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A Study on Sustainable Development Efficiency of Foreign Trade in Western China Based on DEA Model

[1]Yan Xu, [2]Jae-yeon Sim

[1]Professor, Business School, Huaihua University, China
363879538@qq.com
[2]Professor, Dept. of Management, Sehan University, Korea
simjy@sehan.ac.kr

Abstract

The purpose of this paper is output oriented, in order to maximize the output level of sustainable development efficiency of foreign trade in western China with limited input. This paper adopts the relevant input-output indicators of sustainable foreign trade development of 11 provinces and cities in western China from 2016 to 2020, and uses DEA model to measure their technical efficiency, pure technical efficiency and scale efficiency. Malmquist index was used to calculate the total factor productivity change index of each province in western China from 2016 to 2020. We found that, on the whole, the average values of technical efficiency, pure technical efficiency and scale efficiency of provinces and cities in western China from 2016 to 2020 are greater than 0.8, indicating that the western region has high technical efficiency, relatively high management and institutional level and high existing scale level. Scale efficiency is lower than pure technical efficiency on the whole, indicating that the current sustainable development efficiency of foreign trade in western China is mainly limited by its scale level. The technological progress index is higher than the technological efficiency change index, indicating that the total factor productivity of the sustainable development of foreign trade in western China is mainly driven by technological progress and more influenced by external factors. We think the conclusion of this study can provide important reference information for the sustainable development of foreign trade of provinces and cities in western China.

Keywords: *Western Region, Sustainable Development of Foreign Trade, Efficiency, DEA Model, Malmquist Index*

1. Introduction

1.1 Research Background

In our Common Future, the World Commission on Environment and Development states that "sustainable development" refers to development that meets the needs of the present without compromising the ability of future generations to meet their own needs [1]. It is a complex system engineering, which includes three parts: economic sustainable development, social sustainable development and ecological environment sustainable development. It not only requires the contemporary people to leave precious natural resources

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Corresponding Author: simjy@sehan.ac.kr
Tel:*** - **** - **** Fax: +82-41-359-6104
Professor, Dept. of Management, Sehan Univ., Korea

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and ecological environment for the future generations in the economic development, but also requires the adjustment of the current development theory and economic policy from the aspects of economic structure, population, employment, income distribution and so on, so as to ensure the healthy development of contemporary economy and society. Sustainable trade development is an integral part of sustainable economic development. In its narrow sense, it is reflected in how to reduce resource consumption and damage to the environment and gain increasing trade benefits in the process of participating in international division of labor and trade. The welfare pursued by foreign trade not only includes the consumption of goods and services, but also includes the improvement or avoidance of environmental deterioration, which is the unity of "sustainable" and "development".

Western China covers eleven provinces and cities: Neimenggu, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang. The main contents of China's regional economic and social development are: western development, northeast rejuvenation, central rise, and eastern development. "Western Development" is a policy of the central government of the People's Republic of China, which aims to use the surplus economic development capacity of the eastern coastal areas to improve the economic and social development level of the western regions.

According to the statistics of China Customs, in 2020, the total value of import and export in Western China reached 427 million YUAN, up 9.17 percent year on year. Among them, the export reached 257 million yuan, up 10.48%; Import 181 million yuan, up 7.42%; The trade surplus was 76 million yuan, up 38.18%. Figure 1 shows that during the five-year period from 2016 to 2020, the total import and export volume in western China showed an overall upward trend. In 2020, the total volume of imports and exports in western China also increased due to the COVID-19 pandemic. Sichuan, Chongqing, Gansu, Shaanxi and Yunnan ranked the top four in terms of total import and export volume. The next three are Ningxia, Qinghai and Tibet, and the total import and export volume of these three provinces is so small that it can hardly be shown in the figure. Neimemggu and Ningxia are neck and neck. So are Shaanxi and Gansu. Ningxia, Qinghai and Xizang, which rank the bottom three in terms of total imports and exports, differ greatly from other provinces and cities in the western region. It shows that the total amount of foreign trade imports and exports of provinces and cities in western China is unbalanced.

