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Sustainable Development Efficiency of High Resource Consumption Countries and The Impact of Energy Imports

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Abstract

Through the constructed inputs, desired and non-desired outputs of highly resource-consuming countries for 2010-2023, sustainable development efficiency values were calculated and analyzed using the SBM-DEA model. Then considering that the SBM model can only measure static efficiency and cannot reflect the inter-period changes in sustainable development efficiency, the changes in sustainable development efficiency were dynamically analyzed by calculating the Malmquist index. Considering the factor that highly resource-consuming countries have a large demand for energy consumption while their own countries need to import a lot of energy resources with limited energy resources, the impact of energy imports on the sustainable development level of highly resource-consuming countries is explored with sustainable development efficiency as the explanatory variable and energy imports as the core explanatory variable. The results show that: (1) the value of sustainable development efficiency of countries as a whole shows an upward trend, maintained at about 0.6 on average, but there is some variability among countries; (2) from a dynamic point of view, the Malmquist index is generally stable, consistent with the analysis of the results of the SBM-DEA model and the sustainable development efficiency is mainly dependent on the technical efficiency; (3) energy imports can improve the efficiency of sustainable development, but it is necessary to (3) Energy imports can improve the efficiency of sustainable development, but it is necessary to balance the relationship with renewable energy to avoid the economic and environmental risks of over-reliance.

Keywords

Highly resource-consuming countries, Sustainable development efficiency, SBM model, Energy imports, Tobit regression.

1. Introduction

At the end of the twentieth century, the world faced environmental degradation, poverty and inequality. To address these challenges, the international community recognized the need for a more balanced development model that preserves the integrity of ecosystems and ensures equality of economic and social opportunities.The concept of sustainable development was first proposed by the Brundtland Commission in 1987 in its report Our Common Future, and since then there has been a global consensus on the balance between environmental protection, social justice and economic development. With the intensification of global environmental problems, sustainable development has become an area of international focus, including environmental science, sustainable energy, economics and other aspects. In recent years, with the deepening of technological innovation and international cooperation, sustainable development research has continued to evolve, especially as the Millennium Development Goals (MDGs) of 2000 and the Sustainable Development Goals (SDGs) of 2015 have clarified the direction of global action. Current sustainable development research exhibits a multidisciplinary character, covering the three dimensions of environment, economy and society. Researchers have combined scientific research, policy development, technological

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development, and social change to drive the development of new technologies and strategies. In this paper, factors such as labor force, fixed capital, energy consumption and GDP are incorporated into the sustainable development assessment framework, and data envelopment analysis (DEA) is used to calculate the efficiency, assess the current status of sustainable development through the study of 11 high-resource-consuming countries, and explore the influencing factors, so as to provide recommendations for the achievement of the sustainable development goals.

2. Literature Review

2.1. Current status of research on sustainable development efficiency

The concept of sustainable development was first introduced in 1980 in the World Conservation Strategy, and since then, the idea of sustainable development has evolved into an integrated, global goal encompassing economic stability, social inclusiveness, and environmental preservation of natural cycles and biodiversity, which has been incorporated into international treaties and has become a guiding principle for policymaking, corporate strategy and public life, with three main areas at its core: Environmental protection, economic growth and social well-being. The concept of sustainable development has attracted widespread attention, and Zhang Qin analyzes the factors that shape regional sustainability, including changes in human needs, informatization, new industrialization, marketization, new technologies, and institutional optimization. Research on the efficiency of sustainable development is increasing, and Flávia de Castro Camioto uses the SBM model to compare the efficiency of sustainable development in the BRICS and the G7 to provide advice0 ; Song Wang calculates the sustainable development efficiency of Chinese provinces and cities based on the DPSIR framework using the super-efficient SBM model and analyzes the impact of scientific and technological innovations[2] ; Cheng Shixiong used the super-efficient SBM-DEA and GML models to assess the efficiency of BRICS and G7, and used the STIRPAT method to study the environmental pollution factors[3] .

