

Which Members of OECD are Inactive or Laissez-Faire at Reducing Greenhouse Gas Emissions

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Abstract Global climate change has become a global challenge. Greenhouse gases are one of the leading causes of climate change, especially the emission of carbon dioxide and other greenhouse gases. The emissions of these gases mainly come from human activities such as energy production and use, industrial activities, transportation, and agriculture. The international community has adopted various agreements to reduce global greenhouse gas emissions and achieve climate goals in response to climate change. However, achieving greenhouse gas targets is about more than just reducing overall emissions. Economic efficiency must also be considered. Economic efficiency refers to the maximum effect achieved in achieving a specific goal: the maximum greenhouse gas reduction effect at the least cost. This study analyzed the economic and greenhouse gas emission reduction efficiency of OECD member countries through the two-stage data envelopment analysis method. And, using quartiles, the OECD member countries' comprehensive efficiency grouping to distinguish which countries are inactive in greenhouse gas emission reduction or countries that are laissez-faire. Finally, the study found that Iceland, Luxembourg, and Ireland chose not to curb greenhouse gas emissions to pursue economic development, while Latvia engaged to do both. Meanwhile, Australia, Canada, and the United States have adopted a laissez-faire approach, making no effort to rein in greenhouse gas emissions and boost national economic growth. The results of this study will provide the United Nations and international organizations with a policy reference to promote the reduction of global greenhouse gas emissions.

Keywords: greenhouse gas reduction, air pollution, data envelopment analysis, efficiency analysis, GDP

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1. Introduction

Global climate change has become a global challenge with severe environmental, economic, and social impacts. Greenhouse gases are one of the leading causes of climate change, especially the emission of carbon dioxide (CO₂) and other greenhouse gases. The emissions of these gases mainly come from human activities such as energy production and use, industrial activities, transportation, and agriculture. To combat climate change, the international community has adopted various agreements, including the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, to reduce global greenhouse gas emissions and achieve climate targets. However, achieving greenhouse gas reduction targets is about more than just reducing overall emissions. Economic efficiency also needs to be considered. Economic efficiency refers to the maximum effect achieved in achieving a specific goal: the maximum greenhouse gas reduction effect at the least cost.

The aim of studying the efficiency of greenhouse gas

reduction is to find ways to maximize the economic benefits of reducing emissions. This includes assessing the cost-effectiveness of different policies and measures, exploring technological and innovative solutions, and studying factors affecting countries' and regions' efficiency in reducing emissions. By studying the efficiency of greenhouse gas emission reduction, we can better understand the performance of different countries and regions, look for successful cases and best practices, and guide policymakers to develop more effective emission reduction strategies. At the same time, such research can promote technological innovation, sustainable development, and the transition to a low-carbon economy. In the relevant research on greenhouse gas emissions, [1] discussed the carbon footprint of carbon crops and agricultural management. [2] studied the impact of economy and energy on greenhouse gas emissions in China and the United States. [3] examine how climate finance impacts renewable energy. [4] tried to calculate how shared bikes affect greenhouse gas emissions. In the relevant research of data envelopment analysis on greenhouse gas emissions, [5] conducted environmental efficiency assessment of major Asian economies by DEA.

[6] evaluates ecological benefit indicators of EU countries by using a two-stage DEA model. [7] Using DEA to assess energy, environmental, and economic efficiency in the top 20 industrial countries.

The OECD (Organization for Economic Co-operation and Development) is an international organization of 38 countries that aims to promote economic growth, employment, and sustainable development. The OECD brings together governments, policymakers, and citizens to establish evidence-based international standards, from the polluter pays principle to crack down on tax evasion. However, some OECD countries are not active or laissez-faire in reducing greenhouse gas emissions, possibly for several reasons:

Economic benefits first: Some countries may focus more on economic development and benefits while placing a lower priority on the importance of mitigation actions. This may involve support for traditional high-carbon industries or underinvestment in renewable and low-carbon technologies.

Energy dependence: Some countries may rely on high-carbon energy sources, such as fossil fuels, and face the challenge of reducing their dependence on these sources. This may involve problems with energy supply and inadequate investment and technology for the transition.

Political pressure: Political factors may also influence a country's performance in reducing emissions. Some countries may face pressure from specific interest groups, industry interests, or voters, limiting the ability of governments to push through measures to reduce emissions.

Insufficient international commitments: Some countries may need to set clear emission reduction targets or meet committed targets. The lack of specific targets and legal requirements may make these countries less motivated and willing to act on reducing emissions.

Technology and resource constraints: Some countries may face technology and resource constraints that may hinder the adoption and feasibility of emission reduction technologies.

Therefore, it is essential to study OECD member countries that need to be more active in improving the efficiency of greenhouse gas emission reduction. This can help to understand why some countries have made slow or insufficient progress in addressing climate change and reducing greenhouse gas emissions. Such research can provide insight into barriers, challenges, and possible solutions and guide the development of more effective policies and measures.

