,z_{cj})$, where x_{lj} denoted the l-th type of input of the j-th DMU, y_{mj} denoted the m-th type of desired output of the j-th DMU, and z_{nj} denoted the n-th type of non-desired output of the j-th DMU. The GEE production possibility set was:

$$P=\left\{(x,y,z)\,|\,x\geq X_j\eta, y\leq Y_j\eta, z\geq Z_j\eta, \eta\geq 0\right\}. \quad (1)$$

Supposition of constant returns to scale, the formula of the SBM model with non-desired outputs for evaluating DMU (x_0, y_0, z_0) was as follows:

$$\varphi=\min\left[\frac{1-\frac{1}{a}\sum_{l=1}^{a}\frac{S_l^-}{x_{l0}}}{1+\frac{1}{b+c}\left(\sum_{m=1}^{b}\frac{S_m^b}{y_{m0}}+\sum_{n=1}^{c}\frac{S_n^c}{z_{n0}}\right)}\right]; \quad (2)$$

$$s.t.\begin{cases} x_0=X_j\eta+S^- \\ y_0=Y_j\eta-S^b \\ z_0=Z_j\eta+S^c \\ S^-\geq 0, S^b\geq 0, S^c\geq 0, \eta\geq 0 \end{cases}. \quad (3)$$

In Equation (2), φ indicated the GEE value of the DMU, which varied from 0 to 1. S^-, S^b, S^c indicated the slack in inputs, desired output, and non-desired output, respectively. The nonlinear Equation (2) could be transformed into a linear model based on Charnes-Cooper transformation, which was as follows:

$$\gamma=\min\left(T-\frac{1}{a}\sum_{l=1}^{a}\frac{S_l^-}{x_{l0}}\right); \quad (4)$$

$$s.t.\begin{cases} 1=T+\frac{1}{b+c}\left(\sum_{m=1}^{b}\frac{S_m^b}{y_{m0}}+\sum_{n=1}^{c}\frac{S_n^c}{z_{n0}}\right) \\ x_0T=X_j\beta+S^- \\ y_0T=Y_j\beta-S^b \\ z_0T=Z_j\beta+S^c \\ S^-\geq 0, S^b\geq 0, S^c\geq 0, T\geq 0 \end{cases}. \quad (5)$$

The Super-SBM model with non-desired output was described as follows:

$$\varphi^*=\min\left[\frac{\frac{1}{a}\sum_{l=1}^{a}\frac{\bar{x}_l}{x_{l0}}}{\frac{1}{b+c}\left(\sum_{m=1}^{b}\frac{\bar{y}_m}{y_{m0}}+\sum_{n=1}^{c}\frac{\bar{z}_n}{z_{n0}}\right)}\right]; \quad (6)$$

$$s.t.\begin{cases} \bar{x}\geq \sum_{j=1,\neq 0}^{J}\eta_j x_j \\ \bar{y}\leq \sum_{j=1,\neq 0}^{J}\eta_j y_j \\ \bar{z}\geq \sum_{j=1,\neq 0}^{J}\eta_j z_j \\ \bar{x}\geq x_0, \bar{y}\leq y_0, \bar{z}\geq z_0, \eta_j\geq 0 \end{cases}. \quad (7)$$

In Equation (6), φ^* indicated the super GEE value of the DMU, which varied greater than 1.

This paper referred to the study of Liu et al. (2023), using the Super-SBM model, selecting labor, capital and land as input indicators, economic output as expected output indicator, pollutant emissions as unexpected output indicator (each indicator as shown in Table 1), measured the GEE of China's provinces. Taking into consideration the availability of the data, the input and output indicators in Table 1 were chosen from the data of 30 provinces of China, excluding Tibet, Hong Kong, Macao and Taiwan, from 2011 to 2021 (given that the statistics on industrial wastewater and industrial waste gas emissions in the China Environmental Statistical Yearbook were currently updated only until 2021, to ensure comparability of the data, the analysis data was used until 2021), all from China Statistical Yearbook and China Environmental Statistics Yearbook. The data obtained was then integrated into Dearun software and the program's Super-SBM module was utilized to compute the GEE value of each province in China.