2.2. Current Research Status of SBM-DEA Modeling

The SBM model (Slacks-Based Measure) is an extension of Data Envelopment Analysis (DEA) specifically designed to assess the relative efficiency of decision-making units, taking into account both input redundancy and output deficiencies. Proposed by Tone in 2001, the model provides a more comprehensive efficiency evaluation through slack variables, is applicable to multiple input and multiple output situations, and is widely used in energy consumption, environmental efficiency and public service efficiency analysis. Since the SBM model was proposed, it has been researched and promoted by several scholars, and it has been widely used in theory and practice, especially playing an important role in sustainable and environmentally friendly development. Zhu Liyun and He Feng constructed a multi-stage non-expectation network SBM-DEA model, which improves the efficiency assessment of multi-stage production processes[4] ; Liu Haoran used the super-efficient SBM model to measure the green development efficiency in the Beijing-Tianjin-Hebei region, and analyzed the influencing factors through the Tobit model[5] .

2.3. Current status of research on factors influencing the efficiency of sustainable development

Sustainable development involves complex interactions between the environment, the economy and society, and is influenced by political, economic, social and technological factors. Zou Yicheng assessed the impact of the Belt and Road Initiative on sustainable development [6].[6] Wang Huan analyzed the relationship between green finance and sustainable energy development [7].[7] Cheng Guangbin et al. investigated the sustainable development capacity

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of cities in the Silk Road Economic Belt and its influencing factors through super-efficient DEA and panel Tobit model [8].[8] .

In summarizing the literature, it is clear that, despite the maturing of research on sustainable development, most of the existing studies have focused on the economic, ecological or energy dimensions and have lacked a comprehensive assessment of the efficiency of integrated sustainable development. Existing studies have focused mainly on regional sustainable development or the relationship between energy and sustainable development, and have paid less attention to the impact of energy imports on countries with high resource consumption. In view of the global importance of sustainable development, the present study takes highly resource-consuming countries as its target and analyzes the impact of their resource consumption and energy imports on sustainable development, with a view to providing theoretical support and practical guidance for the long-term sustainable development of those countries.

3. Research Modeling and Methodology

3.1. SBM-DEA model with undesired outputs

This study draws on the research of other scholars to construct an SBM model that includes non-desired outputs, assuming that there are n decision-making units, each of which contains the input factor X, desired outputsY , non-desired output Z, and assuming X>0, Y>0, Z>0, andλ is the weight vector. When considering the non-desired output scenario, the non-desired output scenario in the inefficient case is not a case of insufficient output but excessive output, and a new slack variable needs to be introduced$s^{+'}$ to standardize the non-desired output, remember the actual desired output, the actual non-desired output are q, h respectively, thus constructing the model, the specific SBM model is as follows.

$$\theta^* = min \frac{1-\frac{1}{m}\sum_{i=1}^{m}\frac{s_i^-}{x_{io}}}{1+\frac{1}{q+h}\left(\sum_{r=1}^{q}\frac{s_r^+}{y_{ro}}+\sum_{r=1}^{h}\frac{s_r^{+'}}{z_{ro}}\right)} \tag{1}$$

$$s.t\begin{cases} \overrightarrow{x_0} = X\vec{\lambda} + s^- \\ \overrightarrow{y_0} = Y\vec{\lambda} - s^+ \\ \overrightarrow{z_0} = Z\vec{\lambda} + s^{+'} \\ \vec{\lambda} \geq 0, s^- \geq 0, s^+ \geq 0, s^{+'} \geq 0 \end{cases} \tag{2}$$

When a particular DMU reaches the efficiency optimumθ^*=1,s^-=0,s^+=0,$s^{+'}$=0.

3.2. Malmquist Index

The SBM-DEA model based on non-expected outputs can only measure static efficiency and cannot reflect inter-periodic changes in sustainability efficiency. To solve this problem, Sten Malmquist proposed the Malmquist index method. The method evaluates productivity changes by comparing the distance between the actual output of the decision unit and the theoretical production frontier, which is divided into two parts: efficiency change (EC) and technical change (TC).The Malmquist index, combining EC and TC, is able to dynamically evaluate the production efficiency of multiple inputs and multiple outputs, and to measure the total factor productivity changes from one period to the next, thus realizing a sustainable development The dynamic analysis of efficiency is given by the formula:

