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Resource Status and Curse Threshold

An Empirical Study Based on Cross-national Panel Data*

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***Abstract*—Different from the existing literatures, this paper investigates the nonlinear relationship between natural resource economic growth and resource curse threshold, with particular attention paid to the impact on resource curse of the resource status i.e. the global economic development mode. The empirical results based on the panel data of 90 countries from 1972 to 2011 show that, the impact of natural resource on economic growth is nonlinear and the relationship between them presents an inverted U-shape curve, that is, only when resource abundance cross threshold value, the resource curse effect will occur. In addition, we find the change of resource status has a significant impact on the relationship between resource and economic growth and the resource curse, that is, the rise of the resource status can lower the threshold of resource curse and it is possible that more countries are plagued by the resource curse effect.**

Keywords—natural resource; economic growth; curse threshold; resource status

I. INTRODUCTION

Classical economics theory emphasizes that resource play an important role in economic development. The richer the natural resource a country possesses, the more secure its economic growth will be. The production and export of resource can bring about direct capital accumulation. Abundant resource can lay a solid foundation for industrialization and promote economic growth. The initial development course of some typical developed countries also strongly supports this view (Barbier, 2005; Wright, 1990). The concept of resource curse was first proposed by Auty (1990). He found that by studying the economic development of mineral producing countries, rich natural resource do not necessarily promote economic growth. Instead, they may be a limitation. Matsuyama (1992) later established a theoretical model, the basic conclusion of which is that the massive export of natural resource led to the appreciation of the national currency, making the non-resource sectors uncompetitive (such as manufacturing), and the transfer of material capital and human capital to the primary product sector. As a result, the manufacturing industry has shrunk, weakening the externalities of the manufacturing sector and thus squeezing long-term economic growth. The empirical evidence is represented by Sachs and Warner (1995) using cross-country data. The results show that countries with a higher proportion of primary products in GDP have lower average economic growth rates in subsequent years, that is, natural resource may produce "Curse effect" on economic growth, and put forward the conduction pathways generated from the perspectives of investment, openness and institutions. Since then, many scholars have continued to test this framework using different data sources and methods to verify the existence of resource curses (Gylfason, 2001; Lay and Omar Mahmoud, 2004; Atkinson and Hamilton, 2003; Williams, 2011).

However, some scholars oppose the resource curse effect, suggesting that using different indicators for measuring natural resource will lead to different findings. Stijns (2005) based on empirical studies of cross-country data from 1970-1989 suggested that the effect of resource on economic growth mainly depends on the way a country develops resource and finds that when using energy and mineral reserves as a proxy variable for the abundance of natural resource, it has an effect on economic growth. The impact is not obvious, but the proportion of primary product exports in GDP still has a significant effect on economic growth. Brunnschweiler (2008) believes that most studies do not distinguish between resource dependence and resource abundance when defining the concept of natural resource. The share of natural resource exports measures the dependence of a country's economy on resource, while the "resource curse" should be accurately referred to as the over-reliance on the resource industry which restricts the development of the economy. If the resource reserves indicator is selected, it will be concluded that resource will promote economic growth. The tests based on Chinese data also break into controversial conclusions: some think

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resource abundance and economic growth are negatively related, some believe they are inconspicuous, and others find an inverted-U-shaped-curve relationship between them (Xu Kangning and Wang Jian, 2006; Ding Juhong et al., 2007; Shao Shuai et al. 2013).

