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Research on the Coupling of Industrial Structure and Environment between China and the “Belt and Road” Countries

- Take the 10 ASEAN countries as an example

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Abstract. *This paper is using the panel data of the “Belt and Road” of ASEAN 10 countries and China from 2010 to 2016. And the principal component analysis method is used to construct the comprehensive index of industrial structure and the comprehensive index of environmental quality. The coupling degree and coupling coordination degree model are established to empirically analyze the industrial structure and environment. The coupling of mass and empirical results show that the coupling degree and coupling coordination degree are generally rising, but the value of coupling degree is always greater than the coupling coordination degree. Finally, a series of policy recommendations are proposed based on the empirical analysis.*

Key Words: *Belt and Road, Industrial Structure; Environmental Quality, Coupling Degree, Coupling Coordination Degree*

1. Introduction

Since the " Belt and Road " strategy is proposed to help China and neighboring countries achieve complementary advantages and mutual benefit, the development of the research strategy is crucial. The way of economic growth plays an important role in how economic development affects the ecological environment. The industrial structure is precisely the way to measure economic growth. The type of industrial structure links economic activities and environmental quality. The traditional economic growth mode in China is an extensive economy that relies on cheap labor and resource consumption. Such an industrial structure will cause

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environmental damage. Nowadays, China is committed to adjusting the industrial structure, from extensive to intensive, reducing the proportion of the first and second industries, and vigorously developing the tertiary industry. By examining the changes in industrial structure and environmental quality of China and neighboring countries from 2010 to 2016, it can provide certain reference value for promoting the coordinated development of environment and economy. Most of the existing literatures on such problems rarely use panel data. Most of them study the relationship between industrial structure and environmental quality in a particular region. Therefore, the research based on panel data also has certain theoretical significance.

2. Literature Review

The most famous theory for studying the relationship between industrial structure and environmental quality is the Kuznets Curve (EKC), which believes that the initial economic development is slow and the resulting pollution is less. With the acceleration of economic development, frequent social activities and increased resource consumption, environmental pollution has also increased. When the economy develops to a certain extent, people's awareness of environmental protection is strengthened, and more and more attention is paid to ecology, which will consciously reduce environmental pollution. This dynamic trend of the environment and the dynamic development process of per capita GDP show an inverted "U" curve. Herman Daley believes that when we adjust the industrial structure, we need to reduce the scale of traditional industries that must rely on a large amount of resources to be developed. This is the scale of reducing the scale of the extensive industry. At the same time, it is necessary to transfer the adjustment of the industrial structure's center of gravity to a small-pollution or non-polluting industry as much as possible, so that the production of environmental pollutants can be fundamentally reduced. Liu Rongmao (2006) analyzed the relationship between economic growth and environmental quality, and verified the Kuznets curve based on time series data from 29 provinces in China. It is concluded that the adjustment of the industrial structure is conducive to improving the environment. For the relationship between environmental pollution and economic growth in China, almost all provinces have been studied. The relationship between the two is not only inverted U-shaped, but also U-shaped, N-shaped and linear. Han Yujun (2009) conducted a group test of 165 countries, and concluded that the EKC curve of high-industrial high-income countries is inverted U-shaped, the curve of low-industrial low-income countries is weak and inverted U-shaped, and the curve of low-industrial high-income countries is wave-shaped. The curve of high-industrial low-income countries shows a simultaneous growth trend. Wang Feicheng (2014) empirically analyzed the impact of economic growth on environmental pollution in 29 provinces in China in accordance with the environmental Kuznets curve. It is concluded that China is currently in the inverted U-shaped decline, while the west is N-shaped and is on the right side of the rise, and the central and eastern regions are in the inverted U-down. Liu Yu (2013) used the 1985-2010 data of Liaoning Province to conduct a co integration test on industrial structure evolution and environmental quality, and concluded that the role of industrial structure in environmental quality has existed for a long time. In summary, most of the research at home and abroad is divided into three forms, one is the verification of the Kuznets curve for the region. Two is to use panel data to study the impact of the first two or three industries on the environment. Three is to study the coupling degree and coupling coordination degree of urbanization and ecological environment in various regions in a certain year. In the domestic and international research, there are few studies on the industry as an overall industrial structure, and there are few studies that combine the coupling degree model with the panel data. Therefore, based on panel data, this paper takes the industrial structure as a whole and studies the “Belt and Road”. Coupling degree and coupling coordination degree of industrial structure and environment along the country.