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$$TFP = EC \times TC = \frac{D^{t+1}(x^{t+1},y^{t+1})}{D^{t}(x^{t},y^{t})} \times \left[\frac{D^{t}(x^{t},y^{t})}{D^{t+1}(x^{t},y^{t})} \times \frac{D^{t}(x^{t+1},y^{t+1})}{D^{t+1}(x^{t+1},y^{t+1})}\right]^{\frac{1}{2}} \tag{3}$$

As shown in Eq. D() denotes the distance function, which easures the proportion of actual output y relative to the maximum possible output under the technological conditions in a given period t. x and y represent the input and output vectors at time t, respectively, and the Malmquist index (TFP) denotes the degree of change in the productivity of the decision unit in the period t to period t+1. If TFP>1, it indicates that total factor productivity is in an upward phase If TFP>1, total factor productivity is in a declining stage; TFP<1, total factor productivity is in a declining stage; EC>1, the closer the decision-making unit is to the production frontier, the more the technological efficiency improves; EC<1, the decision-making unit does not utilize the existing technology very well; TC>1, there is technological progress or technological innovation, and the production frontier is shifted to the front.

3.3. Tobit model

The Tobit regression model was introduced by economist James Tobit in 1958 and is specifically designed to deal with the analysis of data where there is truncation of the dependent variable. It is a linear regression model for situations where the dependent variable is truncated within a specific interval, for example, where the values are restricted to be taken between 0 and positive infinity.Tobit regression models are widely used in areas such as productivity, wages, and consumer spending by transforming truncated data into probabilistic models that enable the statistical analysis of truncated data. The standard Tobit regression model of type I is as follows:

$$y^{*} = \beta' x_i + u_i \tag{4}$$

$$y^{*} = \begin{cases} y_i, y^{*} > 0 \\ 0, y^{*} \leq 0 \end{cases} \tag{5}$$

wherey_i^* is the latent dependent variable, which is observed when the latent variable is greater than 0 and takes the value ofy_i , which is truncated at point 0 when the latent variable is less than or equal to 0, andx_i is the vector of independent variables andβ is the vector of coefficients, and the error termu_i are independent and follow a normal distribution:$u_i \sim N(0,\sigma^2)$. Combining the characteristics of the panel data on sustainable development of highly resource-consuming countries from 2010 to 2023, the Tobit regression model is built as follows:

$$SDE_{it} = \beta_0 + \beta_1 IMP_{it} + \beta_2 REC_{it} + \beta_3 (IMP_{it} * REC_{it}) + \beta_4 GDP_{it} + \beta_5 UN_{it} + \beta_6 PE_{it} + \beta_7 NFDI_{it} + \beta_8 RD_{it} + \beta_9 PEI_{it} + \varepsilon \tag{6}$$

3.4. Data sources and processing

3.4.1. Sample country selection

The selected sample period for all models is 2010-2023, based on data availability, completeness and accuracy, and the selected sample countries are 11 countries that are highly resource-consuming countries (China, United Kingdom, Indonesia, India, Japan, United States, South Korea, France, Russia, Germany, Brazil).

The consumption-based material footprint (MF) was selected for measurement, and the consumption-based MF was calculated using the overall consumption-based MF based on the dataset and the calculation methodology in the table below. The relevance of the sample can be

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recognized from the fact that these 11 countries consume 67% of the world's resources (see Table 1) and have the highest scores in infrastructure development, and that these countries are at the top of the Global Innovation Index and are characterized as technologically advanced.

Table 1. Consumption-based material footprint of the sample countries

serial number	nations	MF (billion tons)	Percentage of global share
1	China	444.41	33.90%
2	United Kingdom	16.02	1.22%
3	Indonesia	25.76	1.97%
4	India	85.2	6.50%
5	Japan	34.52	2.63%
6	United States of America	139.05	10.61%
7	Republic of Korea	16.19	1.24%
8	French	15.96	1.22%
9	Russia	25.01	1.91%
10	German	28.37	2.17%
11	Brazil	51.13	3.90%
	total	881.62	67.25%
	the whole world	1310.87	
Note: MF includes biomass, fossil fuels, metal ores, and non-metallic minerals.			
Source: Authors' calculations based on data from the Global Material Flow Database, 2010-2023.			