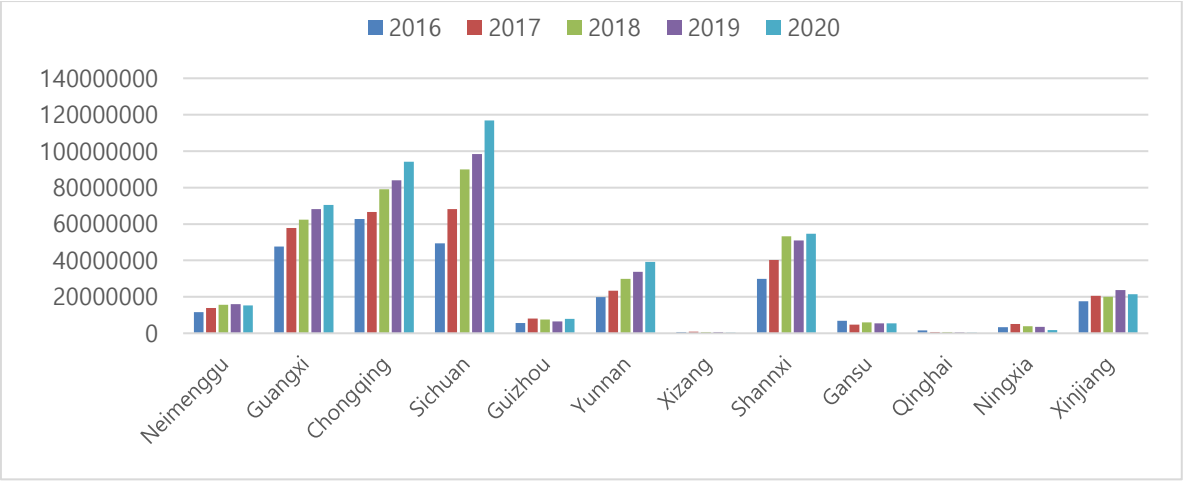

Figure 1. Total import and export volume of western China from 2016 to 2020

The rapid development of foreign trade has not only achieved rapid economic growth, but also caused great harm to the environment. For a long time, China's foreign trade development model is basically an extensive trade mode of "high investment, high consumption, high pollution and low income", and the western region is no exception. Therefore, to a certain extent, China's western trade development is at the cost of environmental pollution and resource consumption. Environmental and resource problems not only affect the development speed and efficiency of foreign trade itself, but also restrict the development speed and efficiency of the whole national economy to a great extent, making foreign trade in western China face more and more severe challenges.

With the rapid economic growth and the expansion of foreign trade, the environment has deteriorated sharply, and the discharge and production of "three wastes" (waste gas, waste water and solid waste) of industry has continued to increase. From the perspective of ecological sustainable development, taking the net discharge of three wastes in foreign trade as an example, the author consulted the Statistical Yearbook of China in recent five years. Figure 2 shows the discharge of three wastes in each province in western China from 2016 to 2020. From 2016 to 2020, the discharge of three wastes in western China showed an increasing trend, and the pollutant discharge and import and export data showed an obvious trend consistency. From 2016 to 2020, Sichuan province ranked first in the discharge of three wastes, while the total import and export volume of Sichuan province ranked first in the western region. It can be seen that the development of Sichuan's foreign trade is at the cost of environmental pollution and resource consumption. In western China, the growth rate of waste discharge is directly proportional to that of total import and export volume. Ningxia, Gansu and Qinghai are small foreign trade provinces, but their discharge of three wastes is very large, which has a negative impact on the ecological environment.

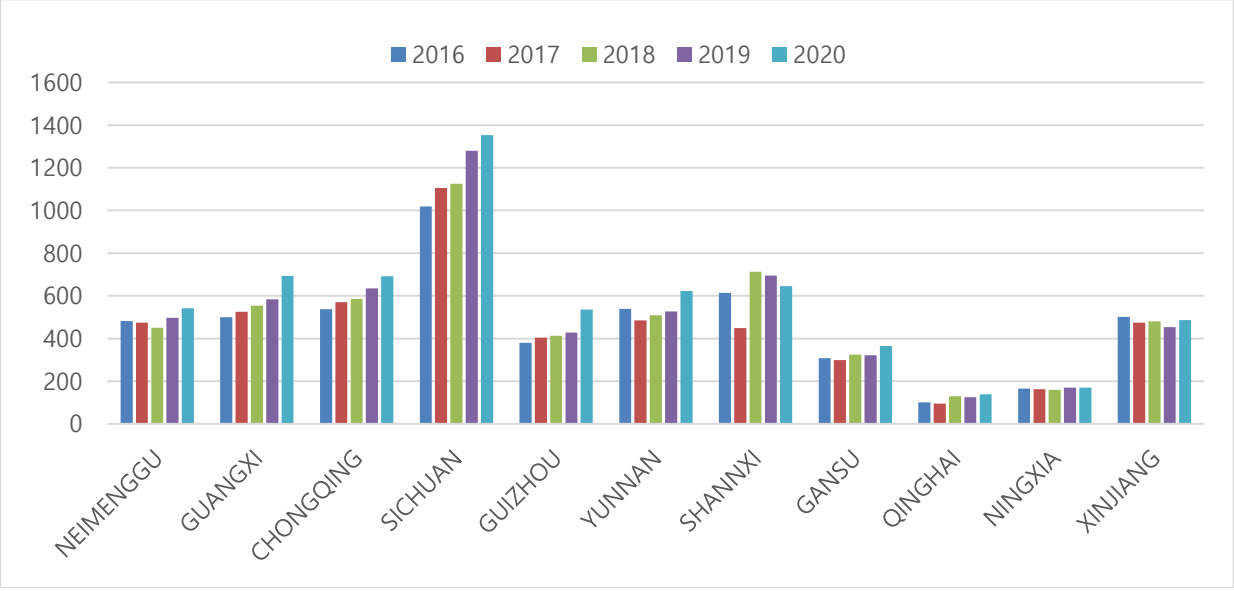

Figure 2. Emissions of three wastes volume in western China from 2016 to 2020

Since the reform and opening up, the development of foreign trade in western China has made great achievements, but there are still big problems in the structure of foreign trade, which also cause a variety of problems such as the disharmony between foreign trade and environmental protection. At the same time, people began to think about whether this foreign trade mode driving economic growth is sustainable, whether it is conducive to effectively improving the efficiency of resource allocation, and whether it is conducive to the

