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Developing an Assessment Model for Sustainable Economic Development in China's High-Speed Rail Construction

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Abstract: In the modern world, exports, energy investment and CO2 emissions are some main factors that are associated with sustainable development. This paper proposes an adjusted analytical model to address the issue of assessing the relationship between economic development and environmental impact. It aims to explore this relationship in China's high-speed rail (HSR) network, by analyzing the key railway sections constructed by China. This paper is based on the content and indicators of sustainable development analysis by the Cobb–Douglas production function model, combines the multiple-criteria decision analysis (MCDA) to standardize the indicators, and adjusts the invalid indicators in the context of China's HSR. The research results show that the adjusted Cobb–Douglas production function model has certain practicability and reliability in the assessment of sustainable economic development of China's HSR. Besides, economic development has a linear relationship with carbon emissions. Furthermore, new energy resources play a crucial role in China's HSR, showing the alignment with the country's environmental and economic goals in the future.

1. Introduction

With sustainable economic development attracting more countries' attention, many western countries have already reached a carbon peak. However, China is still devoting itself to realizing this objective. Historically, the global economy has been highly associated with carbon emissions. Since the First Industrial Revolution, many newly industrialized countries have faced many environmental pollution problems, such as the green house effect. Today, we are still facing this issue. Since China joined the WTO, in response to the new environment of the world's green development, the environmental protection industry has produced many new opportunities. The Chinese government also advocates the concept of a "low-carbon economy" [1]. How to balance carbon emissions and economic development will be a concern that China must consider and take action.

Meanwhile, High-Speed Rail Construction such a good way to lower carbon emissions. High-speed rail (HSR) is a type of rail transport network utilizing trains that run significantly faster than those of traditional rail. China has the world's largest HSR network, but the only high-speed rails in China that are still profitable are quite limited [2]. Even if the railway itself cannot be lucrative, whether the regional economic development along the railway has been improved as well as the surrounding environment changes is worth studying. Besides, the energy consumption and carbon emissions of the power supply system of HSR are worthy of attention.

As for how to comprehensively assess the performance of HSR construction projects by China in the context of sustainable economic development, no detailed plan has been proposed. So, it is necessary to collect and analyze the relevant data, adjust the original sustainable economic development assessment model based on the context of China, and conclude the weakness and threats of China's HSR needs to improve. The research on the Multiple-Criteria Decision Analysis (MCDA) model is of great significance to adjusting the original assessment model, which is in the context of European and American countries. The research on the Production Function Model of Cobb–Douglas in the era of green innovation has attracted the attention of relevant. Literature puts forward research on the core three factors which significantly affect GDP, including exports, energy investment and CO2 emissions [3]. Among them, the "exports" is also reflected in China's railway construction. After experiencing the epidemic of the century, Southeast Asian countries have mainly focused on economic and social recovery and development, which has brought opportunities for China to export railway construction. China has already helped build the Boten-Vientiane railway and Whoosh railway in Southeast Asian countries. It is also worth assessing whether these HSR projects financed by China overseas will contribute to China's sustainable economic development.

Given the problems existing in the above situation and literature, this paper puts forward a comprehensive assessment method for China's HSR in sustainable economic development. The adjusted Cobb–Douglas production function model, based on the MCDA, establishes a well-developed evaluating system for China's HSR. Moreover, there is a close relationship between spatial carbon performance and spatial morphological characteristics of the HSR station area [4]. Based on the relevant literature and the results of the assessment model, the appropriate relevant measures to achieve improvement can be further inferred.

2. Adjusted Cobb-Douglas Production Function Model

To adjust the Cobb-Douglas production function model for China's HSR construction in a sustainable economy in the era of the green revolution, we should first identify the basic principle of the original production function, and learn the MCDA to analyze the way to adjust the production function model. Finally, we can simulate a competitive appropriate model to be tested by the real data from China's HSR. Then, the descriptive statistics and co-integration results can be applied to the adjusted Cobb-Douglas production function model to further analyze the feasibility and effectiveness of the model.