3.4.2. SBM-DEA model variable selection

In order to reasonably and efficiently evaluate the efficiency of sustainable development in highly resource-consuming countries, this paper adopts the SBM-DEA model with non-desired outputs, using labor (L), energy consumption (E), and total fixed inputs of capital (K) as inputs, GDP as desired outputs, and carbon dioxide emissions as non-desired outputs.

Table 2. SBM-DEA model variable selection

form	Sustainable dimensions	variant
throw oneself into	societies	labor force
	economics	Gross fixed capital formation
	environment	energy consumption
Expected outputs	economics	GDP
Non-expected outputs	environment	Carbon dioxide emissions

3.4.3. SBM-DEA model variable treatment

Since efficiency changes in sustainable development are closely related to input and output elements, this study focuses on these elements and provides a comprehensive analysis of data for the period 2010 to 2023.

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Table 3. Descriptive statistics of input-output variables

Indicator category	variant	average value	(statistics) standard deviation	maximum values	minimum value
throw oneself into	Labor force/million people	176.248	229.731	780.71	25.42
	Gross fixed capital formation/billion dollars	1326.15	1540.8	6240.25	234.075
	Energy consumption/TJ	22145283	24807282	91597122	4776935
Expected outputs	GDP/billion dollars	4221.03	3996.39	15049	755.094
Non-expected outputs	Carbon dioxide emissions/tens of millions of tons	207.343	282.133	1094.47	26.716

3.4.4. Tobit model variable selection

In order to reasonably and efficiently explore the factors influencing sustainable development efficiency in highly resource-consuming countries, this paper adopts a Tobit regression model using sustainable development efficiency as the explanatory variable, energy imports as the core explanatory variable, and GDP per capita, unemployment rate, public education expenditures, net inflows of FDI, R&D expenditures, energy intensity of primary energy, and renewable energy consumption as the control variables.

Table 4. Tobit model variable selection

Variable type	variable name	variable symbol	Variable Interpretation
explanatory variable	Sustainable development efficiency	SDE	The SBM-DEA model of non-desired output calculates that
core variable	Energy imports	IMP	Total imports of energy types beginning with 27 in the HS92 six-digit code
control variable	GDP per capita	GDP	GDP divided by total population
	unemployment rate	UN	Number of people in the labor force who sought but did not obtain a job as a percentage of the total labor force
	Public education expenditure	PE	Public expenditure on education as a percentage of total government expenditure
	Net inflows of foreign direct investment	NFDI	Net capital inflows from international investors as a percentage of GDP
	R&D expenditures	RD	R&D expenditure as a percentage of GDP
	Energy intensity of primary energy sources	PEI	Amount of primary energy consumed per unit of GDP
	Renewable energy consumption	REC	Share of renewable energy in total final energy consumption

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3.4.5. Tobit model variable treatment

In order to have a clearer understanding of the relationship between the relevant explanatory variables and the explained variables, we will explore their performance in the dataset and their potential associations with each other through detailed descriptive statistical analysis.

Table 5. Descriptive statistics of variables in Tobit regression analysis

variant	note	observed value	average value	(statistics) standard deviation	Min	Max.
SDE	Sustainable development efficiency	154	0.633	0.330	0.187	1
IMP	Energy imports	154	107000000	91100000	1763861	422000000
GDP	GDP per capita	154	27063.64	19748.82	1350.634	76329.58
UN	unemployment rate	154	5.696	2.464	2.35	13.7
PE	Public education expenditure	154	12.152	3.032	2.196	21.079
NFDI	Net inflows of foreign direct investment	154	1.889	1.427	-1.776	12.079
RD	R&D expenditures	154	2.132	1.214	0.085	5.305
PEI	Energy intensity of primary energy sources	154	4.690	1.750	2.2	8.96
REC	Renewable energy consumption	154	16.214	13.351	0.263	53.192

4. Analysis of Empirical Results

4.1. Analysis of the results of the sustainable development efficiency rating

By applying the SBM-DEA model with non-expected outputs, this study evaluates the sustainable development efficiency of highly resource-consuming countries during the period from 2010 to 2023. The evaluation results are displayed in the table below, where higher scores indicate better sustainable development efficiency, and a score of 1 means that the country's sustainable development efficiency is at the efficiency frontier and at the optimum. By analyzing the sustainable development efficiency of each country and its average score, the following conclusions were drawn.