long-term healthy economic development of western China [2].How to realize the quantitative growth of foreign trade in western China while ensuring the improvement and improvement of foreign trade economic quality? How to realize the coordinated development of population, resources, environment and trade? How to measure the effectiveness of such coordinated development has become the focus of many scholars. That is, the sustainable development efficiency of foreign trade in western China urgently needs to be solved.

1.2 Research Objectives and Significance

This paper intends to use Data Envelopment Analysis (DEA) method to analyze the sustainable development efficiency of foreign trade from 2016 to 2020 from the perspective of output, based on the foreign trade statistics of 11 provinces and cities in western China from 2016 to 2020. DEA and Malmquist index methods were used to measure and compare the sustainable development efficiency of foreign trade in 11 provinces and cities in western China, and the influence of technological efficiency changes and technological progress on total factor productivity was studied. The economic development of the western region is relatively backward, and the input resources in foreign trade activities are limited, so it needs to focus on improving its output level. Therefore, this paper chooses output orientation in order to maximize the output level in western China with limited input. In short, the purpose of this study is to maximize the output level of sustainable development efficiency of foreign trade in western China with limited input by selecting appropriate input-output indicators and taking output orientation.

By measuring the sustainable development efficiency of foreign trade in 11 provinces and cities in western China, this paper can analyze the geographical difference of sustainable development efficiency of foreign trade in western China, and put forward different policy suggestions for different provinces and cities in western China, so as to improve the sustainable development efficiency of each province according to local conditions. This is of great significance to China's technological progress, environmental protection, economic development and the promotion of global competitiveness.

2. Literature Review

2.1 Theory of Input-output Efficiency

With the continuous development of western economic theory, western economics plays a particularly important role in academic research. Its various theories and hypotheses have laid a solid theoretical foundation for many researches, and efficiency theory is no exception. Resource allocation is one of the main research contents of Western economics, while efficiency theory studies optimal resource allocation, that is, how to allocate limited resources to maximize benefits [3]. Someone empirically measured efficiency, who decomposed total efficiency into allocator efficiency and technical efficiency [4]. Total technical efficiency can be divided into pure technical efficiency and scale efficiency based on the assumption that return to scale remains unchanged [5]. Pure technical efficiency is the distance between the current production point and the production frontier when returns to scale are variable. Scale efficiency is the distance between the production frontier with constant scale return and the production frontier with variable scale return. Total technical efficiency is the product of pure technical efficiency and scale efficiency.

2.2 Research on Evaluation of Sustainable Development Efficiency of Foreign Trade by DEA Method

Each Decision Making Units (DMU) in the same evaluation group has the same kind of resource consumption, that is, each DMU has the same input index and the same output index [6]. Judging whether the DEA is valid according to the data observed on each DMU is essentially judging whether it is located on the

"production frontier" of the production possible set [7]. Nine cities were taken in the Guangdong-Hong Kong-Macao Greater Bay Area as DMU and applied the BCC model in data Envelopment Analysis (DEA) to evaluate and analyze the overall situation of the sustainable development efficiency of foreign trade in the Greater Bay Area from 2010 to 2016 [8]. A scholar established a data envelopment analysis model, quantitatively discussed the main factors affecting the sustainable development efficiency of Jilin Province's foreign trade, and objectively evaluated its sustainable development efficiency [9]. The three-stage DEA model was used to conduct research from the perspective of input-output [10]. The export efficiency and its influencing factors of 16 prefecture-level cities in Anhui Province based on DEA model and panel regression model were analyzed and evaluated [11]. A comparative analysis of the sustainable development ability of foreign trade of 29 Provinces in China through DEA model was made, obtaining the ranking of the sustainable development ability of foreign trade of all provinces [12]. The sustainable development efficiency of Zhejiang's foreign trade by using DEA model based on the foreign trade-related statistical data of Zhejiang province from 2000 to 2008 was studied [13]. DEA method was used to study and analyze the sustainable development efficiency of foreign trade in Jiangsu Province [14].