Table 1. Indicators of input and output to assess the GEE

Indicator classification		Element	Symbolic	Indicator measurement	Unit
Input Asset input Land input		Labor input	LI	Employed population	Ten thousand people
		KI	Fixed-asset investment	Hundred million yuan	
		SI	Built-up area	Ten thousand square meters	
Output	Desired output	Economic output	EO	Per capita GDP	Yuan
	Non-desired output	Pollutant emission	WO	Industrial waste water emission	Ton
			GO	Industrial waste gas emission	Ton

3.2. Regression model

3.2.1. Variable description

(1) SD was a dependent variable. From the three elements of economic growth, ecological balance and social development, a total of 14 indicators were chosen to construct a framework for assessing SD, indications detailed in Table 2. These indicators were taken from China Statistical Yearbook data for the 30 provinces of China from 2011 to 2021. The weighting of indicators and the value of SD for each province was computed following the entropy method.

Table 2. System of indicators for measuring SD

Elements	Indicators	Unit	Properties
Economic growth	GDP growth rate	%	+
	Growth rate of disposable income per capita	%	+
	Growth rate of consumption per capita	%	+
	Growth rate of the number of active patents	%	+
Ecological balance	Rate of forest cover	%	+
	Area of nature reserves	Ten thousand hectares	+
	Greening coverage in built-up areas	%	+
	Water resources per capita	Cubic meters	+
	Rate of domestic garbage harmless treatment	%	+
Social development	Percentage of illiterate population	%	–
	Urban unemployment rate	%	–
	Road surface area per capita	Square meter	+
	Production capacity of tap water supply	Cubic meters/ day	+
	Occupancy rate of hospital beds	%	–

(2) GEE was the explanatory variable, which was computed by the Super-SBM model.

(3) The ISU was chosen as the intermediate variable to investigate its mechanisms of involvement in GEE influence on SD, computing the formula as follows.

$$ISU = \sum_{m=1}^{3} (s_{jm} \times m). \quad (8)$$

Considering that ISU generally represented an increase in the percentage of higher-productivity industries in the industry as a whole, the bigger the number computed in Equation 4 showed the higher the degree of ISU in the province. Where sjm denoted the l-th province the m-th industry value added as a share of GDP, m respectively referred to the primary, secondary and tertiary industries. The indicator was computed in line with formula 4 by gathering relevant data from each province in China Statistical Yearbook for the period 2011 to 2021.

(4) Total population (TP), trade value (TV) and urbanization rate (UR) indicators were chosen as controlled variables. These three indicators showed the influence of population size, openness and urban expansion on SD, and controls might more precisely reflect GEE impact on SD. The data for the above three control variables were from China Statistical Yearbook.

3.2.2. Intermediate effect econometric model

To assess the intermediate impact of the ISU, provided that the value of the dependent variable SD was between 0 and 1, model 1and model 3 used the Tobit model regression match, model 2 used the minimal duplication match. The models are as follows:

Model 1:

$$SD_{it} = \alpha_0 + \alpha_1 GEE_{it} + \alpha_3 GEE_{it}^2 + \alpha_4 TP_{it} + \alpha_5 TV_{it} + \alpha_6 UR_{it} + \varepsilon_{it}. \quad (9)$$

Model 2:

$$ISU_{it} = \beta_0 + \beta_1 GEE_{it} + \beta_2 TP_{it} + \beta_3 TV_{it} + \beta_4 UR_{it} + \varepsilon_{it}. \quad (10)$$

Model 3:

$$SD_{it} = \gamma_0 + \gamma_1 GEE_{it} + \gamma_2 GEE_{it}^2 + \gamma_3 ISU_{it} + \gamma_4 TP_{it} + \gamma_5 TV_{it} + \gamma_6 UR_{it} + \varepsilon_{it}. \quad (11)$$

Where GEE^2 denotes the squared term of GEE to test the nonlinear relationship, α, β, γ represent the coefficient of each variable, ε represents the random perturbation term. When the β_1, γ_1, γ_2 and γ_3 coefficients are significant indicates that ISU plays a mediating role between SD and GEE.