(1) Overall sustainable development efficiency rises each year from 2010 to 2023. Although there are fluctuations in efficiency in Japan, the Republic of Korea, Russia and Brazil, high-resource-consuming countries have generally entered a phase of slow increase. Developed Western countries are more efficient because of their economic and technological advantages, while developing Asian countries, although less efficient, are gradually improving their efficiency with better environmental protection measures and policies.

(2) In analyzing the efficiency of sustainable development: ① The UK and the US are consistently the most efficient and have superior performance. ② Japan, France, Russia, Germany and Brazil have unstable efficiency, affected by economy, policies and challenges. (iii) China's efficiency value is 0.18-0.26, with a mean of 0.23; Indonesia is 0.26-0.28, with a mean of 0.27; India is 0.21-0.27, with a mean of 0.24; Japan is 0.7-1, with a mean of 0.83, showing a downward trend; South Korea is 0.39-0.5, with a mean of 0.45, with an upward trend; Russia is

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0.31-1, with a mean of 0.39, showing a large fluctuations; Germany 0.75-1, mean 0.96, but declining in 2020; Brazil efficiency value of 0.34-1, mean 0.69, from stable growth to rapid improvement.

Table 6. Sustainable development efficiency values

nations	China	United Kingdom	Indonesia	India	Japan	United States of America	Republic of Korea	French	Russian	German	Brazil
2010	0.187	1	0.264	0.217	1	1	0.394	1	0.333	1	0.578
2011	0.194	1	0.264	0.210	1	1	0.402	1	0.358	1	0.588
2012	0.210	1	0.268	0.218	1	1	0.429	1	0.381	1	0.565
2013	0.212	1	0.270	0.222	0.822	1	0.440	1	0.384	1	0.532
2014	0.213	1	0.251	0.225	0.755	1	0.451	1	0.356	1	0.485
2015	0.243	1	0.265	0.242	0.817	1	0.479	1	0.323	1	0.417
2016	0.247	1	0.284	0.252	0.825	1	0.473	1	0.318	1	1
2017	0.247	1	0.292	0.263	0.817	1	0.481	1	0.349	1	1
2018	0.255	1	0.276	0.248	0.802	1	0.491	1	0.327	1	1
2019	0.262	1	0.285	0.264	0.796	1	0.483	1	0.330	1	1
2020	0.260	1	0.282	0.266	0.778	1	0.474	1	0.318	0.890	1
2021	0.284	1	0.304	0.270	0.753	1	0.505	1	0.299	0.833	0.356
2022	0.232	1	0.251	0.210	0.682	1	0.389	0.586	1	0.751	0.397
2023	0.234	1	0.230	0.213	0.700	1	0.428	0.762	0.258	0.804	0.342
average value	0.235	1	0.273	0.239	0.834	1	0.453	0.968	0.391	0.960	0.686

The average value shows that the sustainable development efficiency of highly resource-consuming countries stays around 0.6. It rose from 2010-2012, fell to its lowest level from 2012-2014, and then increased sharply after 2015 and stayed around 0.68 after reaching its highest point in 2017. Since the launch of the United Nations Sustainable Development Goals in 2015, countries have upgraded renewable energy, low-carbon transportation and urban quality of life, but high pollution emissions and inefficient resource use continue to constrain efficiency gains, resulting in varying performance and fluctuating efficiency levels.