This study will collect the economic and greenhouse gas emission-related variables of OECD member countries for the efficiency analysis of the two-stage data envelopment analysis method. By understanding the analysis results of the first-stage economic efficiency and the second-stage greenhouse gas emission reduction efficiency of OECD member countries, try to explore the following research questions:

RQ 1: Which OECD members are inactive countries that do not control greenhouse gas emissions but only seek economic development?

RQ 2: Which OECD members are win-win countries that pay equal attention to economic development and control of greenhouse gas emissions?

RQ 3: Which OECD members are laissez-faire countries that do not control greenhouse gas emissions and do not seek economic development?

2. Background and Preliminary

2.1. Greenhouse Gas Emission Reduction and Efficiency Analysis

According to the U.S. Environmental Protection Agency (EPA), gases that trap heat in the atmosphere are called greenhouse gases. It contains carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O) [8]. Carbon dioxide is the most important greenhouse gas and the main culprit of climate change [9]. The increase in greenhouse gas emissions will also lead to the intensification of greenhouse influence. However, the unhindered continuation of global warming will lead to significant climate change, life-threatening and other serious natural and social impacts [10].

There is abundant research on greenhouse gas emission reduction. Early studies mainly investigated and studied greenhouse gas emissions through correlation, quantitative, and other data analyses [11,12]. For the prediction of greenhouse gas emissions, [13] and [14] used Grey Theory and time series (LSTM) to predict carbon emissions. [15] used neural networks (NN) and multiple linear regression (MLP) to predict agricultural carbon. Table 1 shows the related research on global greenhouse gases organized by this research Institute. In the case study, [2] discussed the impact of the economy and greenhouse gas emissions in China and the United States, and the results showed that economic factors had slightly different impacts on China and the United States. China's economic factors increased greenhouse gas emissions, while the United States' greenhouse gas emissions decreased. Renewable energy production has led to sustainable development in the United States and China. [4] studied whether bike-sharing in Shanghai, China, could curb part of greenhouse gas emissions. The research results showed the environmental benefits of bike-sharing and provided a valuable reference for improving urban transportation systems and developing sustainable cities. In the relevant research on greenhouse gases through data envelopment analysis, [7] tried to analyze the environmental efficiency of the top 20 countries with carbon emissions through DEA. They found that Australia, China, Japan, and other countries are the countries with the best energy efficiency and found that the performance of economic efficiency is higher than that of environmental efficiency in most countries. [16] established an undesirable output model through DEA to measure the efficiency of the top 20 economies in Asia, and the result showed that Japan was a model of sustainable development that considered economic development and environmental protection at the same time.

Table 1. Greenhouse gas related research

Field	Topic	Author
Prediction	Forecasting greenhouse gas emissions	[13]
		[14]
	Prediction of CO ₂ emission	[15]
Review	Greenhouse gas emissions from soils	[17]
	The relationship between GHG emissions and agricultural management	[1]
	A review of greenhouse gas emissions trends from 1990 to 2018	[18]
Case Study	Economic and energy impacts on GHG emissions	[2]
	Evaluation of shared bikes to reduce GHG emissions	[4]
	Detection of GHG emission sources	[19]
DEA	Evaluation of environmental efficiency	[7]
		[16]
	Evaluation of Eco-Efficiency	[6]

2.2. Finance and Efficiency in Reducing Greenhouse Gas Emissions

There is a close relationship between greenhouse gas emission reduction efficiency and finance. Greenhouse gas emission reduction efficiency refers to the input or cost per unit of emission reduction required to reduce greenhouse gas emissions. On the other hand, finance involves capital, investment, and financial instruments, which play an essential role in achieving greenhouse gas emission reduction targets and promoting climate change-related projects. The following are several relationships between greenhouse gas emission reduction efficiency and finance:

Investment direction: Finance can affect the efficiency of greenhouse gas emission reduction. For example, investors can choose to invest in projects to develop clean energy, energy efficiency improvements, green transport, and low-carbon technologies, and finance can support the implementation of these projects through the provision of finance. These investments can support renewable energy generation, energy efficiency improvements, and energy conservation projects, thereby reducing greenhouse gas emissions and meeting emission reduction targets.

Financing and policy support: Governments, international financial institutions, and private investors can increase the efficiency of greenhouse gas reduction by investing and financing to support clean energy projects, energy efficiency improvements, and low-carbon technologies. This funding can help projects move forward and scale up to achieve more considerable reductions in greenhouse gas emissions. In order to achieve emission reduction targets, many countries and regions have launched policies and measures, such as carbon markets, carbon trading, and carbon price mechanisms, to promote greenhouse gas emission reduction and climate change-related projects. At the same time, governments and regulators can provide financial support and incentives through policies and regulations to encourage enterprises and projects to reduce emissions and improve their efficiency.