2.1. Overall Description of the Production Function Model

To provide an appropriate framework for economic modelling, this article considers incorporating the Cobb–Douglas production function, which is widely used for its flexibility and ability to represent a variety of construction analysis. According to the theories from Ergin Akalpler, we can expand the traditional production function by including energy as a crucial input except capital and labor [3]. The Cobb–Douglas function can be expressed as follows. In the equation, a, b and c refer to the output elasticity of capital (K), energy (E) and labor (L), respectively. These parameters indicate the sensitivity of the output to changes in additional input. The sum of the elasticity is typically assumed to equal one, reflecting constant returns to scale. The basic principles are as follows:

$$Y = f(K, E, L) \tag{1}$$

$$Y = K^a * E^b * L^c \tag{2}$$

$$a + b + c = 1 \tag{3}$$

By further expanding the production function, Ergin Akalpler got the following equation which was based on the context of the U.S. economy[3]:

$$RGDP = c + a * ENGY + b * INENG + d * EXPO + e * CO2 + f * COAL + g * NGAS + h * COIL + \ldots . u_i \tag{4}$$

In formula. (4), RGDP for the real gross domestic product per capita. ENGY adjust for the energy consumption per capita. INENG represents industrial energy investment. EXPO represents the export per capita. CO2 represents the carbon dioxide emission. NGAS represents the natural gas consumption. Coal represents the coal usage. ui represents the residual error term. Similarly, the small case letters from a to h represent the output elasticity of each factor.

In this original production function from Ergin Akalpler, the author expected to find the correlation coefficients between CO2, coal use, natural gas, and industrial energy consumption according to RGDP in the United States. This paper will adjust the relationship and variables in the following analysis.

2.2. Overall Description of the Multiple-Criteria Decision Analysis (MCDA)

To assess the energy efficiency of construction, L.P. Neves and other scholars used a problem structuring method, Soft Systems Methodology (SSM), to structure the multiple-criteria decision analysis (MCDA) model, which was useful to help the main predictors involved, as well as to analyse the relevant objectives for each stakeholder in the general environment [5]. In their original MCDA models, there are four main factors that affect the project’s implementation benefits maximization, including profit maximization, other benefits maximization, risk minimization and societal obligations. Based on its structured MCDA models, we can easily judge the key factors of sustainable economic development in China’s HSR construction.

2.3. Adjusting the Invalid Indicators in the Context of China's HSR

To adjust the invalid indicators in the context of China's HSR based on the original MCDA model from L.P. Neves and other scholars, we need to first adjust the main object, which is to maximize sustainable economic development benefits of China’s HSR. Then, we need to adjust the four main factors as follows.

First, profit maximization was referred to the corporation assessment in their research. When considering China’s HSR, in the context of the whole country, we need to adjust it to the RGDP considering the production function mentioned above. For the detailed reasons of this part, we also need to remove the energy sales due to China’s HSR construction is not an energy selling industry.

Next, from the associated reasons mentioned above of other benefits, including increasing market share, comparable with strategic objectives and improving public image, we can conclude that energy investment highly meets the need of China’s HSR construction in this part. The Chinese government advocates the concept of "green" development and the development of a "low-carbon economy"[2]. This not only meets the strategic objectives (strategic obj.) of the Chinese government, but also improve the public image of the sustainable construction projects. Besides, China's railway investment in fixed assets in 2023 is expected to be more than 760 billion yuan, a huge market share of the whole county transport system [6]. This strongly shows that other benefit maximization needs to be adjusted to energy investment, especially green energy investment.