2.3 Innovations of the Paper

At present, no scholars have used DEA model to analyze the efficiency of sustainable development of foreign trade in western China. Therefore, the study in this paper will be a strong supplement to this field. The innovation of this paper still lies in the empirical object. A large number of literature have discussed the definition of sustainable development capacity of foreign trade and the construction of sustainable development capacity evaluation indicators. A few literature have carried out empirical research on the sustainable development capacity of trade of a single province, but there are few comparative studies involving various provinces. This paper analyzes the comparative situation of the trade sustainable development capacity of 11 provinces in western China, which is an innovation in the empirical object.

3. Research Design

3.1 DEA Model

In this paper, Data Envelopment Analysis, referred to as DEA, is a systematic Analysis method developed on the basis of "relative efficiency evaluation" by American operational [15]. It is used to study the relative effectiveness of decision making units with multiple inputs and outputs. The advantages of this method are that there is no need to set the function form in advance, which avoids the dependence of parameters on the specific form of the model in application, and the number of samples required is also less. DEA method takes the weight coefficients of input and output indexes of decision making units as optimization variables, and projects decision making units on to DEA front surfaces by means of mathematical programming. It makes a comprehensive evaluation on the relative effectiveness of decision making units by comparing the deviation degree of decision making units from DEA frontier, and obtains a lot of management information reflecting decision making units.

The basic idea of sustainable development of foreign trade is to obtain the maximum economic, ecological and social benefits with the minimum investment and the minimum environmental cost. This is consistent with the requirement of DEA for input-output index. Therefore, using data envelopment analysis method to study the sustainable development of foreign trade is a feasible choice. In this paper, CCR model (used to measure comprehensive efficiency) and BCC model (used to measure pure technology and scale efficiency) of DEA model are used to study the sustainable development efficiency of foreign trade of 11 provinces and cities in western China.

3.2 Malmquist Index Method

In 1982, Caves derived the productivity index, namely Malmquist Productivity Index (MPI), by means of the ratio of production distance function. MPI has also been rapidly paid attention to by the academic community and has been widely used in various fields. MPI is used to measure and obtain information to find out the contribution of changes in pure technical efficiency and scale efficiency to changes in technical efficiency. In the empirical analysis part of this study, Malmquist index method is used to measure and analyze the changes of total factor productivity in 11 provinces and cities in western China.

3.3 Selection of Input-output Indicators

The selection of input-output indicators directly affects the analysis results of logistics efficiency [16]. This paper adopts DEA model and MPI to study the sustainable development efficiency of foreign trade in Western China from 2016 to 2020. The index system of foreign trade sustainable development capability should be scientific, systematic, operable, guiding, dynamic and stable.

This paper considers the sustainable development of foreign trade economy, society and ecology, and selects the following evaluation indicators, as shown in Table 1.

Table 1. Input-output indicators

One class index	Two class index	three class index	indicator type
Evaluation of sustainable development efficiency of foreign trade	Economic sustainability	Import and Export Volume	Output
		Provincial GDP	Output
		FDI	Input
	Social sustainability	Employment in Foreign Trade	Input
		Per Capita Income of Foreign Trade Industry	Output
	Ecological sustainability	Net Emissions of Three Wastes in Foreign Trade	Input

As shown in Table 1, there are 3 input indexes and 3 output indexes in this paper. The input index includes the number of employment in foreign trade, FDI and Net Emissions of Three Wastes in Foreign Trade. Output indicators include Import and Export Volume provincial GDP and per capita income in foreign trade industries.

The number of employed persons in the foreign trade industry selects the number of employed persons in urban units, because the statistical department does not have the employment statistics for employees in the foreign trade industry. The annual foreign direct investment (FDI) of 11 provinces and cities in western China was selected to represent the corresponding capital input. The environmental cost is the net discharge of three wastes from foreign trade, which is calculated by the net discharge of industrial waste water, waste gas and waste residue. The lower the net emissions of "three wastes" in foreign trade, the higher the production technology level of export products. It also shows that the higher the comprehensive utilization of resources, the less pollution to the environment, the less damage caused by foreign trade production to the natural environment of a country or region, and the stronger the sustainable development capacity of foreign trade. In the corresponding output of the system, the GDP of each province is selected as the economic output index of

the system to reflect the development level of the macro economy. The total amount of import and export is selected as the development index of foreign trade to reflect the level of foreign trade development of provinces and cities. The per capita income of foreign trade industry is expressed by the average income of employees in cities and towns of each province. The larger its value is, the more income foreign trade brings to citizens.

3.4 Data Sources and Research Objects

According to the statistical yearbook of 11 provinces and cities in western China from 2016 to 2020 and the statistical bulletin of national economic and social development from 2016 to 2020, this paper sorted out and plotted the relevant data of input and output indicators of 11 provinces and cities in western China. The research subjects (DMU) were 11 provinces and cities in western China, including Neimenggu, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shannxi, Gansu, Qinghai, Ningxia and Xinjiang. The data of Tibet Ethnic Autonomous Region was seriously missing, so it was not included in the research scope of DMU.