Risk management and insurance: Insurance companies and financial institutions can provide environmental risk assessment and management to ensure that the implementation of emission reduction projects can

cope with possible environmental risks, reduce the risk cost of emission reduction projects, and improve the efficiency of emission reduction. In addition, financial institutions can also provide risk insurance and other financial instruments to ensure that emission reduction projects can cope with possible environmental risks in the implementation process, reduce the risk cost of emission reduction projects, and reduce losses and uncertainties, to increase investors' confidence in emission reduction projects and improve the efficiency of greenhouse gas emission reduction.

Financial innovation and incentives: Financial institutions can promote market development by innovating financial products and services, and governments can encourage enterprises and institutions to invest in low-carbon and environmentally friendly technologies through green finance policies and incentives. For example, the carbon market, carbon trading, and carbon price mechanism can encourage enterprises and institutions to reduce greenhouse gas emissions by allocating and trading carbon allowances, thereby improving emission reduction efficiency.

Return on investment and synergies: Investments in clean energy and environmental technologies will likely yield stable returns over the long term and other synergies such as energy security, environmental protection, and social benefits. This can attract more financial resources to emission reduction projects, thus improving the efficiency of emission reduction.

In general, finance has an important impact on the efficiency of greenhouse gas emission reduction in terms of financial support, policy incentives, risk management, and market development. It can promote the realization of emission reduction targets.

2.3. Data Envelopment Analysis

DEA method is behind linear mathematical programming, which is a decision-making tool used to measure the relative production efficiency between decision units (DMUs), estimate production boundaries, and evaluate the efficiency of DMUs, and can be used to evaluate the efficiency analysis of multiple inputs and outputs in a decision unit.

DEA allows multiple inputs and outputs to be considered simultaneously without making any assumptions about data distribution. DEA models can be subdivided into input-oriented models, which minimize input while at least satisfying a given output level, and output-oriented models, which maximize output without requiring more input values [20]. In each case, efficiency is measured regarding proportional changes in input or output. With the development and maturity of DEA technology, there are many studies on efficiency analysis through DEA in many fields, such as the efficiency measurement of insurance companies [21], traffic data analysis [22], Efficiency analysis of Balanced corporate scorecard [23] and efficiency evaluation of technological innovation [24].

In addition to the efficiency of greenhouse gas emissions, DEA has its shadow in other fields, which can be regarded as one of the most valuable tools for efficiency analysis. Studies on DEA are abundant and

applied in many research fields. This study integrates the studies related to DEA in recent years into Table 2.

Table 2. DEA related research

Field	Topic	Author
GHG Emission	Evaluation of environmental efficiency	[7]
	Evaluation of Eco-Efficiency	[6]
Efficiency analysis for companies	Review of insurance company's efficiency	[21]
	Evaluation of municipal water and wastewater company's efficiency	[23]
	Evaluation of manufacturing company's efficiency	[21]
	Evaluation of fashion company's efficiency	[25]
Transportation	Review of transportation systems efficiency	[22]
	Evaluation of bus line's efficiency	[26]
	Evaluation of port's efficiency	[27]
Strategy	Efficiency Evaluation of green technology innovation	[24]
	Efficiency Evaluation of Public security	[28]

3. Materials and Methods

3.1. Dataset

The data sources for this study are taken from the 2020 OECD (<https://data.oecd.org/>) and The Global Economy (<https://www.theglobaleconomy.com/>) Open Data databases. OECD Repository is an online resource of various economic, social, and environmental indicators, providing many statistical data and policy analysis reports from OECD member countries. The OECD database contains over 80,000 indicators covering various topics, including economics, trade, labor markets, education, environment, energy, health, technology, and social welfare.

The Global Economy (<https://www.theglobaleconomy.com/>) is a website that provides global economic data and national economic indicators. The website compiles economic statistics from countries around the world. It contains over 4,000 economic indicators, including gross domestic product (GDP), employment, inflation, trade, finance, energy, demographic and social indicators.

This study collects variables related to greenhouse gas emissions and the economy through a literature review, determines the input and output variables of the DEA two-stage model, and then analyzes the efficiency of each stage of OECD member countries through the two-stage DEA analysis. Finally, using quartiles, the OECD member countries' comprehensive efficiency grouping to distinguish which countries are inactive in greenhouse gas emission reduction or countries that are laissez-faire.

3.2. Input/Output variable

This study uses literature review research to determine DEA's output and input variables. [7] pointed out that GDP is produced by consuming labor, capital, and energy and will generate carbon dioxide emissions. Therefore, this study adopts a two-stage DEA to analyze the efficiency of OECD member countries, and the first stage

is economic efficiency; according to [7], in the process of measuring national or regional environmental efficiency or energy efficiency, countries use energy consumption and population as inputs to produce desirable and undesirable outputs. Therefore, when conducting environmental and economic efficiency, GDP and trade openness index are taken as ideal outputs, and CO2 emissions are taken as undesirable outputs. [5] rank global cities through economic performance, climate change mitigation, and DEA, using population as the input variable, GDP as the desired output, and greenhouse gas emissions as the undesirable output. [6] explores the relationship between greenhouse gas emission and ecological efficiency for EU member States through DEA, taking labor, energy, and electricity use as inputs, GDP as desired output, and greenhouse gas emission as undesirable output. [29] conducted an eco-efficiency assessment through life cycle assessment and DEA. The input and output variables and original references of the two-stage DEA adopted in this study are shown in Table 3.