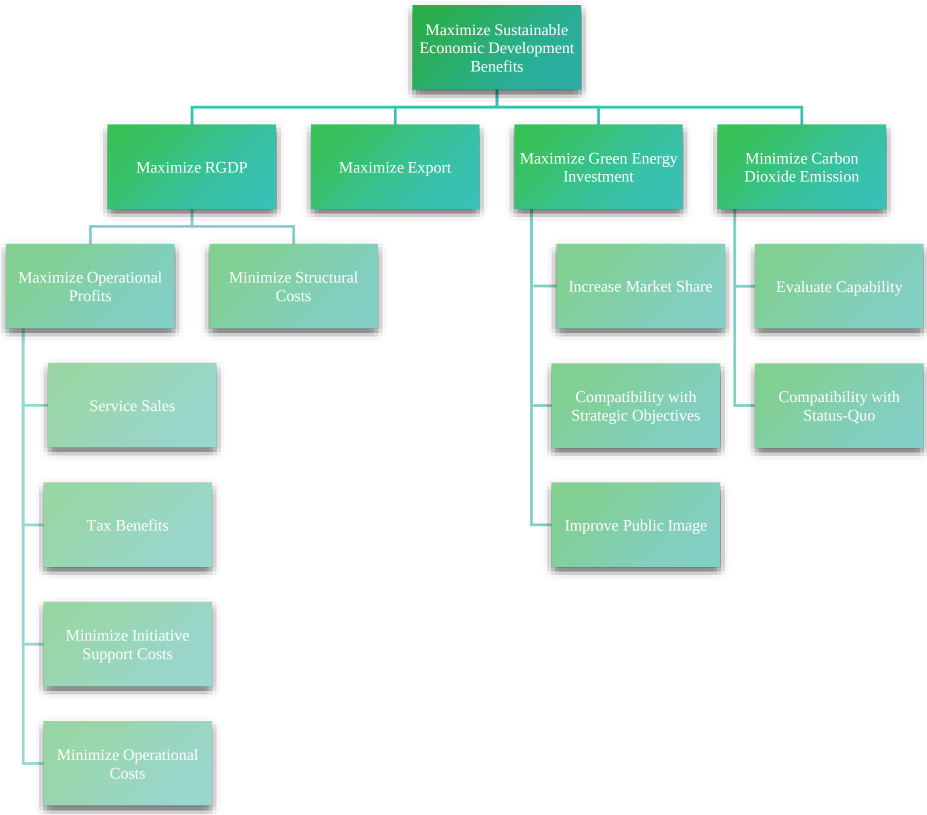

Figure 1: The Fundamental Objectives of China's HSR Construction in Promoting Sustainable Economic Development.

The original third part relates to risk minimization. Considering the global situation of temperature increase due to greenhouse gases, especially carbon dioxide, we need to pay specific attention to CO2 emissions. According to the sustainable economic development theory mentioned above, we need to maximize our profits without compromising future generations' needs. How to balance business profits, people's concerns and the planet's health involves many opportunities and risks. Evaluating the capability of the environmental capacity and considering the status-quo of the highly advanced modern technology development, the third factor needs to be adjusted to carbon dioxide emission minimization.

Moreover, the original fourth part is the societal obligations. According to research by China Railway Construction Corporation, the percentage of China's total global railway investment during 2005-2022 has a huge proportion in many countries, especially African regions which includes more than 70 percent and Southeast Asia with nearly 30 percent [7]. Among them, the part of Southeast Asia has two HSR lines been put into use, as mentioned above, including the Boten-Vientiane railway and Whoosh railway, which need to pay high attention when we assess the existing China's HSR construction projects. So, the fourth factor needs to be adjusted more precisely to maximize the export.

Last but not least, all of the above factors are related to labor(L), also known as the passenger flow volume in the evaluation of China's HSR, which is also closely associated with sustainable economic development of construction projects. Each person's wages are associated with the GDP of the whole country as well as the real gross domestic product per capita. As this paper mentioned above, public image also has a strong relationship with green energy investment. Besides, the rising global temperature affects the current generation, such as affecting the crops grow. Carbon dioxide emissions are not only related to our future generations, but also associated with our physical health as well. It is worth noting that exports seem to have no direct relation to China's GDP, but it is actually worth a lot. For example, the construction of the Tanzania Zambia Railway is very difficult, but China is willing to help East African countries build a cross-country railway, and the cost will be borne by those countries and repaid without interest [8]. At the same time, China sent labor to help with the construction, overcome those difficulties, and complete the final construction. China has always adhered to the diplomatic principle of peaceful coexistence and will not intervene in other countries' interests or interfere in other countries' internal affairs. The railway construction aid from China is a great achievement after the negotiations between the two countries. This directly shows the importance of labor when assessing China's HSR economic development.