3.Empirical Analysis

3.1 Model Setting

Coupling Degree Model

Coupling refers to the dynamic coordination process of interaction and interaction between various subsystems. The industrial structure and environmental quality of countries along the Belt and Road are two complex systems. They interact with each other and affect each other through a special way. Coupling degree model is to measure the interaction between industrial structure and environmental quality, but the degree of coupling cannot be used as a criterion for judging system quality. It can only explain the degree of interaction between systems. This paper talked about the relation between industrial structure and environment. I established separately comprehensive evaluation index systems, and the degree of coupling is estimated by an empirical method.

Suppose $X_1, X_2 \dots X_n$ are n indicators describing the industrial structure. $Y_1, Y_2 \dots Y_m$ are m indicators describing environmental quality. The Principal Component Analysis method is used to reduce the dimension. Calculate the weight of each principal component and construct the functions f(x) and g(x) of the industrial structure and environmental quality composite index. The formula of the coupling degree is：

$$C = \left\{ \frac{f(x) * g(x)}{\left[\frac{f(x)+g(x)}{2}\right]^2} \right\}^2 \qquad (1)$$

C is the coupling degree between industrial structure and environmental quality, and its value range is [0, 1]. 0 indicates that the degree of coupling is low, and the various elements between the systems and the internal factors of the system are independent of each other, and the system will develop toward the disordered direction. When the value reaches 1, it indicates that the two are highly coupled, achieving benign resonance coupling and coordinated development.

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Coupling Coordination Model

The coupling degree model can only reflect the interaction between the two, but it does not reflect the development level of the two. The coupling coordination degree is an index that can reflect the relationship between the various elements of a system. The formula is as follows :

$$D = \sqrt{C * T} \quad (2)$$

$$T = \partial f(x) + \beta g(y) \quad (3)$$

T is the comprehensive coordination index of industrial structure and environmental quality, reflecting the overall synergy or contribution of regional economy and industrial structure. Since industrial structure and environmental quality have equal importance, $\partial = 0.5\ \beta = 0.5$. When D is 1, the industrial structure and environmental quality are highly coordinated. When D is 0, the coordination is the worst.

3.2 Indicator Selection and Data Processing

Indicator Selection

This paper selects the data from 2010 to 2016 in the ASEAN countries along the “Belt and Road” and China which are all 11 countries. The comprehensive evaluation system of industrial structure includes the proportion of output value of primary industry, secondary industry and tertiary industry to GDP. The environmental quality comprehensive evaluation system is divided into two levels of ecological environment pressure and ecological environment status, as shown in Table 1 below:

Table 1

Target	Criteria	Indicator
Industrial structure indicator system	Industrial output structure	primary industry to GDP
		secondary industry to GDP
		tertiary industry to GDP
Environmental quality indicator system	ecological environment pressure	Per capita GDP
		The population density
		Renewable energy consumption ratio
		Per capita CO_2 emissions
		Power rate

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	ecological environment status	Per capita cultivated area
		Forest cover rate
		PM2.5 concentration
		Land and marine protected area
		Renewable inland freshwater resources
		Total natural resource rent as a percentage of GDP

Data Processing

The 14 indicators selected in this paper are from the World Bank database, but some data are obtained through certain calculations. For example, the per capita arable land area is not in the database, so it is obtained by dividing the cultivated land area by the population. Moreover, due to the lack of data in some countries, the missing value analysis function of spss software is used for data estimation.

There are positive and negative indicators in the selected data. In order to eliminate the effects caused by different dimensions, the raw data should be standardized first, and the processing formula is as follows:

Positive indicator: $$x' = \frac{x-\min(x)}{\max(x)-\min(x)} \quad (4)$$

Negative indicator： $$x' = \frac{\max(x)-x}{\max(x)-\min(x)} \quad (5)$$

Based on the indicators reflecting different industrial structure and environmental quality, this paper uses principal component analysis to establish a comprehensive index of industrial structure and a comprehensive index of environmental quality. Principal component analysis is the recombination of a series of related indicators into a new set of mutually independent indicators that replace the original indicators. Mainly by using the idea of dimensionality reduction, the multiple variables are reduced to several unrelated principal components for analysis. This thesis uses the principal component analysis of panel data. In China, for example, if there are 14 indicators of raw data missing, the missing value analysis is performed first, followed by standardization, and then the principal component analysis of the data is performed using the pca command of the STATA software to obtain the value and variance contribution rate of each principal component. And the variable factor load matrix, as shown in Table 2, Table 3, and Table 4 below:

Table 2 Principal component factor value, contribution rate, and cumulative contribution rate

	component	value	contribution	cumulate
industrial structure	1	1.70604	0.5687	0.5687
	2	1.00957	0.3365	0.9052

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	3	0.284388	0.0948	1
environmental quality	1	3.97323	0.4612	0.4612
	2	1.99319	0.2812	0.7424
	3	1.18439	0.1077	0.8501

The principle of extracting the number of principal components is that the eigenvalues of the first n principal components are greater than 1 and the cumulative contribution rate is greater than 85%. Then n principal components can be extracted. From Table 2, the target structure of the industrial structure can extract two main components ingredients, and select two to represent 90.52% of the original data. In the target layer of environmental quality, three principal components can be extracted, which can represent 85.01% of the original data.