Table 3. Input/Output Variables

Variable	Attribute	Source	Reference
Inputs			
x_1 : Population	Numerical	OECD Database	[7] [5]
x_2 : Labor Force	Numerical	OECD Database	[6]
x_3 : Gasoline Consumption	Numerical	TheGlobalEconomy.com	[29]
x_4 : Coal Consumption	Numerical	TheGlobalEconomy.com	[7] [5] [6]
x_5 : Electricity Consumption	Numerical	TheGlobalEconomy.com	[7] [5] [6]
Intermediate			
z_6 : GDP	Numerical	OECD Database	[7] [5] [16] [6]
z_7 : Trade Openness	Numerical	TheGlobalEconomy.com	[7]
Outputs			
y_8 : CO2 Emission	Numerical	OECD Database	[7] [5] [16] [6]
y_9 : GHG Emission	Numerical	OECD Database	[7] [5] [6]

3.3. Efficiency Evaluation of Two-Stage Data Envelopment Analysis

The two-stage DEA proposed by [30] is adopted as the efficiency analysis method in this study. The production process is assumed to consist of two sub-processes, as shown in Figure 1, the whole process uses m inputs and $X_{ik}, i=1, \dots, m$, and produces the output of s and $Y_{rk}, r=1, \dots, s$. Where q is intermediate products and $Z_{pk}, p=1, \dots, q$. The intermediate product Z_{pk} is the output of subprocess 1 and the input of subprocess 2. The equation for evaluating the model efficiency E_k^1 of stage 1 and the model efficiency E_k^2 of Stage 1 is as follows:

$$E_k^1 = \max \sum_{p=1}^q w_p Z_{pk} / \sum_{i=1}^m v_i X_{ik} \quad (1a)$$

$$\text{s.t. } \sum_{p=1}^q w_p Z_{pj} / \sum_{i=1}^m v_i X_{ij} \leq 1, j = 1, \dots, n,$$

$$w_p, v_i \geq \varepsilon, p = 1, \dots, q, \quad i = 1, \dots, m,$$

$$E_k^2 = \max \sum_{r=1}^s u_r Y_{rk} / \sum_{p=1}^q w_p Z_{pk} \quad (2b)$$

$$\text{s.t. } \sum_{r=1}^s u_r Y_{rj} / \sum_{p=1}^q w_p Z_{pj} \leq 1, j = 1, \dots, n,$$

$$u_r, w_p \geq \varepsilon, r = 1, \dots, s, \quad p = 1, \dots, q.$$

The two-phase sub-models are like the original model (1) in that the efficiency is calculated independently. In order to connect the two subprocesses with the whole process, a model must be created to describe the series relationship between the whole process and the two sub-processes. Considering DMU k , the equations representing the symbols u_r^* , v_i^* , and w_p^* as multipliers chosen by DMU k to calculate its overall efficiency E_k and subprocess efficiency E_k^1 and E_k^2 are:

$$E_k = \sum_{r=1}^s u_r^* Y_{rk} / \sum_{i=1}^m v_i^* X_{ik} \leq 1, \quad (2)$$

$$E_k^1 = \sum_{p=1}^q w_p^* Z_{pk} / \sum_{i=1}^m v_i^* X_{ik} \leq 1,$$

$$E_k^2 = \sum_{r=1}^s u_r^* Y_{rk} / \sum_{p=1}^q w_p^* Z_{pk} \leq 1,$$

The overall efficiency is multiplied by the efficiency of the two subprocesses.

$$E_k = E_k^1 * E_k^2 \quad (3)$$

Based on this concept, the calculation method of comprehensive efficiency E_k considers the series relationship of the two subprocesses and incorporates the proportional constraints of the two subprocesses into the model.