4. Empirical Analysis

This paper selects panel data of 11 provinces and cities in western China from 2016 to 2020 to analyze the efficiency of the sustainable development of foreign trade in western China by using the output-oriented DEA model, in order to maximize the output level of western China with limited input. Therefore, both DEA analysis and Malmquist analysis only analyze BCC-O and CCR-O models. Combined with the relevant data of input-output indicators in Table 1, DEAP 2.1 software was used to calculate the relevant data, and finally the sustainable development efficiency of foreign trade of 11 provinces and cities in western China was obtained.

4.1 Analysis of DEA Static Results

4.1.1 Technical Efficiency Analysis

This paper firstly uses DEA-CCR model with constant return to scale to calculate the technical efficiency of sustainable foreign trade development in western China, and then uses the DEA-BCC model with variable return to scale to decompose the technical efficiency into pure technical efficiency of sustainable foreign trade development and scale efficiency of sustainable foreign trade development. Firstly, technical efficiency TE is measured by using CCR model, and its technical efficiency value is given in Table 2.

Table 2. Result of DEA model about CCR from 2016-2020

DMU	2016	2017	2018	2019	2020	AVG.
GANSU	0.944	1.000	1.000	1.000	1.000	0.989
GUANGXI	1.000	1.000	1.000	1.000	1.000	1.000
GUIZHOU	0.984	0.965	1.000	0.924	0.989	0.972
NEIMENGGU	1.000	1.000	1.000	0.979	0.947	0.985
NINGXIA	1.000	1.000	1.000	1.000	1.000	1.000
QINGHAI	1.000	1.000	1.000	1.000	1.000	1.000
SHANNXI	0.926	1.000	0.888	0.882	1.000	0.939
SICHUAN	0.970	0.971	1.000	0.931	0.923	0.959
XINJIANG	0.790	1.000	0.953	0.821	1.000	0.913
YUNNAN	0.981	1.000	1.000	1.000	1.000	0.996
CHONGQING	1.000	1.000	1.000	1.000	1.000	1.000
AVG.	0.963	0.994	0.986	0.958	0.987	0.978

As shown in Table 2, technical efficiency reflects the overall situation of resource allocation in foreign trade activities. On the whole, the average technical efficiency of provinces and cities in the western region from 2016 to 2020 is 0.978, close to 1, indicating that the technical efficiency of the sustainable development of foreign trade in the western region is good. In terms of different years, the average technical efficiency from 2016 to 2020 rose from 0.963 in 2016 to 0.987 in 2020. The number of effective provinces and cities was 5 in 2016 and 7 in 2020, indicating that the average technical efficiency showed an overall upward trend. From the perspective of different provinces, the average technical efficiency of Guangxi, Ningxia, Qinghai and Chongqing is 1, realizing DEA effectiveness, accounting for 36.36% of the sample provinces and cities, reaching the frontier of technical efficiency, and the resource allocation structure in foreign trade activities is relatively reasonable. The average technical efficiency of Gansu, Guizhou, Neimenggu, Shannxi, Sichuan, Xinjiang and Yunnan is less than 1, which is still far from the frontier. Therefore, the input and output structure of foreign trade activities in Gansu, Guizhou, Neimenggu, Shannxi, Sichuan, Xinjiang and Yunnan needs to be further optimized.

4.1.2 Pure Technical Efficiency Analysis

Table 3 shows the pure technical efficiency (PTE) of 11 provinces and cities in western China from 2016 to 2020.

Table 3. Result of DEA model about BCC from 2015 to 2020

DMU	2016	2017	2018	2019	2020	AVG.
GANSU	1.000	1.000	1.000	1.000	1.000	1.000
GUANGXI	1.000	1.000	1.000	1.000	1.000	1.000
GUIZHOU	1.000	1.000	1.000	0.949	0.990	0.988
NEIMENGGU	1.000	1.000	1.000	0.981	0.950	0.986
NINGXIA	1.000	1.000	1.000	1.000	1.000	1.000
QINGHAI	1.000	1.000	1.000	1.000	1.000	1.000
SHANNXI	0.934	1.000	0.901	0.925	1.000	0.952
SICHUAN	1.000	1.000	1.000	1.000	1.000	1.000
XINJIANG	1.000	1.000	1.000	0.934	1.000	0.987
YUNNAN	1.000	1.000	1.000	1.000	1.000	1.000
CHONGQING	1.000	1.000	1.000	1.000	1.000	1.000
AVG.	0.994	1.000	0.991	0.981	0.995	0.992

Pure technical efficiency reflects the management and system level in foreign trade activities. On the whole, the average pure technical efficiency of all provinces and cities in the western region from 2016 to 2020 is 0.992, close to 1, indicating that the management and system of sustainable development of foreign trade in the western region is good. From the perspective of different years, the overall trend of pure technical efficiency increased first and then decreased. The mean value of pure technical efficiency increased from 0.994 in 2016 to 1 in 2017 and decreased to 0.995 in 2020. The number of effective provinces fell from 10 to 9, and the number of effective provinces fell from 90.9 percent to 81.8 percent. From the perspective of different provinces and cities, the mean of pure technical efficiency of Gansu, Guangxi, Ningxia, Qinghai, Sichuan, Yunnan and Chongqing is 1, accounting for 63.63% of the sample provinces, which has a high level of management and system. The mean value of pure technical efficiency in Guizhou, Neimenggu, Shannxi and Xinjiang is less than 1. However, the pure technical efficiency values of these four provinces are all greater than 0.8, which is in an efficient state. The pure technical efficiency value of BCC model from 2016 to 2020 is

higher than that of CCR model.