4. Results

4.1. Analysis of GEE and SD computations in China

Analyzing the curve variations in Figure 1, we can observe that both GEE and SD in China exhibit an increased trend of volatility. At the same time, we can notice the variations of the two curves separated into three distinct phases. Until 2016, China's GEE and SD movements were reasonably smooth, suggesting a tiny year-on-year slower increase tendency. But after 2016, notably in 2017 and 2018, China's GEE and SD showed substantial variations. After two years of turbulence, China's GEE and SD were on the rise again from 2019 to 2021. The key explanation for the fluctuating trend was that after 2016, China's economic growth was experiencing a change from the "old drive" of high-consumption development to the "new drive" of high-quality development. As the outcomes of the new economic transformation progressively appeared, China's GEE and SD returned to growth after 2019.

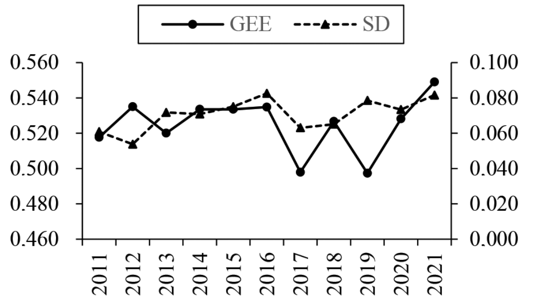

Figure 1. Trends in China's GEE and SD from 2011 to 2021

4.2. Analysis of the outcomes of the econometric model

The econometric model of mediation effect was calculated using the Stata 14.0 software, and the estimates of the equation (5) in analysis Table 3 indicated that GEE had the linear and quadratic term of 0.2177 and –0.1329, respectively, both of which had a substantial influence on SD. This finding revealed that GEE increased SD, but the GEE's quadratic term was negative and substantial, suggesting that its changes were nonlinear, demonstrating an inverse U-type connection. This further implied that the growth in GEE initially led to SD, and that when GEE climbed to a particular level and its contribution to SD reached its peak, the subsequent increase in the GEE would suppress SD. The consequence may be created by an overzealous pursuit of efficiency in the process of establishing a green economy, resulting to higher expenses.

Table 3. Regression results of the intermediate effect econometric model

Variables	Model 1	Model 2	Model 3
GEE	0.2177^{***} (0.0672)	0.1948^{***} (0.0781)	0.2234^{***} (0.0669)
GEE^2	-0.1329^{***} (0.0427)		-0.1345^{***} (0.0425)
ISU			0.0163^{*} (0.0094)
TP	0.0343^{*} (0.0183)	0.0544 (0.0353)	0.0365^{*} (0.0183)
TV	-0.0430^{***} (0.0053)	0.0145 (0.0135)	-0.0434^{***} (0.0052)
UR	0.2608^{***} (0.0376)	0.3495^{**} (0.1499)	0.2490^{***} (0.0380)
Intercept term	0.2323 (0.1454)	1.3691^{***} (0.2398)	0.1868 (0.1474)
Sample size	330	330	330

Note: the superscript ***, **, * are significant at the levels of 1%, 5%, and 10% correspondingly, while the values in the brackets denote the standard difference.

The estimated results of the equation (6) in Table 3 revealed that the ISU coefficient was 0.1948, which had a substantial influence on GEE, suggesting that ISU contributed to the growth in GEE. The regression findings of the equation (7) in Table 3 demonstrated that the GEE's linear, quadratic and ISU variable terms of 0.2234, –0.1345, and 0.0163, respectively, had significant impacts on SD. The aforementioned findings suggested that the ISU variable worked as an intermediate between GEE and SD. This impact mechanism may be characterized as the rise in GEE led to ISU, while the improvement in ISU further contributed to SD.