According to the existing literature, natural resource can bring dividends for economic growth, which has been widely recognized by the academic community. However, this kind of dividend is not endless. "Excessive" resource can be used to distort the industrial structure, lead to rent-seeking behavior, and induce lazy and dependent people, which have negative effects on economic growth. Considering the two-sided mechanism of resource comprehensively, it seem to be able to speculate that the effect of natural resource on economic growth is neither a completely suppression nor a promotion, but rather an inverted U-shaped curve relationship that proves the existence of a threshold. Resource curses occur when resource abundance exceeds the threshold. On the other hand, due to the evolution of economic development methods, the importance of different production factors such as labor force, capital, technology, and natural resource will also change in different historical stages (Summers and Heston, 1991), and the status of resource as an external environment change on a global scale, which is bound to have an impact on the relationship between national resource and economic growth in different countries. This is rarely noticed by the academic community. A reasonable inference should be that with the rise of global resource, the impact of a country's resource on its own economic growth will become even stronger, and the threshold for the occurrence of a resource curse will be reduced accordingly, and vice versa. Based on the above understanding, this paper begins with the nonlinearity of natural resource and economic growth and the threshold of resource curse, introduces the global resource status variable, and empirically investigates the curse effect of resource and its dynamic changes, in order to provide new perspectives and empirical evidence for a comprehensive understanding of the impact of resource on economic growth.

II. RESEARCH DESIGN

A. Model Construction

The empirical model for examining the relationship between natural resource and economic growth is generally based on the practice of Sachs and Warner (1995), whose basic form is shown in equation (1):

$$GR_{it} = \beta_0 + \beta_1 R_{it} + \beta_2 X_{it} + \varepsilon_{it} \quad (1)$$

Of which GR represents a country's economic growth, R represents a country's resource abundance, X is a control variable, and ε is a random disturbance item.

The model is based on a linear relationship between resource and economic growth. As mentioned earlier, the relationship between resource and economic growth may be nonlinear, i.e., it is an inverted U-shaped curve. Therefore, we will introduce the quadratic term of the resource variable into the above-mentioned classical model and obtain the model as shown in formula (2):

$$GR_{it} = \beta_0 + \beta_1 R_{it} + \beta_2 R_{it}^2 + \beta_3 X_{it} + \varepsilon_{it} \quad (2)$$

When there is an inverse U-shaped curve relationship between the two, it is reflected in the model that the coefficient of the resource variable is positive, and the quadratic term coefficient is negative, and the "threshold value" can be obtained by the formula (3):

$$R_0 = -\frac{\beta_1}{2\beta_2} \quad (3)$$

When resource abundance does not exceed this "threshold value", resource is still beneficial to economic growth. When this value is exceeded, the negative effects of resource even exceed the positive effects of the resource themselves, then the resource begins to deteriorate the economic growth, and a curse effect occurs.

In order to examine the dynamic impact of resource status changes on the relationship between resource and economic growth and on the curse effect, which is closely related to the global economic growth pattern, we include the global resource status factor (S_t) as a moderating variable, i.e. introducing the interaction variables between resource abundance and global resource status, the square of resource abundance and global resource status (RS and R^2S), the model is adjusted as shown in equation (4):

$$GR_{it} = \beta_0 + \beta_1 R_{it} + \beta_2 R_{it}^2 + \beta_3 R_{it} S_t + \beta_4 R_{it}^2 S_t + \beta_5 X_{it} + \varepsilon_{it} \quad (4)$$

Similarly, we can use Equation (5) to calculate its "threshold value":

$$R_0 = -\frac{\beta_1 + \beta_3 S_t}{2(\beta_2 + \beta_4 S_t)} \quad (5)$$

Using this equation to get the derivation of S_t:

$$dR_t / dS_t = \frac{\beta_1\beta_4 - \beta_2\beta_3}{2(\beta_2 + \beta_4 S_t)^2} \quad (6)$$

From equation (6), we can see that the size relationship between $\beta_1\beta_4$ and $\beta_2\beta_3$ determines the direction of the influence of resource status on "threshold value". When $\beta_1\beta_4 < \beta_2\beta_3$, the derivative $dR_t / dS_t < 0$, resource status rises, which makes the "threshold value" become smaller and the resource curse effect is more likely to occur, and vice versa.

B. Selection of Indicators

1) Explained variable: Economic Growth (GR) adopts per capita GDP growth rate. Compared with the total GDP, the GDP per capita excludes the country's size and population factors and thus can reflect the level of comprehensive economic development in a more accurate way. Higher per capita GDP is usually accompanied by a better social security and medical care system and a higher level of national education. In specific calculation, the per capita GDP of a country for the year is obtained by using the Purchasing-Power-Parity (PPP)-adjusted real GDP divided by the population, and then the per capita GDP growth rate is calculated on this basis.