4.1.3 Scale Efficiency Analysis

Scale efficiency reflects the gap between the existing scale of foreign trade and the optimal scale. The results of SE calculation are shown in Table 4. On the whole, the average scale efficiency of western China from 2016 to 2020 is 0.985, indicating that the current scale level of sustainable development of foreign trade in western and central China is relatively high. From 2016 to 2020, the scale efficiency of sustainable foreign trade development in Guangxi, Ningxia, Qinghai and Chongqing is effective, accounting for 36.36% of the sample provinces and cities. The average scale efficiency of the other 7 provinces and cities during 2016-2020 is higher than 0.8, but less than effective state 1.Neimenggu and Sichuan as a whole showed a trend of declining fluctuation, indicating that the scale level has been regressive and the input-output structure is unreasonable, which requires further optimization of their management and institutional level.

By comparing pure technical efficiency and scale efficiency, it can be found that scale efficiency is lower than pure technical efficiency, indicating that the current sustainable development efficiency of foreign trade in western China is mainly limited by its scale level. It is necessary to focus on optimizing the scale and promoting the optimization of input and output structure while paying attention to its management and technical level.

Table 4. Result of DEA model about SE from 2016 to 2020

DMU	2016	2017	2018	2019	2020	Mean
GANSU	0.944	1.000	1.000	1.000	1.000	0.989
GUANGXI	1.000	1.000	1.000	1.000	1.000	1.000
GUIZHOU	0.984	0.965	1.000	0.974	0.999	0.984
NEIMENGGU	1.000	1.000	1.000	0.998	0.997	0.999
NINGXIA	1.000	1.000	1.000	1.000	1.000	1.000
QINGHAI	1.000	1.000	1.000	1.000	1.000	1.000
SHANNXI	0.991	1.000	0.986	0.954	1.000	0.986
SICHUAN	0.970	0.971	1.000	0.931	0.923	0.959
XINJIANG	0.790	1.000	0.953	0.879	1.000	0.924
YUNNAN	0.981	1.000	1.000	1.000	1.000	0.996
CHONGQING	1.000	1.000	1.000	1.000	1.000	1.000
AVG.	0.969	0.994	0.994	0.976	0.993	0.985

4.2 Malmquist Index Results and Dynamic Analysis

In order to analyze productivity and changes, Malmquist index method was used to analyze the change trend and structural characteristics of sustainable development efficiency of foreign trade in 11 provinces and cities in western China. Malmquist index (MPI) represents total factor productivity, which can be divided into technical efficiency Change Index (Effch) and technological progress Index (Techch). A reading of less than 1 indicates a decline in productivity, a reading of 1 indicates no change, and a reading of more than 1 indicates an increase. MPI is influenced by both technological efficiency change index and technological progress index. Comparing the Effch and Techch values, which is larger has a greater impact on the MPI.

DEAP 2.1 was used to investigate the efficiency changes of BCC-O model in four periods in western China. The four periods are 2016-2017, 2017-2018, 2018-2019 and 2019-2020. See Table 5, Table 6 and Table 7 for details.

4.2.1 Analysis of Total Factor Productivity Change Index

As shown in Table 5, on the whole, the mean change index of total factor production in the sustainable development of foreign trade in the western region from 2016 to 2020 is 1.107>1, with an average annual growth rate of 10.7%. It grew in 2016-2017, 2017-2018 and 2019-2020 by 18.5 percent, 18.4 percent and 7.4 percent, respectively, before declining by 1.4 percent in 2018-2019. From the perspective of 11 provinces and cities in western China, MPI index of all provinces and cities is greater than 1, realizing the growth of total factor productivity. Xinjiang province had the highest growth rate, with an average annual growth rate of 20.7%.Gansu province had the lowest annual growth rate of 2%. The change index of Total factor productivity in Xinjiang showed a trend of decreasing fluctuation, with a decline of 18.6% from 2018 to 2019. The total factor productivity change index of Qinghai experienced drastic fluctuations during the sample period, which decreased by 10.7% from 2016 to 2017, increased by 94.6% from 2017 to 2017, dropped by 72.8% from 2018 to 2019, and increased by 68.9% from 2019 to 2020. These indicate that the MPI index of Qinghai province changes stably. The total factor productivity of Inner Mongolia, Ningxia and Chongqing showed a steady growth trend.