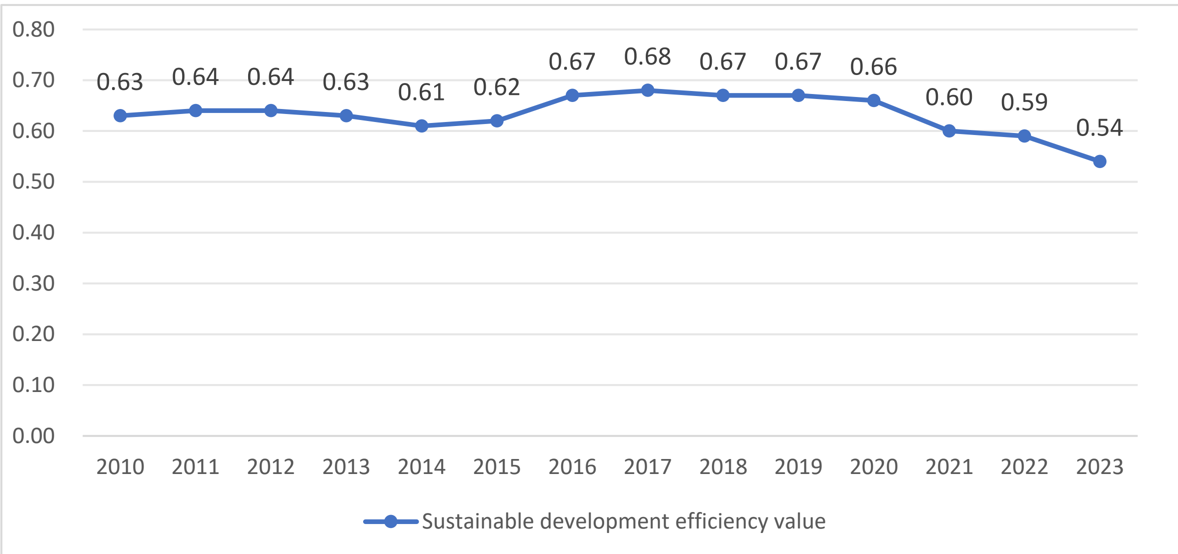

Figure 1. Average value of sustainable development efficiency

4.2. Analysis of Malmquist Index results

The Malmquist index calculation method with dynamic characteristics is used to calculate and analyze the panel data of the sustainable development of highly resource-consuming countries for the period of 2010-2023, and to observe the changes in the efficiency of the sustainable

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development of highly resource-consuming countries in relation to the previous year, as well as the magnitude of the changes. After calculating the panel data using Malmquist in DEAP software, the results obtained are shown in Table 7.

Table 7. Analysis of the results of the country's average Malmquist index by year

phase	Efficiency index (effch)	Technological progress index (techch)	Pure technical efficiency changes (pech)	Scale efficiency change (sech)	Malmquist Index (tfpch)
2010-2011	1.003	1.015	0.995	1.007	1.018
2011-2012	1.001	0.985	1.009	0.992	0.986
2012-2013	1.013	0.986	1.003	1.01	0.999
2013-2014	1.010	1.009	1.011	0.999	1.019
2014-2015	1.010	0.995	1.008	1.001	1.005
2015-2016	1.012	0.988	1.001	1.011	1
2016-2017	1.009	0.988	1	1.009	0.996
2017-2018	1.006	1.009	1	1.006	1.015
2018-2019	0.995	0.995	0.998	0.997	0.99
2019-2020	1.002	0.986	1.001	1.001	0.988
2020-2021	0.997	0.995	0.998	0.999	0.993
2021-2022	0.969	0.989	0.995	0.974	0.958
2022-2023	1.016	0.975	1.001	1.014	0.990
average value	1.003	0.993	1.002	1.002	0.996

From the table, the average Malmquist index and its decomposition results for each year of the highly resource-intensive countries' sustainability efficiency in 2010-2023 are characterized by the following two main features:

(1) From a dynamic perspective, the Malmquist index is generally stable. the index declined in 2010-2013, increased in 2013-2018, and declined again in 2018-2020. This indicates the dynamic stability of sustainable development efficiency across countries, which is consistent with the analysis of the SBM-DEA model. Technical efficiency contributes 0.3% to the Malmquist index, but the contribution of technical progress is negative, indicating that efficiency is mainly dependent on technical efficiency. The growth of technical efficiency is slow (0.2%), and there is a need to improve the efficiency of resource utilization to enhance technical efficiency.

(2) In terms of time periods, the Malmquist Index shows an increasing trend in most years and stays around 1. However, in the time intervals of 2011-2012, 2019-2020 and 2020-2023, the Malmquist Index experienced negative growth. The main reasons for this may be: first, the escalation of the sovereign debt crisis in developed countries after 2011 had a significant impact on the global economy, which in turn was detrimental to the technical efficiency, the efficiency of technological progress, and the efficiency of scale in each country, leading to a decline in the Malmquist Index. Secondly, the outbreak of the New Crown epidemic in 2020, which had a huge impact on the financial sector and all aspects of society, led to a decline in the efficiency of technical progress and affected the Malmquist index.