2) Explanatory variables: Resource Abundance (R): at present, differences exist in the indicators for measuring natural resource, such as the proportion of primary product exports as an percentage of GDP used in classical literature, which essentially measures the degree of dependence on resource exports. Since there are no accurate nature resource reserves data, the proxy variable chosen in this paper is per capita energy mineral output. The more resource a country has, the more it will develop and utilize its resource, so the output is highly correlated with reserves. Resource Abundance is obtained by using the World Bank data of primary energy output divided by the population of a country.

Global resource status (S) takes the contribution rate of global resource to economic growth as a proxy variable. Resource status as an important reflection of the global economic growth mode is the most direct manifestation of its importance in output. The higher contribution of resource to output means that producers tend to use more resource for production, and the global economy as a whole reliance on resource increases, thereby strengthening the impact of resource on economic growth. Specifically refer to Chen Jianglong et al (2004)'s approach to calculate the contribution of resource to output using the following formula:

Global Resource Contribution Rate = Percentage of Resource Growth * Output Elasticity Factor of Resource / Percentage of Real Economic Growth

The elasticity coefficient of resource output in the formula is based on the regression analysis of Cobb-Douglas production function in 90 countries from 1972 to 2017. It is limited in length, therefore; we will not discuss any further hereafter.

3) Control variables: Economic Development (Y_{t-1}): according to Solow (1956), under the assumption of diminishing marginal returns, the higher the national average income per capita is, the lower the economic growth rate is, followed by Barro and Sala-i-Martin's adjustment (1990) to the model which proves a conditional convergence in economic growth while controlling other factors that affect convergence, such as human capital, government investment and etc.. Therefore, we introduce the lagged variable of economic development as a control variable, which is specifically measured by the lagged PPP-adjusted GDP per capita, in order to be consistent with the explanatory variables.

Human capital (HC): from an output point of view, a higher level of human capital can improve labor efficiency and thus directly promote economic growth; and raising the level of human capital is conducive to promoting democracy and equality, thereby improving the economic development environment and laying the foundation for economic growth in the long term (Barro, 1997). Therefore, this paper introduces human capital, an important factor affecting economic growth, into the model. The most critical factor in the composition of human capital is the degree of education, and most empirical studies also use this type of indicator, such as the enrollment rate of secondary education and the enrollment rate of primary education. This article uses a relatively comprehensive indicator, i.e. the human capital index from Penn World Table 8.0 as a proxy variable, which is based on the number of years of education and the rate of return on education investment.

Material Capital Investment (MC): in neoclassical growth theory, investment is included in the model as an important factor for economic growth. Investment constitutes a component of aggregate demand in the short term, providing the necessary material basis for subsequent economic growth in the long term, and its promotion of economic growth has been universally recognized in the academic community. A systematic study by De Long and Summers (1990) shows that the ratio of fixed asset investment to GDP has a significant positive correlation with economic growth. In this paper, the Material Capital Investment is introduced into the model as a control variable, which is measured by the newly added fixed asset investment as a percentage of GDP, with reference to the general practice of the literature.

C. Sample Selection and Data Sources

This article selects relevant data from 90 countries from 1972 to 2017 as research samples. In the selection of the study time range, due to the impact of the oil crisis in the early 1970s, the world resource situation has undergone major changes. Therefore, the period of sample data selection began in 1972 to avoid data abrupt changes. The time span is 46 years, which is longer than the general literature of the same kind, and it is easier to examine the impact of the dynamic changes in global resource status. In the selection of sample countries, some countries with incomplete data are excluded. The total GDP of sample countries exceeds 70% of the world's total economic output. It basically includes the world's major economies and covers countries with different levels of economic development. It includes major exporting countries rich in resource, covering more than half of Organization of Petroleum Exporting Countries (OPEC) such as Saudi Arabia, Iraq, Iran, Kuwait, Qatar and Venezuela, as well as countries with relatively scarce resource such as Japan and South Korea.

The data used in this paper is mainly from the Penn World Table 9.0. Some of the data are from World Bank Indicators. The specific sources of model variables, metrics, and required data are shown in "Table I".