In a brief summary, all of these factors are used to graph the fundamental objectives of China's HSR construction in promoting sustainable economic development, which is in Figure 1.

2.4. The Adjusted Cobb–Douglas Production Function Model

From the above analysis, we can conclude the final adjusted Cobb-Douglas production function model, which is as follows:

$$\mathrm{RGDP} = a * \mathrm{INENG} + b * \mathrm{CO2} + c * \mathrm{EXPO} + d * \mathrm{L} + e_i \tag{5}$$

In formula. (5), RGDP for the real gross domestic product per capita. INENG represents energy investment, especially green energy investment to lower carbon emissions. CO2 represents the carbon dioxide emission. EXPO represents the export per capita. L represents the labor, also known as the passenger flow volume in the evaluation of China's HSR context. "ei" represents the residual error term. Similarly, the small case letters from a to d represent the output elasticity of each factor.

In this adjusted production function, we expected to find the correlation coefficients between INENG, CO2, EXPO and L according to RGDP in China's HSR sustainable economic development. These coefficients will reflect whether the relations are positive or negative as well as their magnitude. A positive relationship shows that as the whole country's GDP per capita grows, those factors also increase, while a negative relationship implies the opposite. The positive larger magnitude of the coefficient relates to a higher impact of the factor, which is the strength of China's HSR and needs to be kept. A positive smaller magnitude of the coefficient relates to a lower impact of the factor, which is the weakness of China's HSR and needs to be improved. Moreover, as the economy develops, the use of clean energy sources, such as wind energy and tide energy, tends to lead to a decrease in CO2 emissions from these projects in China's HSR that promote sustainable development. These contexts in China's society does have a direct relation to China's HSR construction.

2.5. The Basic Methods for Estimating the Numerical Values of Each Factor

By using the GDP of the cities along the HSR railway lines as well as the growth rate, we can estimate the RGDP of each railway line [9]. By using the HSR investment portion in the total energy investment of the cities along the HSR railway lines, we can estimate the INENG of each railway line [10]. Considering the data of distance, HSR frequency, and HSR CO2 emission power of each railway line, we can estimate the "CO2" factor [11]. By using the data of total investment and exporting portion, we can estimate the EXPO [12]. Finally, by using the seating quantity, HSR frequency and attendance rate of each railway line, we can estimate the L [13].

In the next part, the descriptive statistics and co-integration results will be applied to this adjusted Cobb-Douglas production function model to further analyze the feasibility and effectiveness of the model. This research will also analyze the relationship and variables in the following inspiration and suggestions part to further evaluate the opportunities and threats of China's HSR construction in sustainable economic development.

3. Analysis of Data from Key Railway Sections Constructed by China

To further verify the effectiveness of the adjusted Cobb-Douglas production function model, this paper used the data of China's HSR construction from the second half of 2023 to the first half of 2024 [14],[15]. Up till today, China has helped build and put into use the Boten-Vientiane railway and Whoosh railway outside its mainland. To balance these two lines focused on the export factor and considering the total five factors, we will also pick other eight representative HSR lines in the Chinese mainland as our research object. These lines have the top eight largest passenger flow volume. By using the methods of part two of this paper, we can get the following tables from the Table 1 to Table 8.

3.1. Descriptive Statistics for Considered Parameters

Firstly, the lines on the Chinese mainland do not have export and the lines outside the Chinese mainland use energy from other countries, which does not directly affect China's RGDP, so all these data is zero. "-" means the line between to cities. "J" represents Beijing. "H" represents Shanghai. "S" represents Shenzhen. "Y" represents Guangzhou. "C" represents Chengdu. "T" represents Tianjin. "B-V" represents the Boten-Vientiane railway. "Wh" represents the Whoosh railway. The original estimated data is as follows:

Table 1: Original Estimated Data for Considered Parameters.