$$E_k = \max \sum_{r=1}^s u_r Y_{rk} / \sum_{i=1}^m v_i X_{ik} \quad (4)$$

$$\text{s.t. } \sum_{r=1}^s u_r Y_{rj} / \sum_{i=1}^m v_i X_{ij} \leq 1, \quad j = 1, \dots, n,$$

$$\sum_{p=1}^q w_p Z_{pj} / \sum_{i=1}^m v_i X_{ij} \leq 1, \quad j = 1, \dots, n,$$

$$\sum_{r=1}^s u_r Y_{rj} / \sum_{p=1}^q w_p Z_{pj} \leq 1, \quad j = 1, \dots, n,$$

$$u_r, v_i, w_p \geq \varepsilon, r = 1, \dots, s;$$

$$i = 1, \dots, m; p = 1, \dots, q.$$

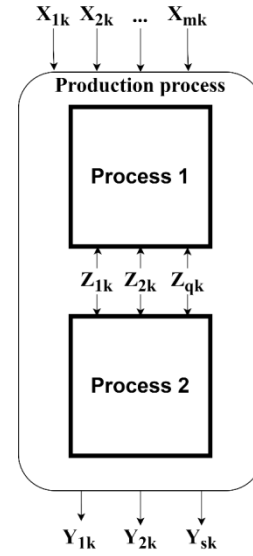


Figure 1. Two-stage DEA model

This study attempts to analyze the efficiency of greenhouse gas emission reduction of OECD member states through the two-stage DEA. The selection of input and input variables in the first and second stages was carried out through a literature review. The two-stage DEA analysis situation is shown in Figure 2. This study integrates the variables collected by OECD and TheGlobalEconomy database into the research data set. In the pre-processing program of the data set, the linear interpolation method of SPSS 25 was used in this study to fill in the missing values, and the numerical value of greenhouse gases with non-ideal output was carried out by a standard method for subsequent efficiency analysis [31].

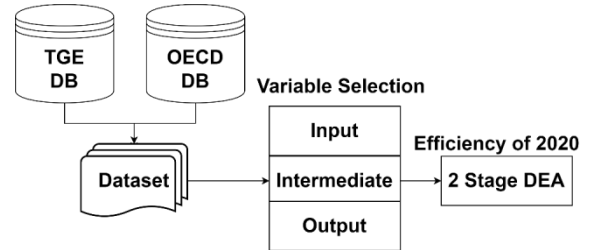


Figure 2. Efficiency Analysis Scenario

3.4. Research Hypothesis and Research Framework

According to the research of [32], the 20th century was an era of unprecedented population growth and global economic scale. [33] also compared the growth rate of GDP with population. It is also found that the population's age distribution has a more significant impact on the GDP growth rate than some economic trends. [34] shows a two-way short-term causality between trade openness, GDP, and population through the Granger causality test. To sum up the above arguments, this study assumes the following relationships:

H1. The input of the population affects the output of economic efficiency

According to the OECD's website (<https://data.oecd.org/emp/labour-force.htm>), the Labor force is defined as the current working population includes

all those who meet the requirements for employment (civilian employment plus armed forces) or unemployment. The index is seasonally adjusted and measured on a human scale. Help the economy by creating jobs in the workforce and generating GDP [7,35]. When the demand for a product or service increases, firms increase production to meet the increased demand, spending more money in the economy, further increasing demand [35]. [36] pointed out that a higher degree of trade openness in developing countries may promote economic growth. [37] studied the influence of trade openness on the labor force participation rate and found that the change in the labor force population accounted for 27% of the change in the unemployment rate after trade liberalization. To sum up the above arguments, this study assumes the following relationships:

H2. The input of the labor force affects the output of economic efficiency

[38] point out that in Latin American countries, the impact of increased energy consumption on GDP is significant. [39] believed that energy consumption and economic development became the focus of policymakers, and their research showed evidence of a one-way causal relationship between energy consumption and GDP. [40] Through long-term cross-country data analysis, energy use and economic growth in developing economies show a synchronous upward trend. [41] found a one-way causal relationship between trade openness and energy consumption. [42] pointed out the long-term two-way relationship between energy consumption and income, trade openness and income, and trade openness and energy consumption, and also believed that energy measures to reduce energy use in the economy will impede economic growth. [43] also show that energy consumption has a strong trade dependence on economic promotion, and the driving effect of foreign trade on economic growth is more significant in countries with a lower level of economic development. To sum up the above arguments, this study assumes the following relationships:

H3. The input of energy use affects the output of economic efficiency

[44] showed a positive correlation between carbon dioxide emissions and GDP. The study of [45] explores the relationship between GDP and per capita emissions of greenhouse gas carbon dioxide to observe the possible impact of economic growth on environmental degradation. Empirical results show that per capita GDP and carbon dioxide emissions correlate positively. This suggests that increased GDP per capita leads to increased carbon dioxide emissions. [46] showed that the economic growth of many countries is closely related to the increase of greenhouse gas (GHG) emissions, and the strong coupling between economic growth and GHG emissions has been the leading cause of human-induced climate change. To sum up the above arguments, this study assumes the following relationships:

H4. The input of GDP will affect the output of greenhouse gas emission reduction efficiency