Table 3 Factor load matrix of industrial structure

Factor x	First Principal	Second Principal
Primary industry	-0.5565	0.6161
Secondary industry	0.4323	0.7876
Tertiary industry	0.7095	0.0033

Table 4 Factor load matrix of environmental quality

Factor y	First Principal	Second Principal	Third Principal
Per capita GDP	0.29878	0.2809	-0.2628
Per capita cultivated area	-0.2143	0.4361	0.1248
Forest cover rate	0.0339	0.501	0.5504
The population density	-0.4746	0.0303	0.1151
Per capita CO2 emissions	0.2369	-0.4023	0.2956
PM2.5 concentration	0.0845	-0.4396	0.0627
Renewable energy consumption ratio	0.0098	0.2495	-0.4988
Land and marine protected area	0.4293	0.0205	0.0677
Renewable inland freshwater resources	-0.3604	-0.0953	0.3563

After obtaining the matrix of principal component score coefficients, the functions f(x) and g(x) of the industrial structure and environmental quality composite index can be calculated.

Main component of industrial structure:

$$Z1=-0.5565x1+0.4323x2+0.7095x3 \quad (6)$$

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Z2=0.6161x1+0.7876x2+0.0033x3（7）

Environmental quality main component:

Z3=0.29878y1-0.2143y2+0.0339y3-0.4746y4+0.2369y5+0.0845y6+0.0098y7+0.4293y8-0.3604y9 （8）

Z4=0.2809y1+0.4361y2+0.501y3+0.0303y4-0.4023y5-0.4396y6+0.2495y7+0.0205y8-0.0953y9 （9）

Z5=-0.2628y1+0.1248y2+0.5504y3+0.1151y4+0.2956y5+0.0627y6-0.4955y7+0.0677y8+0.3563y9（10）

Industrial Structure Composite Index:

f(x)= 0.5687Z1+0.3365Z2 (11)

Environmental Quality Composite Index:

g(x)= 0.4612Z3+0.2812Z4+0.1077Z5 (12)

Since there is a negative number in the obtained Z1 - Z5, the normalization process is performed again. The normalized data is then brought into f(x) and g(x), and finally the coupling degree and coupling coordination model are introduced. The values of coupling degree and coupling coordination degree of industrial structure and environmental quality of each country are calculated.

3.3 Empirical Result

According to the model above, the data of the coupling degree and coupling coordination degree of ASEAN countries along the “Belt and Road” from 2010 to 2016 can be calculated. When the coupling degree is between 0 and 0.3, it is in the low level coupling period. The interaction between the industrial structure and the environmental quality is small, and the ecological environment has a large bearing capacity for the adjustment of the industrial structure. When the value is between 0.3 and 0.5, it is in the period of antagonism, that is, the economy has developed and the environmental quality has improved, and there is a great potential. When the value is at 0.5 to 0.8, it is in the stage of benign coupling, and economic development and environmental quality are developing rapidly. When the value is between 0.8 and 1, the industrial structure and the environmental quality are mutually promoted, and the unified functional bodies of the two are basically formed and the development level of the two reaches the optimal point. When the coupling coordination degree is between 0 and 0.3, it is in a low coordination period, indicating that the overall synergy efficiency or contribution rate between industrial structure and environmental quality is poor. There are three cases of low coordination:

(1) The development level of industrial structure and environmental quality is low;

(2) The level of development of the industrial structure is high and the environmental quality is poor;

(3) The level of environmental quality development is high and the level of industrial structure development is low;

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When the value is between 0.3 and 0.5, it is moderately coordinated, indicating that the overall synergistic efficiency or contribution rate of industrial structure and environmental quality reaches a moderate level of development. Highly coordinated when the value is between 0.5 and 0.8. When the value is between 0.8 and 1, it is in extreme coordination, and the development of environmental quality and industrial structure has reached a high level. The two promote each other and develop synergistically.