	RGDP	INENG	CO2	EXPO	L
J-H	235.29	22.69	302.52	0.00	1.19
H-S	223.17	18.29	231.71	0.00	0.82
H-Y	211.00	18.80	280.00	0.00	1.00
J-C	313.33	41.78	266.67	0.00	0.45
J-Y	195.38	23.08	323.08	0.00	1.30
J-T	51.83	2.32	44.51	0.00	1.64
H-C	176.56	35.16	234.38	0.00	0.64
Y-C	230.91	27.27	181.82	0.00	0.55
B-V	353.88	0.00	375.00	500.00	0.08
Wh	161.54	0.00	846.15	346.15	0.13

On the Table 1 and Table 2, the prefix "D" means descriptive. "/" means meaningless numerical values. RGDP, INENG, and EXPO used units of dollars per person. CO_2 used units of kilograms per person. L used units of 100 million people. When calculating, the zeros are extracted.

Table 2: Descriptive Statistics for Considered Parameters.

	DRGDP	DINENG	DCO2	DEXPO	DL
Mean	215.29	23.67	308.58	423.08	0.78
Median	217.09	22.88	273.33	423.08	0.73
Maximum	353.88	41.78	846.15	500.00	1.64
Minimum	51.83	2.32	44.51	346.15	0.08
Std. Dev	82.36	11.85	209.08	108.79	0.51
Skewness	-0.24	-0.29	2.04	/	0.20
Sum	2152.90	189.38	3085.83	846.15	7.80

According to the table, there is a huge difference between the mean value of DCO2 and the median value of DCO2. Simultaneously, the mean is greater than the median, which shows the carbon emissions impact a lot on some HSR railway lines. Besides, the huge difference between the maximum value of DCO2 and the minimum value of DCO2 also shows the same situation. Then, the standard deviation of DCO2 is very high, which shows carbon emissions differ a lot between each railway line. The second-highest standard deviation refers to the DEXPO, which may be due to limited exportation of China's HSR export until now with fewer samples. Moreover, there is a significant positive skewness of DCO2, which shows the crucial affects of carbon emissions. L also shows a positive skewness. We may see there is a huge impact of passenger flow on GDP in our further analysis.

3.2. Co-Integration Analysis

Table 3: Co-Integration Results.

	Coefficients	Standard Error
ei	93.960850	171.451018
INENG	5.693587	3.202391
CO2	-0.115386	0.136073
EXPO	0.564138	0.343937
L	0.000176	0.009625

According to the Table 3, the weight of INENG is significantly larger than the weights of other three factors (CO2, EXPO and L). It is also greater than zero, which shows a strong positive relationship between INENG and RGDP. Energy investment plays a crucial role in improving the RGDP of a country. According to the Table 1, the Beijing-Tianjin HSR rails invest the least average energy per person. It may be due to the short distance or the advanced technologies to decrease energy consumption. Shanghai-Shenzhen and Shanghai-Guangzhou HSR rails invest the second and the third HSR rails, which may also be due to its newer technologies.

The coefficient of EXPO is also positive, but competitively smaller than the coefficient of INENG. This may be due to limited China's HSR construction outside its mainland with a limited sample. However, the positive relationship shows it has a strong prospect for the future. Among them, the Boten-Vientiane railway does better. This may be due to the distance between it and China is shorter than the Whoosh railway, so its environment is quite similar to China. China has a strong power to deal with a similar situation in HSR construction.

Then, the coefficient of L is still positive, but almost towards zero. We can conclude the passenger flow is not a significant factor in affecting the RGDP. The most affection comes from the other three factors. Considering all the factors are from the average person, this may also decrease the total affection towards the function. It is also worth noticing there is less passenger flow on the HSR lines outside China. This is because China has a relatively larger population and people in China may have a competitively stronger financial power to buy HSR rail tickets.