[47] evaluate the relationship between trade openness and CO₂ and its influencing mechanism of the trilateral FTA countries and finds that trade openness significantly

promotes CO₂ emissions in these countries. Imports will lead to more CO₂ emissions in countries, while exports will restrain domestic CO₂ emissions. [48] pointed out that improving trade openness significantly impacts carbon dioxide emissions. [49] pointed out that producing goods and services generates greenhouse gases (GHG) and air pollution through supply chain activities. Furthermore, it determined that each unit increase in trade openness leads to a 10 to 23 percent increase in emissions in international trade (EET). To sum up the above arguments, this study assumes the following relationships:

H4. The input of GDP will affect the output of greenhouse gas emission reduction efficiency

[47] evaluate the relationship between trade openness and CO₂ and its influencing mechanism of the trilateral FTA countries and finds that trade openness significantly promotes CO₂ emissions in these countries. Imports will lead to more CO₂ emissions in countries, while exports will restrain domestic CO₂ emissions. [48] pointed out that improving trade openness significantly impacts carbon dioxide emissions. [47] pointed out that producing goods and services generates greenhouse gases (GHG) and air pollution through supply chain activities. Furthermore, it determined that each unit increase in trade openness leads to a 10 to 23 percent increase in emissions in international trade (EET). To sum up the above arguments, this study assumes the following relationships:

H5. The input of Trade Openness will affect the output of greenhouse gas emission reduction efficiency

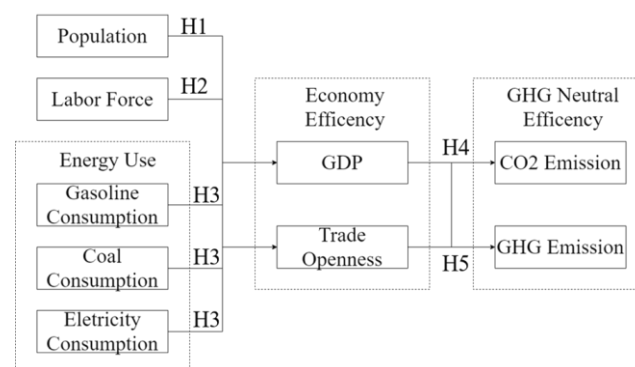


Figure 3. Research framework of two-stage DEA

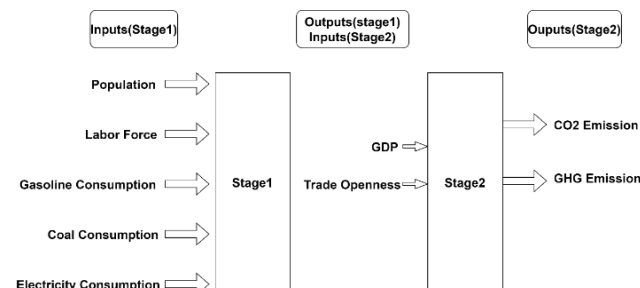


Figure 4. Research framework of two-stage DEA

Based on the above hypothesis, this study proposes a two-stage model connecting economy and greenhouse gas emission reduction, which combines population, labor force, and energy consumption with GDP and Trade Openness as the economic efficiency in the first stage. At the same time, the output of the first stage is also the input of the second stage, so the input of GDP and trade

openness, output carbon emission, and greenhouse gas emission are the second stage's greenhouse gas emission reduction efficiency. Figure 3 shows the two-stage DEA research dimension proposed in this study, and Figure 4 shows the analysis framework of the two-stage DEA efficiency.

Table 4. Descriptive statistical of input/output variables

	Min	Max	Mean	SD	Var
x_1	0.366	331.50	36.1	59.73	3567.41
x_2	205.8	160742.3	17284.07	28835.1	831462857
x_3	2.37	8049.22	341.97	1298.85	1687
x_4	3.82	477395	40465.11	88906.5	7904365979
x_5	6.21	3897.89	271.50	635.13	403388.54
z_6	15650	119871	46951	19687	387603847
z_7	23.26	373	98.38	64.95	4218.45
y_8	1.29	14.57	6.02	3.11	9.68
y_9	4.47	20.54	9.23	3.71	13.75

Table 5. Results of two-stage DEA efficiency analysis

OECD Country	Overall Efficiency	Stage1 Efficiency	Stage2 Efficiency
EST	0.711	1.000	0.421
ISL	0.619	1.000	0.238
LVA	0.547	0.437	0.796
LUX	0.542	1.000	0.084
LTU	0.389	0.375	0.427
SVN	0.330	0.307	0.405
IRL	0.301	0.363	0.133
SVK	0.243	0.233	0.284
CHE	0.204	0.170	0.407
NOR	0.181	0.170	0.246
PRT	0.136	0.085	0.741
DNK	0.133	0.112	0.318
AUT	0.111	0.093	0.306
FIN	0.104	0.086	0.320
HUN	0.102	0.084	0.321
BEL	0.089	0.074	0.286
SWE	0.087	0.058	0.576
CZE	0.081	0.067	0.289
NZL	0.066	0.058	0.206
GRC	0.057	0.034	0.728
CRI	0.046	0.034	0.395
NLD	0.045	0.037	0.257
TUR	0.044	0.025	0.820
ISR	0.042	0.031	0.389
ESP	0.032	0.020	0.655
CHL	0.030	0.019	0.636
POL	0.025	0.018	0.422
ITA	0.024	0.016	0.522
COL	0.023	0.011	1.000
FRA	0.021	0.014	0.509
GBR	0.016	0.011	0.521
KOR	0.014	0.010	0.350
AUS	0.013	0.012	0.126
DEU	0.008	0.007	0.292
CAN	0.008	0.007	0.173
MEX	0.006	0.004	0.451
JPN	0.004	0.003	0.379
USA	0.001	0.001	0.125
Mean	0.143	0.16	0.41