Table 5. Total factor productivity change index

DMU	MPI				
	2016-2017	2017-2018	2018-2019	2019-2020	Mean
GANSU	1.183	1.066	0.804	0.953	1.002
GUANGXI	1.182	1.286	1.350	0.828	1.162
GUIZHOU	1.110	1.151	1.049	0.989	1.075
NEIMENGGU	1.123	1.120	1.067	1.048	1.090
NINGXIA	1.151	1.114	1.017	1.090	1.093
QINGHAI	0.893	1.946	0.278	1.689	1.202
SHANNXI	1.388	0.851	1.084	1.095	1.105
SICHUAN	1.105	1.131	1.020	0.978	1.059
XINJIANG	1.651	1.142	0.946	1.090	1.207
YUNNAN	1.169	1.084	1.151	0.987	1.098
CHONGQING	1.075	1.135	1.075	1.070	1.089
AVG.	1.185	1.184	0.986	1.074	1.107

4.2.2 Analysis of Technical Efficiency Change Index

As shown in Table 6, on the whole, the average change index of technical efficiency of sustainable development of foreign trade in western China from 2016 to 2020 is 1.035>1, with an average annual growth rate of 0.9%. It maintained an increase of 3.7% and 3.5% in 2016-2017 and 2019-2020 respectively, and decreased by 0.8% and 2.8% in 2017-2018 and 2018-2019 respectively. In terms of different regions, Gansu, Guizhou, Shannxi, Xinjiang and Yunnan provinces showed slight growth, with an average annual growth rate of 1.5%, 0.3%, 2.4% and 0.5% respectively. The change index of technical efficiency in Guangxi, Ningxia, Qinghai and Chongqing was 1, showing no obvious progress or regression. Sichuan and Neimenggu ranked the last two, with an average of less than 1, down 1.1% and 1.3%, respectively. Among them, Sichuan province saw growth of 0.1 percent and 3 percent in 2016-2017 and 2017-2018 respectively, while it regressed in 2018-2019 and 2019-2020, with a decline of 6.9 percent and 0.8 percent, respectively. The change index of technical efficiency in Neimenggu showed a downward trend during the whole sample period, and the index in 2016-2017 and 2017-2018 was 1, showing no change. There was a downward trend

in 2018-2019 and 2019-2020, with a decline of 2.1 percent and 3.2 percent, respectively.

Table 6. Index of change in technical efficiency

DMU	Effch				
	2016-2017	2017-2018	2018-2019	2019-2020	Mean
GANSU	1.060	1.000	1.000	1.000	1.015
GUANGXI	1.000	1.000	1.000	1.000	1.000
GUIZHOU	0.980	1.037	0.924	1.070	1.003
NEIMENGGU	1.000	1.000	0.979	0.968	0.987
NINGXIA	1.000	1.000	1.000	1.000	1.000
QINGHAI	1.000	1.000	1.000	1.000	1.000
SHANNXI	1.080	0.888	0.993	1.134	1.024
SICHUAN	1.001	1.030	0.931	0.992	0.989
XINJIANG	1.265	0.953	0.861	1.218	1.074
YUNNAN	1.020	1.000	1.000	1.000	1.005
CHONGQING	1.000	1.000	1.000	1.000	1.000
AVG.	1.037	0.992	0.972	1.035	1.009

4.2.3 Analysis of Technological Progress Index

Technological Progress Index is shown in Table 7. On the whole, the average value of the technological Progress index of the sustainable development of foreign trade in western China from 2016 to 2020 is 1.097, with an average annual growth rate of 9.7%. Moreover, it shows an increasing state during the whole sample period, increasing by 13.8%, 19.2%, 1.7% and 4.3%, respectively. In terms of different regions, 11 provinces and cities in central China, except For Gansu, which saw a decrease of 1.5%, and the other 10 provinces and cities all realized the growth of technological progress. Among them, Qinghai Province and Guangxi Province saw a higher growth rate, with the average annual growth rate of 20.15% and 16.15% respectively. Qinghai's technological progress index and total factor productivity change index have the same trend and range of change during the sample period, and both experienced drastic fluctuation changes, with a decline of 10.7% from 2016 to 2017, a sharp increase of 94.6% from 2017 to 2017, and a precipitous decline of 72.8% from 2018 to 2019. The sharp increase of 68.9% from 2019 to 2020 indicates that the technological progress index of Qinghai province changes stably. The technical efficiency change index of Qinghai province in the sample period is 1, so the change of its total factor productivity index is completely determined by the technological progress index. The technological progress index of Guangxi province has an average annual growth rate of 16.2% during the sample period, while its technological efficiency change index is 1, which determines that the annual growth rate of total factor productivity is also 16.2%, which is consistent with the conclusion above.