The only negative coefficient is from CO2 emissions. It's not stronger than the EXPO and the INENG, but it's significantly stronger than the L affection. We can conclude that CO2 emissions really have a negative impact on China's HSR construction. Among these lines, the highest CO2 emissions is from the Whoosh railway. Considering the different environmental situation in tropical areas, China's technology in HSR seems to still need to be improved to decrease the CO2 emissions on this line. The Beijing-Tianjin HSR rails show the least CO2 emissions. This shows the lines use the technology significantly decrease CO2 emissions, which is worth for other lines to imitate.

Finally, there is a large error coefficient factor. This shows different lines have different conditions and have weaknesses in different factors. The standard error of INENG is also large.

Considering the above analysis, this shows we need to consider how to balance energy investment and CO_2 emissions in a specific and effective way. This standard error of EXPO is also worth noticing. It is relatively large, but we can expect to decrease this when China builds more HSR lines outside its mainland.

3.3. Wald Test results

To test the correctness of the relationship between the dependent variable and independent variables, we use Wald test results for analysis. According to Equation.(5), we can deduce the following equations (ei1, ei2, ei3, and ei4 represent the residual error terms in each equation):

$$\mathrm{INENG} = \frac{1}{a}\mathrm{RGDP} - \frac{b}{a} * \mathrm{CO2} - \frac{c}{a} * \mathrm{EXPO} - \frac{d}{a} * \mathrm{L} + e_{i1} \quad (6)$$

$$\mathrm{CO2} = \frac{1}{b}\mathrm{RGDP} - \frac{a}{b} * \mathrm{INENG} - \frac{c}{b} * \mathrm{EXPO} - \frac{d}{b} * \mathrm{L} + e_{i2} \quad (7)$$

$$\mathrm{EXPO} = \frac{1}{c}\mathrm{RGDP} - \frac{a}{c} * \mathrm{INENG} - \frac{b}{c} * \mathrm{CO2} - \frac{d}{c} * \mathrm{L} + e_{i3} \quad (8)$$

$$\mathrm{L} = \frac{1}{d}\mathrm{RGDP} - \frac{a}{d} * \mathrm{INENG} - \frac{b}{d} * \mathrm{CO2} - \frac{c}{d} * \mathrm{EXPO} + e_{i4} \quad (9)$$

The Wald test results of five variables are as follows:

Table 4: Wald Test Results for Equation.(5).

Dependent Variable	Independent Variables	p-value
RGDP	INENG	0.135558
	CO2	0.435160
	EXPO	0.161880
	L	0.986110

Considering 0.05 as the critical value [3], the p-values for INENG, CO2, EXPO, and L are greater than 0.05. This means that the independent variables are considered in the Table 4 have no effect on RGDP. If we choose Equation.(5) as null hypothesis(H0) , we fail to reject H0.

Table 5: Wald Test Results for Equation.(6).

Dependent Variable	Independent Variables	p-value
INENG	RGDP	0.135558
	CO2	0.878519
	EXPO	0.003588
	L	0.131005

Considering 0.05 as the critical value [3], the p-values for RGDP, CO2, and L are greater than 0.05. This means that these independent variables have no effect on RGDP. However, the p-values for EXPO were found to be less than 0.05, indicating that they do have some effect on the INENG. If we choose Equation.(6) as null hypothesis(H0) , we reject H0.

Table 6: Wald Test Results for Equation.(7).

Dependent Variable	Independent Variables	p-value
CO2	RGDP	0.435160
	INENG	0.878519
	EXPO	0.639041
	L	0.503967

Considering 0.05 as the critical value [3], the p-values for RGDP, INENG, EXPO, and L are

greater than 0.05. This means that the independent variables are considered in the Table 6 have no effect on CO2. If we choose Equation.(7) as null hypothesis(H0) , we also fail to reject H0. This shows the effectiveness of Equation.(7) to further analysis of the adjusted production function.

Table 7: Wald Test Results for Equation.(8).