Similarly, this paper also measures and analyzes the average Malmquist index of sustainable development efficiency of countries in highly resource-consuming countries, and the detailed results are shown in the table.

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Table 8. Average Malmquist index and its decomposition results for each country

nations	Efficiency index (effch)	Technological progress index (techch)	Pure technical efficiency changes (pech)	Scale efficiency change (sech)	Malmquist Index (tfpch)
Indonesia	1.029	0.989	1	1.029	1.018
United Kingdom	1	1.005	1	1	1.005
French	0.99	1.012	1	0.99	1.003
Brazil	1.012	0.989	1.015	0.997	1.001
United States of America	1	0.997	1	1	0.997
German	0.995	1.01	0.997	0.998	0.996
India	1.01	0.985	1.006	1.004	0.995
Russia	1	0.988	1	1	0.988
China	1	0.987	1	1	0.987
Japan	0.999	0.988	0.999	0.999	0.987
Republic of Korea	1	0.986	1	1	0.986
average value	1.003	0.993	1.002	1.002	0.996

From the table, the average Malmquist index of national sustainable development efficiency and its decomposition results for highly resource-consuming countries are characterized by the following two main features:

(1) From a country perspective, the Malmquist Index shows a pattern of growth in most countries. In the time span from 2010 to 2020, 4 out of 11 highly resource-consuming countries have index values above 1, suggesting that these countries are on a growth trajectory in terms of sustainable development efficiency. A deeper analysis of the components of the index reveals that most of the technical efficiency indices are close to 1, suggesting that technical efficiency plays a positive role in driving sustainable development efficiency. It is also observed that in terms of technological innovation, the indexes of the United Kingdom, France and Germany exceed 1, while the other countries do not meet this criterion, indicating that the growth of the Malmquist index in the other eight countries, with the exception of these three, is not due to efficiency gains resulting from technological innovation, but rather is the result of a weakening of the efficiency of technological progress.

(2) In terms of rankings, there are significant differences between countries. Of the 11 highly resource-intensive countries, Indonesia, the United Kingdom and France are in the top three, specifically Indonesia, which has an average annual growth rate of 1.8 per cent, while France, the United Kingdom and Brazil do not have an average annual growth rate of more than 1 per cent. In addition, seven countries have Malmquist Index values below 1, indicating that these countries need to make further efforts in terms of the efficiency of their technological progress. An analysis of the rankings shows that, while some developed countries have a high performance in terms of overall sustainable development efficiency, their dynamic growth rates are relatively low, probably because they have already reached a high level of sustainable development and it is more difficult for them to grow further, and therefore their growth rates are lower than those of some developing countries.

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4.3. Analysis of Tobit regression model results

In this paper, stata is used to regress the above developed Tobit model for regression and the results are shown in the table.

Table 9. Tobit model regression results

variant	ratio	(statistics) standard deviation	t-statistic	significance level
Constant C	0.4834116	0.0762293	6.34	0.000
IMP	4.94e-10	2.02e-10	2.44	0.016
REC	0.0018496	0.0014467	1.28	0.203
IMP*REC	-4.97e-11	1.32e-11	-3.76	0.000
GDP	0.0000133	0.000000889	14.93	0.000
UN	0.0359963	0.004768	7.55	0.000
PE	-0.0149175	0.0033841	-4.41	0.000
NFDI	0.0033212	0.0068105	0.49	0.627
RD	-0.0295899	0.0129159	-2.29	0.023
PEI	-0.0400117	0.0075448	-5.30	0.000