Table 7. Technological progress index

DMU	Techch				
	2016-2017	2017-2018	2018-2019	2019-2020	Mean
GANSU	1.117	1.066	0.804	0.953	0.985
GUANGXI	1.182	1.286	1.350	0.828	1.162
GUIZHOU	1.133	1.110	1.135	0.925	1.076

NEIMENGGU	1.123	1.120	1.090	1.082	1.104
NINGXIA	1.151	1.114	1.017	1.090	1.093
QINGHAI	0.893	1.946	0.278	1.689	1.202
SHANNXI	1.286	0.958	1.092	0.965	1.075
SICHUAN	1.104	1.097	1.096	0.985	1.071
XINJIANG	1.304	1.198	1.098	0.895	1.124
YUNNAN	1.147	1.084	1.151	0.987	1.092
CHONGQING	1.075	1.135	1.075	1.070	1.089
AVG.	1.138	1.192	1.017	1.043	1.097

By comparing the technological progress index and the technological efficiency change index, it can be found that the technological progress index is higher than the technological efficiency change index, indicating that the total factor productivity of the sustainable development of foreign trade in western China from 2016 to 2020 is mainly driven by technological progress, and the technological efficiency needs to be further improved. That is to say, the change of total factor productivity index in western China from 2016 to 2020 is more influenced by external factors.

5. Conclusions

This paper uses DEA model and Malmquist index method to analyze the output efficiency of sustainable foreign trade development in Western China from 2016 to 2020. This paper uses DEA model to measure the technical efficiency, pure technical efficiency and scale efficiency of 11 provinces and cities in western China from 2016 to 2020. Malmquist productivity index was used to analyze the dynamic changes of efficiency in 11 provinces and cities in western China from 2016 to 2020, and the impact of technological efficiency and technological progress on total factor productivity was studied.The main conclusions are as follows:

(1) The average technical efficiency of provinces and cities in the western region from 2016 to 2020 is close to 1, indicating that the technical efficiency of the sustainable development of foreign trade in the western region is good. From the perspective of different years, the overall trend of pure technical efficiency increased first and then decreased. The average technical efficiency of 7 provinces and cities is less than 1, accounting for 63.63% of the sample provinces and cities, indicating that their resource allocation structure is not reasonable, and there is room for further improvement.

(2) On the whole, the average pure technical efficiency of all provinces in western China from 2016 to 2020 is close to 1, indicating that the management and system of sustainable development of foreign trade is good. In different years, the overall pure technical efficiency showed a trend of rising first and then declining, indicating that the level of management and system has been regressive. The pure technical efficiency value of BCC model from 2016 to 2020 is higher than that of CCR model. The average scale efficiency of central region from 2016 to 2020 is close to 1, indicating that the current scale level of sustainable development of foreign trade in western central region is relatively high. The provinces and cities with effective scale efficiency accounted for 36.36% of the sample provinces and cities. The overall scale efficiency is lower than pure technical efficiency, indicating that the current sustainable development efficiency of foreign trade in western China is mainly limited by its scale level, and it is necessary to promote the optimization of input and output structure.

(3) The mean change index of total factor production in the sustainable development of foreign trade in the western region from 2016 to 2020 is greater than 1, achieving growth. From the perspective of 11

provinces and cities in western China, MPI index of all provinces and cities is greater than 1, realizing the growth of total factor productivity. The change index of Total factor productivity in Qinghai experienced drastic fluctuations during the sample period, while the total factor productivity in Neimenggu, Ningxia and Chongqing showed a steady growth trend.

(4) The average change index of technical efficiency of sustainable development of foreign trade in western China from 2016 to 2020 is 1.035>1, with an average annual growth rate of 0.9%. From the perspective of different regions, Gansu, Guizhou, Shaanxi, Xinjiang and Yunnan provinces showed a slight increase, while Guangxi, Ningxia, Qinghai and Chongqing provinces showed a change index of 1, showing no significant progress or regression. The technological efficiency change index of Sichuan and Neimenggu ranked the last two, with an average of less than 1. The technological progress index increased throughout the sample period. The technological progress index of Qinghai and Guangxi is consistent with the change trend and range of the total factor productivity change index during the sample period, so the change of their total factor productivity index is completely determined by the technological progress index. The technological progress index is higher than the technological efficiency change index, indicating that the total factor productivity of the sustainable development of foreign trade in Western China from 2016 to 2020 is mainly driven by technological progress. It is more influenced by external factors. Therefore, it is necessary to respond appropriately to external factors such as government policies, economic environment, social environment or technological development in order to improve efficiency.

We find out that study is limited to the availability of data, and the selection of input-output indicators is not comprehensive enough. It can be further expanded on this basis in the future. The improvement plan for low efficiency provinces and cities needs to be further studied. In future studies, influencing factors of low-efficiency provinces can be studied, and efficiency evaluation and prediction mechanisms can be established, so as to help the government analyze current development and give early warning of future changes.

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