Dependent Variable	Independent Variables	p-value
EXPO	RGDP	0.161880
	INENG	0.003588
	CO2	0.639041
	L	0.090572

Considering 0.05 as the critical value [3], the p-values for RGDP, CO2, and L are greater than 0.05. This means that these independent variables have no effect on RGDP. However, the p-values for INENG were found to be less than 0.05, indicating that they do have some effect on the EXPO. If we choose Equation.(8) as null hypothesis(H0) , we reject H0.

Table 8: Wald Test Results for Equation.(9).

Dependent Variable	Independent Variables	p-value
L	RGDP	0.986110
	INENG	0.131005
	CO2	0.503967
	EXPO	0.090572

Considering 0.05 as the critical value [3], the p-values for RGDP, INENG, CO2, and EXPO are greater than 0.05. This means that the independent variables are considered in the Table 8 have no effect on L. If we choose Equation.(9) as null hypothesis(H0) , we also fail to reject H0. This also shows the effectiveness of Equation.(9) to further analysis of the adjusted production function.

To summarize, the Equation.(5) has effectiveness when analyzing the sustainable economic development of China's HSR. Meanwhile, the Equation.(7) and the Equation.(9) can also be used to further analysis of the adjusted Cobb-Douglas production function.

4. Inspiration and Suggestions

4.1. Break Through the Weaknesses and Threats of Sustainable Economic Development in China's HSR Construction

Based on the above analysis, there are some strengths and opportunities in the evaluation of China's HSR sustainable development. However, there are also some weaknesses and threats we need to pay attention to. According to SWOT analysis [16], we can clearly analyze the internal and external environment of China's HSR as status-quo. As we can analyze by Figure 2, the strengths include the stable energy investment with limited carbon emissions, as well as the large passenger flows using the HSR lines. The weaknesses include the negative impact of carbon emissions on the RGDP and the limited exportation of HSR technologies. The opportunities involve the existing successful investment of China's HSR construction in the Southeast Asia areas as well as the increasing needs of sustainable development. The threats involve limited technologies in different environmental situations as well as the advanced technologies' development from other countries. Considering Figure 1, China's HSR construction may consider minimizing the operational and structural costs to decrease energy investment as well as carbon emissions. China's government may also pay more attention to increasing the market share of HSR construction outside their mainland. Besides, the existing technology weaknesses and threats show that China needs to put more funds to research technologies to improve the current situation.

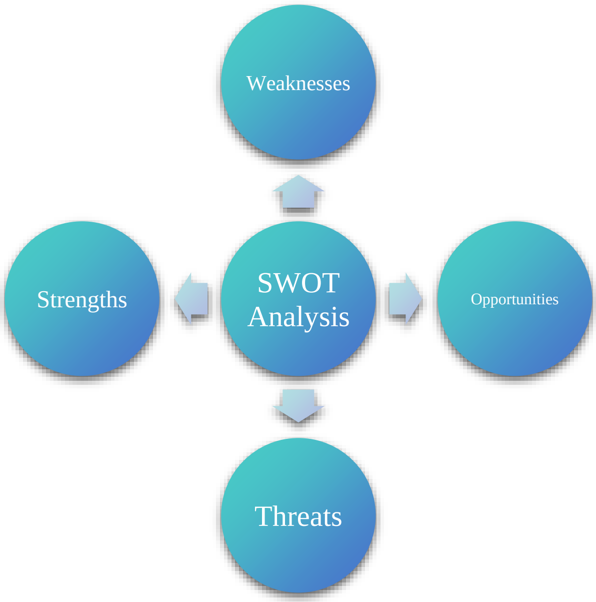

Figure 2: The Fundamental SWOT Analysis.