5. Discussion

Several studies have already identified a non-linear relationship between a green economy and sustainable development. Some authors argued that the nonlinear relationship was caused mainly by policy effects such as environmental regulation that had a threshold effect, that when the threshold was not reached, a green economy had a positive impact on sustainable development, and beyond it, the impact became negative (Aldieri & Vinci, 2018; Xu et al., 2022; Sun et al., 2023). Other empirical studies had shown that human capital and industrial structural upgrading were conducive to the positive impact of the green economy on sustainable development (Sun et al., 2024), while the undercapacity of green technologies for innovation and the inefficiency of green finance constrained the role of green economy in sustainability (Ali et al., 2021). The above results explained the nonlinear relationship between GEE and SD in this research. To further studied the reverse U-shaped relationship between GEE and SD, this paper discussed the extreme value of the nonlinear change.

In Figure 2, when the value of GEE was 0.830, the SD achieved the maximum value of 0.280. The change indicated that when the value of GEE was less than 0.830, GEE had a boosting influence on SD; and when the value of GEE exceeded 0.830, GEE had an inhibitory effect on SD. From 2011 to 2021, the average value of China's GEE was 0.525, the highest value was 0.549 in 2021, and the lowest value was 0.497 in 2019. The values of China's GEE were all lower than 0.830, which demonstrated that the present China's GEE had not achieved its peak, and

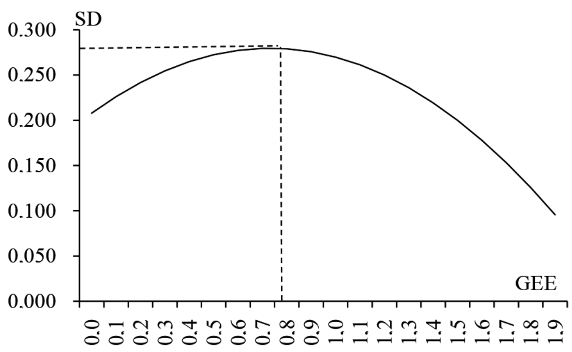

Figure 2. Change diagram demonstrating the link between GEE and SD

rising GEE had useful to support the improvement of SD. In addition, research also demonstrated that the method of boosting ISU by raising GEE, and subsequently ISU promoting SD was still beneficial.

6. Conclusions

This article evaluated China's GEE, SD and the link between them, utilizing data from the provinces of China from 2011 to 2021. The first stage was to generate GEE values for each province using the Super-SBM model, depending on the selection of indicators of input, anticipated output and unexpected output. The second stage was to construct an SD indicator system based on the three aspects of economic growth, ecological balance and social development, and to compute the value of SD in each province using the entropy method. The third stage was to pick the ISU variable, developed an intermediate effect econometric model, and investigated the impact mechanism of GEE on SD. In summarizing the outcomes of the investigation, the paper made three conclusions:

First of all, China's GEE and SD were characterized by phased changes: a sluggish rise trend from 2011 to 2016, a fluctuating pattern from 2017 to 2018, and a rapidly rising trend from 2019 to 2021. This tendency was directly tied to the growth of China's economy around 2016, which switched from old to new dynamics. Secondly, by examining the estimations of the intermediate effect econometric model, it can be observed that the GEE's linear term had a substantial positive influence on SD, while the quadratic term of GEE had a significant negative effect on SD. Thus, the influence of GEE on SD revealed a reverse U-type nonlinear relationship. This suggested that moderate GEE promoted SD, whereas excessive GEE inhibited SD. Thirdly, the predicted findings of the intermediate effect econometric model demonstrated that the ISU played an essential intermediary function between GEE and SD. In other words, GEE promoted ISU and so raised SD.