4. Results and Discussion

4.1. Results of two-stage DEA efficiency analysis

Lingo 20 is used as A software development tool in this study. Input variables are shown in Table 3. The data source is 2020. The descriptive statistics of input variables are shown in Table 4.

In this study, Lingo 20 software was used to write a two-stage DEA efficiency analysis program. The results of the two-stage DEA efficiency analysis for OECD member States are shown in Table 5. The results showed that only four countries had a total efficiency score of more than 0.5. They are Estonia (EST), Iceland (ISL), Latvia (LVA), and Luxembourg (LUX).

4.2. Discussion

This study will explore the research question we raised. Among OECD member countries, which are inactive countries that seek economic development but do not control greenhouse gas emissions? Which Win-Win countries combine economic development with control of greenhouse gas emissions? Are those Laissez-faire countries that have neither increased economic growth nor controlled greenhouse gas emissions?

Algorithm 1. 2-Stage Efficiency Differential Grouping Algorithm

Algorithm1: Group discrimination of OECD countries

Input: Stage1 Efficiency, Stage2 Efficiency

If Stage1 Efficiency > third quartile(Q3) and Stage2 Efficiency < first quartile(Q1) **then**
Output Inactive members

Else if Stage1 Efficiency > third quartile(Q3) and Stage2 Efficiency > third quartile(Q3) **then**
Output Win-Win members

Else if Stage1 Efficiency < first quartile(Q1) and Stage2 Efficiency < first quartile(Q1) **then**
Output Laissez-faire members

Table 6. Discrimination results of OECD member

Inactive members			
OECD	Overall Eff	Stage1 Eff	Stage2 Eff
ISL	0.619	1.000	0.238
LUX	0.542	1.000	0.084
IRL	0.301	0.363	0.133
Win-Win members			
OECD	Overall Eff	Stage1 Eff	Stage2 Eff
LVA	0.547	0.437	0.796
Laissez-faire members			
OECD	Overall Eff	Stage1 Eff	Stage2 Eff
AUS	0.013	0.012	0.126
CAN	0.008	0.007	0.173
USA	0.001	0.001	0.125

In statistics, quartiles are often used as research groups. For example, [50] analyzed the relationship between blood glucose concentration and hospitalization and categorized the groups by quartile. [51] grouped the reading efficiency and eye movement measurements of American primary,

middle, and high school students through the quartile. [52] studied the car use behavior of Spanish households and divided household income into groups by quartile to explore the impact of differences between groups and traffic policies. Based on these quartile grouping studies, this study seeks to determine how OECD member states weigh economic development and greenhouse gas emissions and uses algorithm 1 to conduct grouping discrimination of research questions. The discrimination results are shown in Table 6.

4.2.1. RQ1: Which OECD Members are Inactive Countries that do not Control Greenhouse Gas Emissions but Only Seek Economic Development?

According to the discrimination results in Table 6, the economic efficiency (Stage 1) of Iceland (ISL), Luxembourg (LUX), and Ireland (IRL) is greater than the third quartile (Q3). The greenhouse gas emission reduction efficiency (Stage 2) is smaller than the first quartile (Q1); we classify them as inactive countries. The performance of Luxembourg is the most extreme (1, 0.084). [53] pointed out that Luxembourg has one of the highest per capita GDP in the world. However, it still relies on imported fuel and electricity, while the high-tech and service industry now contributes significantly to economic output—especially banking and other financial exports. As a result, Luxembourg is one of Europe's most prominent investment fund centers [54]. However, a high standard of living and welfare also requires relatively large resource access and environmental assets, mainly due to the lack of energy resources in its small territory, where large amounts of imported non-renewable fuels and electricity supply around 95% of the country's total primary energy supply [54].

Iceland (ISL) is at the other end of the spectrum (1, 0.238). However, it has the group's highest greenhouse gas reduction efficiency, mainly due to Iceland's excellent geography, with almost all its electricity consumption coming from renewable sources (geothermal and hydropower). However, according to [55], Iceland is considered the future case of high consumption and green area globally. However, its carbon footprint covers the world through the supply chain of imported products (about 71% of household emissions are attributed to imported goods). As a result, even with the decarbonization of Iceland's fixed energy sources, the overall carbon footprint remains high. However, Iceland is an example of a few countries that have completed energy transformation, and its greenhouse gas emission reduction efficiency may be further improved in the future. According to the data from the European Union, Iceland is also one of the first countries to ratify the Paris Agreement [56].