4.2. Keep a Triple Bottom Line Thoughts for the Sustainable Development of Renewable Energy

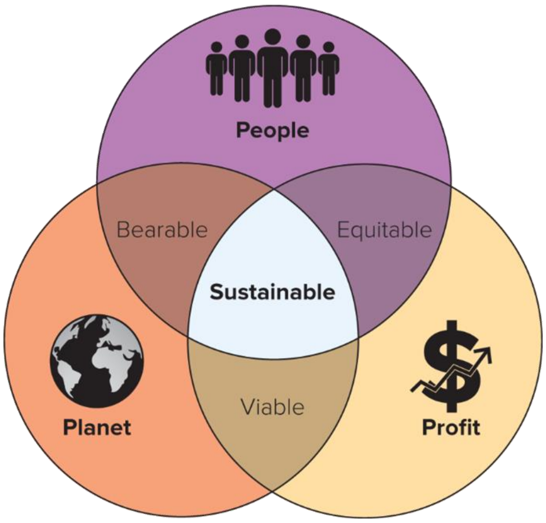

Figure 3: The Triple Bottom Line [16].

The triple bottom line of people, planet, and profit represents a new standard for success of business projects nowadays [16]. As we can analyze by Figure 3, how to balance current people's needs without sacrificing future people's needs as well as realizing sustainable economic development is worth considering. Government regulators need to put an eye on the development of renewable energy to decrease carbon emissions. For instance, there is a close relationship between spatial carbon performance and spatial morphological characteristics of the HSR station area [4]. To minimize carbon dioxide emissions, we not only need to evaluate the HSR rail lines and the along stations' efficiency, but also have to consider the compatibility with the status-quo. Some large cities require a larger space station, which directly increases energy consumption. So, the morphological characteristics play a crucial role, which directly affects the carbon emissions of each HSR line. Those designers require always keep a triple bottom line thoughts as well as the government administrators. Besides, using more proportion of renewable energy would also meet the needs of sustainable economic development [17]. To gain more profit at the same time, it is the essence of minimizing initial support costs for cheaper renewable energy resources.

4.3. Propose Promotion Policies to Appeal Renewable Energy Investment

In 2021, China's government President Xi proposed that, "we will implement the new development concept, take the overall green transformation of economic and social development as the guide, take the green and low-carbon development of energy as the key" [18]. This shows the strong desire of China to lower carbon emissions. Considering Figure 1, China's HSR construction may improve the public image of the low-carbon economy, attracting more investors to invest in renewable energy in China's HSR construction. Besides, the Chinese government needs to set more incentives policies or some limits to promote renewable energy usage. For instance, tax benefits on renewable energy or a price floor on nonrenewable energy would work a lot on this issue. In the future, if China can keep the trend on leading the green economic development, especially in HSR construction, this will also attract more investors to accept China's HSR projects all over the world. The more China exports, the higher RGDP China can gain through this process. When more funds are get and technologies are improved, the weaknesses are fixed and the service of HSR construction goes into maturity, China can export these technologies to more South countries.

5. Conclusion

To test the effectiveness of China's HSR construction in sustainable economic development, the existing Cobb–Douglas production function model lacks the context of China's construction, which leads to some mismatched factors in evaluation. Therefore, this paper proposes an adjusted Cobb–Douglas production function model in this green revolution era based on MCDA model, which carries out descriptive statistics analysis as well as co-integration method to analyze data from China's HSR, and then test the effectiveness of this adjusted model by Wald test results. Results show that the adjusted Cobb–Douglas production function model suggested in this paper is effective. It could be used to evaluate and compare the strength, weaknesses, opportunities, and the threats of different rail lines of China's HSR in sustainable economic development. It can meet the needs of finding ways to further improve the current situation of China's HSR and promoting green economic development.

However, China's HSR still faces many weaknesses and threats, including technical barriers on carbon emissions in different regions with different environment, and limited exportation of the HSR construction. Therefore, government regulators should provide more incentives to attract more investors for the continuous development of the sustainable economy and improve current technologies. China's government administrators should also focus on the renewable energy usage in each HSR line. By keeping the thoughts of triple bottom line and proposing promotion policies, the production cycle of China's HSR construction can be bound to form a virtuous cycle. Therefore, the future development of China's HSR construction should begin with two aspects. On the one hand, formulate appropriate incentive policies to encourage more investors to participate in the development of green economic technologies. On the other hand, the structural costs and energy costs should be minimized at the same time to implement the triple bottom line thoughts.

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