The aforementioned findings in this research give a fresh viewpoint on understanding the link between a green economy efficiency and sustainable development. The conclusions of the current article also give recommendations for specific action by the authorities: on the one hand, by actions such as upgrading the environmental regulating system, encouraging the digital transformation of industry, increasing the role of financial consolidation and promoting green technological innovation, China's green economy continues to increase its efficiency in order to boost its sustainable development level. On the other hand, through fostering the growth of industrial clusters, boosting interregional industrial transfer, and improving the degree of modernization of the industrial chain, circumstances are established for China's industrial structure to upgrade, and therefore better play out its intermediate influence between green economy efficiency and sustainable development.

Disclosure statement

The authors state that this material does not touch the economic, professional or personal interests of others.

References

Ali, E. B., Anufriev, V. P., & Amfo, B. (2021). Green economy implementation in Ghana as a road map for a sustainable development drive: A review. *Scientific African*, *12*, Article e00756. https://doi.org/10.1016/j.sciaf.2021.e00756

Aldieri, L., & Vinci, C. P. (2018). Green economy and sustainable development: The economic impact of innovation on employment. *Sustainability*, *10*(10), Article 3541. https://doi.org/10.3390/su10103541

Broman, G. I., & Robèrt, K. H. (2017). A framework for strategic sustainable development. *Journal of Cleaner Production*, *140*, 17–31. https://doi.org/10.1016/j.jclepro.2015.10.121

Chen, W., Huang, X., Liu, Y., Luan, X., & Song, Y. (2019). The impact of high-tech industry agglomeration on green economy efficiency – Evidence from the Yangtze river economic belt. *Sustainability*, *11*(19), Article 5189. https://doi.org/10.3390/su11195189

Dalevska, N., Khobta, V., Kwilinski, A., & Kravchenko, S. (2019). A model for estimating social and economic indicators of sustainable development. *Entrepreneurship and Sustainability Issues*, *6*(4), 1839–1860. http://doi.org/10.9770/jesi.2019.6.4(21)

Duan, X., Tang, M., & Zhang, K. (2022). How to evaluate the efficiency of green economy and its regional differences: Evidence from China. *Discrete Dynamics in Nature and Society*, *2022*, Article 4902406. https://doi.org/10.1155/2022/4902406

Hak, T., Janoušková, S., & Moldan, B. (2015). Sustainable development goals: A need for relevant indicators. *Ecological Indicators*, *60*, 565–573. https://doi.org/10.1016/j.ecolind.2015.08.003

Kasztelan, A. (2017). Green growth, green economy and sustainable development: Terminological and relational discourse. *Prague Economic Papers*, *26*(4), 487–499. https://doi.org/10.18267/j.pep.626

Kong, L., & Li, J. (2022). Digital economy development and green economic efficiency: Evidence from province-level empirical data in China. *Sustainability*, *15*(1), Article 3. https://doi.org/10.3390/su15010003

Li, C., Jia, Q., & Li, G. (2020). China's energy consumption and green economy efficiency: An empirical research based on the threshold effect. *Environmental Science and Pollution Research*, *27*, 36621–36629. https://doi.org/10.1007/s11356-020-09536-z

Li, W., & Ouyang, X. (2020). Investigating the development efficiency of the green economy in China's equipment manufacturing industry. *Environmental Science and Pollution Research*, *27*, 24070–24080. https://doi.org/10.1007/s11356-020-08811-3

Liu, D., Chang, Y., Yao, H., & Kang, Y. (2023). The impact of green finance on green economy development efficiency: Based on panel data of 30 provinces in China. *Frontiers in Environmental Science*, *11*, 1–15. https://doi.org/10.3389/fenvs.2023.1328914

Liu, Y., & Dong, F. (2021). How technological innovation impacts urban green economy efficiency in emerging econo-

mies: A case study of 278 Chinese cities. *Resources, Conservation and Recycling*, *169*, Article 105534.
https://doi.org/10.1016/j.resconrec.2021.105534

Liu, Z. S., Lai, B. B., Liu, G. H., Fan, Z. G., & Zhang, D. X. (2023). Regional competition, digital inclusive finance promotion and green economic efficiency. *Management Review*, *35*(1), 39–51.