Ireland (IRL) is another country that focuses on economic development and neglects control of greenhouse gas emissions. [57] points out that Ireland has obstacles in reducing greenhouse gas emissions, mainly due to the heavy dependence of many industries on fossil fuels. [58] point out that Ireland has many Biomass energy sources, a relatively cheap and abundant resource that, when properly processed, can significantly increase the global production of renewable energy sources and help reduce carbon emissions.

4.2.2. RQ2: Which OECD Members are Win-Win Countries that Pay Equal Attention to Economic Development and Control of Greenhouse Gas Emissions?

According to the discrimination results in Table 6, Latvia (LVA) is the only member of the OECD whose economic efficiency and greenhouse gas emission reduction efficiency both exceed the third quartile (Q3) (0.437, 0.796). We classify it as a win-win country. [59] pointed out that Latvia's economy is transforming into a sustainable development model, in which one of the driving forces of the country's economic development is the export of manufactured goods and services. Latvia achieved a 41% share of renewable energy in 2019 and plans to reach 50% by 2030, an ambition deemed adequate by The European Commission. [60] argue that fuel consumption has the most significant impact on transport emissions. In order to achieve the goal of decarbonization, fossil fuel consumption needs to be significantly reduced, which can be improved by increasing fuel taxes, supporting environmental infrastructure, increasing the use of electric vehicles, and social innovation. Latvia's adoption of an environmental tax has reduced transport emissions and had a significant fiscal impact.

4.2.3. RQ3: Which OECD Members are Laissez-Faire Countries that do not Control Greenhouse Gas Emissions and do not Seek Economic Development?

According to the discrimination results in Table 6, Australia (AUS), Canada (CAN), and the United States (USA) are OECD member states whose economic efficiency and greenhouse gas emission reduction efficiency are both lower than the first quartile (Q1), and these three countries show two stages of low efficiency. We classify them as laissez-faire countries. Regarding economic efficiency, it is not necessarily that the country is not actively in economic development. However, the economy is facing relatively slow development or stagnation. [61] pointed out that since the beginning of 2020, the outbreak of COVID-19 has weakened Australia's economy and capital market, and many industrial sectors have become more vulnerable, especially the poor performance of the transport industry. [13] mentioned that Canada's economic growth has slowed recently. After hitting its lowest point in 2016, Canada's economy began to recover gradually, with a relatively slow growth rate and economic fatigue. [62] also focus on the impact of the population structure on the economy, labor force, and productivity of American states and find that the aging of the American population reduces the per capita GDP growth rate by 0.3 percentage points every year.

As [63] pointed out in his study, the population of developed countries is usually smaller than that of developing countries. However, a better quality of life leads to higher cumulative greenhouse gas emissions per capita in developed countries. [64] showed that Canada emitted 1.63% of the global greenhouse gas emissions in 2013, making it the 36th largest emitter. However, regarding per capita emission intensity, Canada ranked first among the countries with the highest emissions [65]. The United States is a well-known carbon polluter. [64]

pointed out that China, the United States (USA), and the European Union produced 49.1% of global greenhouse gas emissions in 2013. [66] pointed out that in 2018, China, the United States, India, 28 EU countries, Russia, and Japan were the world's largest carbon dioxide emitters, accounting for 80% of the total population of global fossil fuel consumption. Compared with the increase in emissions in 2017, The US still saw a 2.9% increase, compared with 1.9% in the 28-nation European Union and 1.7% in Japan, so US policies and measures to reduce greenhouse gas emissions still need to work harder.

5. Conclusion

Air pollution and climate change caused by greenhouse gas emissions have become increasingly severe, an essential issue of environmental protection. The greenhouse gases caused by global emissions constantly aggravate the earth's greenhouse effect and lead to extreme climate. However, many countries are bound to produce many greenhouse gas emissions to pursue economic development. Therefore, this study tries to use the two-stage DEA efficiency analysis method to analyze the economic efficiency of the first and second stages of greenhouse gas emission reduction efficiency, and conducts a comprehensive efficiency analysis on OECD member countries. Finally, using quartiles, the OECD member countries' comprehensive efficiency grouping to distinguish which countries are inactive in greenhouse gas emission reduction or countries that are laissez-faire. The study found that Iceland, Luxembourg, and Ireland chose not to control greenhouse gas emissions to pursue economic development, while Latvia engaged to do both. At the same time, Australia, Canada, and the United States took a laissez-faire approach, not controlling greenhouse gas emissions and not trying to promote national economic growth. The results of this study will provide the United Nations and international organizations with a policy reference to promote the reduction of global greenhouse gas emissions.

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