The regression results illustrate that (1) energy imports are positively related to sustainability efficiency with a coefficient of 0.000000000494, corresponding to a p-value of 0.016.(2) The relationship between renewable energy consumption (REC) and sustainability efficiency is not statistically significant, with a specific coefficient of 0.0018496, corresponding to a p-value of 0.203, which suggests that the current data sample does not contain sufficient evidence that an increase in renewable energy consumption significantly enhances sustainable development efficiency. (3) The effect of the interaction of energy imports and renewable energy consumption on sustainable development efficiency is highly significant negatively correlated, indicating that a reasonable balance between the interaction of energy imports and renewable energy consumption is essential for achieving the goal of sustainable development. (4) The coefficient of the GDP per capita indicator is positive and reaches the 1% significance level, reflecting that the level of GDP per capita has a positive impact on the efficiency of sustainable development. (5) The regression coefficient between unemployment rate and sustainable development efficiency is positive and passes the significance test. This reflects that in highly resource-consuming countries, the higher the unemployment rate, the higher the sustainable development efficiency. (6) The regression coefficient between public education expenditure and sustainable development efficiency is negative and passes the significance test. This indicates that the higher the public education expenditure, the lower the sustainable development efficiency. (7) The net inflow of FDI is positively correlated with the level of sustainable development efficiency with a coefficient of 0.0033, indicating that a 1% increase in the net inflow of FDI, the corresponding level of sustainable development efficiency.

The coefficient is 0.0033, indicating that a 1% increase in net FDI inflow can raise the corresponding sustainable development efficiency level by 0.0033% on average, which means that when FDI increases, it is usually accompanied by an increase in the efficiency of the country or region in terms of sustainable development. (8) R&D expenditures negatively affect the level of sustainability efficiency at the 5% level, implying that increased R&D investment may lead to lower sustainability efficiency. (9) There is a significant negative correlation between energy intensity of primary energy sources and sustainability efficiency with a correlation coefficient

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of -0.0400117, indicating that there is a negative correlation of about 1% between an increase in energy intensity and a decrease in sustainability efficiency.

5. Conclusions and Recommendations of The Study

This study takes 11 countries with high resource depletion as the research object, based on the combing of domestic and foreign research results, firstly selects the efficiency as the country's sustainable development evaluation criterion, establishes the sustainable development efficiency evaluation index system from static and dynamic aspects by using the SBM-DEA model and the Malmquist index, and calculates and analyzes the sustainable development efficiency of the countries with high resource depletion. The results show that the sustainable development efficiency of the selected sample countries mostly shows an upward trend, and the efficiency is generally maintained at about 0.6. Meanwhile, this paper takes sustainable development efficiency as the explanatory variable, energy imports as the core explanatory variable, and GDP per capita, unemployment rate, public education expenditure, net inflow of FDI, R&D expenditure, energy intensity of primary energy, renewable energy consumption as the control variables, and applies the Tobit regression analysis to explore its impact on the sustainable development efficiency of highly resource-consuming countries, and arrives at the following The main conclusions are as follows:

Energy imports contribute to the efficiency of sustainable development. Through the introduction of advanced technologies, the optimization of energy supply, the diversification of energy sources and the strengthening of international cooperation, energy imports promote energy efficiency, economic development and environmental protection, thereby facilitating the transition to sustainable development. Despite the potential of renewable energy to contribute to sustainable development, current data show a non-significant relationship between its consumption and sustainable development efficiency, and its development faces high costs, technological challenges, reliability issues, policy instability, and infrastructure transformation challenges. The negative correlation between the interaction terms of energy imports and renewable energy consumption suggests that balancing the two is critical for sustainable development, that overdependence on energy imports may pose economic risks, environmental problems, energy security concerns, and technological and policy challenges that impede the achievement of sustainable development goals, and that managing and regulating the relationship between imported energy and renewable energy consumption requires effective policies and governance mechanisms to promote renewable energy development and reduce the impacts of imported energy on the environment. Managing and regulating the relationship between imported energy and renewable energy consumption requires effective policies and governance mechanisms to promote the development of renewable energy and reduce dependence on imported energy.

Based on the results of the empirical analysis, this paper puts forward the following feasible recommendations: (1) Diversify energy strategies: Introduce different types of energy suppliers, including natural gas, nuclear energy and renewable energy, so as to reduce dependence on a single country or form of energy, such as signing long-term contracts to cooperate with energy suppliers in different countries to ensure the stability of supply. (2) Investing in renewable energy technologies: Setting up a special fund to support research and development of technologies such as wind, solar and geothermal energy, as well as establishing pilot projects to test new technologies, promoting commercial applications and reducing initial investment costs. (3) Improve energy efficiency: Implement energy audits and optimization programs, improve energy efficiency standards for buildings and industrial facilities, and introduce intelligent energy management systems to monitor and adjust energy use in real time to reduce waste.

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