Ma, J., Wang, J., & Shen, X. (2022). Economic policy uncertainty and green economy efficiency: Power or resistance? – Empirical evidence from Chinese major urban agglomerations. *Economic research-Ekonomska istraživanja*, *35*(1), 657–675.
https://doi.org/10.1080/1331677X.2021.1931911

Monkelbaan, J. (2019). Inferences on improving integrative sustainability governance. In *Governance for the sustainable development goals: Exploring an integrative framework of theories, tools, and competencies* (pp. 153–192). Springer.
https://doi.org/10.1007/978-981-13-0475-0_6

Nahman, A., Mahumani, B. K., & De Lange, W. J. (2016). Beyond GDP: Towards a green economy index. *Development Southern Africa*, *33*(2), 215–233.
https://doi.org/10.1080/0376835X.2015.1120649

Pererva, P., Kobielieva, T., Kuchinskyi, V., Garmash, S., & Danko, T. (2021). Ensuring the sustainable development of an industrial enterprise on the principle of compliance-safety. *Studies of Applied Economics*, *39*(5), 1–11.
https://doi.org/10.25115/eea.v39i5.5111

Sachs, J. D., Schmidt-Traub, G., Mazzucato, M., Messner, D., Nakicenovic, N., & Rockström, J. (2019). Six transformations to achieve the sustainable development goals. *Nature Sustainability*, *2*(9), 805–814.
https://doi.org/10.1038/s41893-019-0352-9

Shuai, S., & Fan, Z. (2020). Modeling the role of environmental regulations in regional green economy efficiency of China: Empirical evidence from super efficiency DEA-Tobit model. *Journal of environmental management*, *261*, Article 110227.
https://doi.org/10.1016/j.jenvman.2020.110227

Sun, J., Zhai, N., Miao, J., Mu, H., & Li, W. (2023). How do heterogeneous environmental regulations affect the sustainable development of marine green economy? Empirical evidence from China's coastal areas. *Ocean* & *Coastal Management*, *232*, Article 106448.
https://doi.org/10.1016/j.ocecoaman.2022.106448

Sun, G., Liu, Y., Li, B., & Guo, L. (2024). Road to sustainable development of China: The pursuit of coordinated development between carbon emissions and the green economy. *Journal of Cleaner Production*, *434*, Article 139833.
https://doi.org/10.1016/j.jclepro.2023.139833

Tomislav, K. (2018). The concept of sustainable development: From its beginning to the contemporary issues. *Zagreb International Review of Economics* & *Business*, *21*(1), 67–94.
https://doi.org/10.2478/zireb-2018-0005

Verma, S., & Kandpal, D. (2021). Green economy and sustainable development: A macroeconomic perspective. In *Environmental sustainability and economy* (pp. 325–343). Elsevier.
https://doi.org/10.1016/B978-0-12-822188-4.00016-6

Wu, D., Wang, Y., & Qian, W. (2020). Efficiency evaluation and dynamic evolution of China's regional green economy: A method based on the Super-PEBM model and DEA window analysis. *Journal of Cleaner Production*, *264*, Article 121630.
https://doi.org/10.1016/j.jclepro.2020.121630

Xu, J., Zhao, J., She, S., & Liu, W. (2022). Green growth, natural resources and sustainable development: Evidence from BRICS economies. *Resources Policy*, *79*, Article 103032.
https://doi.org/10.1016/j.resourpol.2022.103032

Xu, Z., Li, Y., Chau, S. N., Dietz, T., Li, C., Wan, L., Zhang, J., Zhang, L., Li, Y., Chung, M. G., & Liu, J. (2020). Impacts of international trade on global sustainable development. *Nature Sustainability*, *3*(11), 964–971.
https://doi.org/10.1038/s41893-020-0572-z