TABLE I. SOURCES OF VARIABLES, METRICS AND REQUIRED DATA

Variables	Metrics	Required Data	Sources
Economic Growth (GR)	Per Capita GDP Growth Rate	PPP-adjusted Real GDP in various countries	Penn World
		the Population in various countries	
Resource Abundance (R)	Per Capita Energy Mineral Output	Total output of energy mineral resource in various countries	World Bank
		the Population in Various Countries	Penn World
Global resource status (S)	Global Resource Contribution Rate	PPP-adjusted Real GDP in Various Countries	Penn World
		Total Input of Energy Mineral Resource in Various Countries	World Bank
		PPP-adjusted Total Capital Stock in Various Countries	Penn World
		The Employed Population in various Countries	Penn World
Economic Development (Y_{t-1})	Lagged GDP Per Capita	the lagged PPP-adjusted GDP Per Capita in Various Countries	Penn World
		the Population in Various Countries	
Human capital (HC)	Human Capital Index	Human Capital Index in Various Countries	Penn World
Material Capital Investment (MC)	Newly Added Fixed Asset Investment as a Percentage of GDP	Newly Added Fixed Asset Investment in Various Countries	Penn World
		PPP-adjusted Real GDP in Various Countries	

III. TEST RESULTS AND ANALYSIS

A. Selection of Measurement Methods

Because panel data of 90 countries for 46 years belong to the panel structure of large N and small T, and more features of cross-section data are displayed. Therefore, this paper does not consider unit root test and cointegration test, and use directly regression on panel data. First, the individual effect F test in the fixed effect model regression results was used to judge whether the sample individual effect was significant. The result showed that the corresponding probability value of the F test was 0.0000, and the null hypothesis that the individual effect was not significant was rejected. Therefore, the mixed regression did not apply. The Housman test was then used to make choices in the fixed-effect and random-effect models. After checking that the probability value of the chi-square statistic was 0.0000, the null hypothesis that there was no significant difference between the fixed effect and the random effect was rejected. A fixed effect model should be used. At the same time, in order to avoid the possibility that the heteroskedasticity problem may have unbiased interference with the results of the regression, we use robust standard errors of heteroskedasticity to correct it. In the process of regression, referring to the practices of Sachs and Warner (1995), variables for empirical tests were gradually added to observe the robustness of the regression results.

B. Test Results

The test results of the model are showed in "Table II".

TABLE II. MODEL TEST RESULTS

Model	(1)	(2)	(3)	(4)	(5)
R	0.0132*** (6.99)	0.0345*** (2.97)	0.0345*** (6.59)	0.0423*** (3.38)	0.0439*** (3.30)
R^2		-0.0012** (-2.33)	-0.0010** (-3.92)	-0.0010* (-1.85)	-0.0010* (-1.71)
RS			0.0163** (2.58)	0.0159** (2.33)	0.0158** (2.33)
R^2S			-0.0026** (-2.77)	-0.0025** (6.59)	-0.0024** (-2.02)
Y_{t-1}				-0.0016*** (-3.12)	-0.0020*** (-3.40)
HC					0.0196** (2.12)
MC					0.0002* (1.66)
Model	(1)	(2)	(3)	(4)	(5)
C	0.0336*** (33.83)	0.0258*** (5.54)	0.0254*** (10.25)	0.0396*** (5.27)	-0.0022 (-0.10)
F-statistic	48.90	120.46	238.53	464.89	141.64
Prob	0.0000	0.0000	0.0000	0.0000	0.0000
Observations	4140	4140	4140	4140	4140

a. Note: The values in () indicate the t statistic, and "***", "**" and "*" indicate significant at the 1%, 5%, and 10% levels respectively.

In regression equation (1), only one item of resource abundance (R) was introduced into the model for regression. The results showed that the coefficient was positive (0.0132) and significant at the 1% level, indicating that in the average sense, natural resource are conducive to economic development, which is consistent with the classic economics.