The coupling degree value generally shows an increasing trend. For example, China has a low level of coupling in 2010 and 2011, that is, the industrial structure has less impact on the ecological environment, and the environment has a greater bearing capacity for the adjustment of the industrial structure. By 2012, the coupling degree rose sharply to 0.66. The two are in the stage of running-in, the industrial structure and the environmental quality interact. Adjusting the industrial structure is conducive to improving the environmental quality, and improving the environmental quality is conducive to adjusting the industrial structure. From 2013 to 2016, the coupling degree in these four years is at a high level. The interaction between environmental quality and industrial structure is coordinated and the development level of the two is improved. The general trend of the degree of coupling in ASEAN countries has increased, and in 2016, the coupling degree of eleven countries is at a high level, indicating that the industrial structure and environmental quality have been developed, and the two interact and develop harmoniously. In 2010 and 2011, China's coupling coordination degree was lower than coordination, and the coordination relationship between industrial structure and environmental quality was poor. Then the coordination degree value increased year by year, and reached a high degree of coordination in 2013. The two promoted and coordinated development. ASEAN countries also generally show growth trends. For example, Brunei may have reduced coordination in 2011 due to policies or other factors, but it has been gradually rising afterwards, and finally reached a high level of coupling coordination in 2016. China has gradually reduced the production mode of households in agriculture and developed high-tech, large-scale and highly mechanized commodity grain bases. In the industrial sector, the proportion of industries has been reduced, but the proportion of basic industries such as manufacturing has increased. With a shortage of resources and raw materials, it is possible to use the cheap labor and resources of countries along the route to transfer labor-intensive and raw material-oriented industries to these countries and to develop new energy sources. In the service sector, the proportion of the service industry has increased. Due to the low level of economy and infrastructure in the countries along the route, China has some overcapacity in the industry. Therefore, it can help these countries to carry out infrastructure construction, which will not only help China to solve overcapacity but also help countries along the route to improve the level of economic and infrastructure construction. However, compared with the coupling degree and coupling coordination degree, the value of the coupling degree is always greater than the coupling coordination degree. This shows that although the industrial structure of China has changed, the utilization efficiency of resources has been improved to reduce the emission of pollutants. However, after a certain degree of adjustment and upgrading of the industrial structure, the environment is still difficult

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to carry the various pollutions brought about by the development. The environmental quality and industrial structure have not reached a high degree of coordinated development, resulting in the value of the coupling degree is always greater than the coupling coordination degree.

In short, as a whole, from the 2010-2016 period, the industrial structure and economic quality of China and ASEAN countries are constantly developing, the industrial structure is continuously optimized, the economic quality is continuously improved, and the coordination between the two systems is increased. However, there is a certain degree of industrial restructuring and upgrading, which makes the environment difficult to bear.

4. Policy Suggestion

The concept of “Belt and Road” is peaceful cooperation, openness and tolerance, mutual learning and mutual learning, mutual benefit and win-win. Domestic industries need to “go out”. Going out can be a marginal industry such as China's traditional manufacturing industry, or it can be China's brand advantage industry and characteristic industries such as high-speed rail. This is conducive to building China's famous brand and establishing a famous industry. In the "introduced" industry, we should pay attention to the choice of the industrial level, should introduce high-tech industries, and strengthen the absorption of comparative advantage industries in higher economies, such as IT industry, media and advanced manufacturing. In terms of products, it is necessary to improve the processing level of products, extend the processing chain of products, and increase the added value of products, which is conducive to reducing the resource consumption per unit of output value. At the same time, if the resources are further processed, the emissions of the three wastes will be reduced. It will also improve the utilization of resources, thereby ultimately reducing waste of resource utilization, increasing resource utilization, and reducing environmental pollution during resource utilization. Second, in terms of products, we should improve the level of product intensification and scale operation. In agriculture and industry, this will overcome small, scattered low-level production models, achieve specialized, intensive production, and improve industrial efficiency. Third, the industry level should be improved. The primary industry should realize the production of commodities at the base and carry out ecological agriculture operations. For the secondary industry, the focus should be on the refinement and high value of products, and the tertiary industry should promote the tertiary industry to informationization. The development of technology and the increase of cultural value need to be dominated by talents, technology and information, rather than resources, which can reduce the consumption of natural resources and reduce the pressure of resource shortage.

Nowadays, people are paying more and more attention to the quality of the ecological environment. Only by establishing a good ecological environment can talents be retained. Only a good ecological environment can satisfy the people’s wishes. We should increase our efforts in environmental management, strengthen the management of “three wastes” in industry, supervise and rectify enterprises that

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do not meet the standards, increase investment in environmental protection, and promote the development of environmental protection industries. The government should use the regulatory role of “visible hand” to formulate public policies, adopt tax collection and certain incentive measures to limit the waste of resources and environmental pollution, and to a certain extent, incentives can promote enterprises to actively protect the environment. It is also necessary to increase the punishment for environmental pollution incidents, so as to "who pollutes, who governs; who develops and who protects."

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