In the regression equation (2), the square of resource abundance (R^2) is added to equation (1). The results showed that the primary coefficient of resource abundance was still positive (0.0345), significant at the 1% level, and its quadratic coefficient was negative (-0.0012), which was significant at the 5% level. "The primary coefficient is positive while the quadratic coefficient is negative" indicates that natural resource and economic growth have an inverted U-shaped relationship. "Threshold value" exists in the impact of resource on a country's economic growth, and the degree of resource abundance is lower than the threshold, resource are beneficial to economic growth, but their promotion function will decrease as the negative effect of resource increases, and when a country's resource abundance exceeds the threshold, i.e. "excessive" nature resource, the negative effects will exceed the positive effects brought about by the resource themselves. On the whole, they are not conducive to economic growth and a resource curse effect will occur. The reasons for this result may be the following: First, the so-called "Dutch disease" phenomenon, excessive development of the resource industry will virtually squeeze out labor, capital and other factors, which is extremely unfavorable to the improvement of production efficiency; Second, the natural resource extraction industry requires a large amount of capital investment, a high entry barrier exists in this segment and thus an oligopolistic and monopolistic market pattern is easily formed. At the same time, the industry and are usually closely related to the government, and thus it is easy to breed rent-seeking and corruption, resulting in resource allocation inefficiency which hinders the long-term development of the economy; in addition, the availability of resource and the high premiums cause the so-called "inducing lazy and dependent people" effect, and the high income generated by natural resource makes it easy for people to become immersed in the improvement of their living standards, lose their aggressiveness, and ignore the long-term economic promotion function of those good comprehensive social factors such as economic management and social equity.

In regression equation (3), the interaction variables between the degree of resource abundance and the resource status, between the square of resource abundance and the resource status (RS and R^2S) are added in the model to observe whether the dynamic change of resource status will have an impact on the economic effect of the resource. The results showed that the sign and significance of one term and the squared term of resource abundance did not change, while the coefficients of the two interaction variables (RS and R^2S) were 0.0163 and -0.0026 respectively, and both were significant at the 5% level. This result confirms our basic previous judgment that the change in the resource status of the world as a whole has exerted moderation on the economic effects of a country's resource. The economic effects of resource and the occurrence conditions of the resource curse are not static, and this dynamic change is not entirely due to the internal reasons of the economy itself, but also due to the global economy growth mode as an external environment in certain degree. Once the resource status changes in the path of economic development, the threshold for the occurrence of the "resource curse" will shift, and the specific direction of deviation will be calculated and analyzed below.

Next, in regression equations (4) and (5), control variables such as economic development level (Y_{t-1}), human capital (HC), and material capital (MC) are added in order to gradually enrich the model and test the robustness of the regression results. The results show that the sign of the existing variables does not change after adding the control variables and are still significant. In terms of control variables, the economic development level is significantly negative at the 1% level (-0.0020), indicating that the economic growth meets the conditional convergence characteristics. Human capital is significantly positive at the 5% level (0.0196), and the positive role of human capital in promoting economic growth has also been affirmed. Material capital investment is significantly positive (0.0002) at 10% level, indicating that material investment is also a key factor of economic growth, which is in line with the classical growth theory.

C. Global Resource Status and Dynamic Changes of "Resource Curse Threshold"

According to the calculation of the regression results in column (5) of "Table II", it can be seen that $\beta\beta < \beta\beta$, i.e. $dR_0/dS_t < 0$, the rise of the global resource status will lead to the "threshold value of the resource curse" becoming smaller, and the decline of the resource status will make the "threshold value" larger, which is consistent with the previous theoretical assumptions.

By formula (6), the inflection point at which resource begin to deteriorate economic growth can be obtained. Figure 1 shows the changes in global resource status and the "resource threshold" since the beginning of the new century. It can be seen that with the increasing importance of global resource status, the critical value generated by the resource curse has constantly shifted left, and the threshold value for falling into the resource curse trap has decreased since 2000. This means that more and more countries are more likely to be subject to the resource curse.

However, judging from the 90 sample countries that we examined, during the sample period, only a few countries such as Kuwait and Qatar have resource abundance exceeded the threshold value in some years. Most countries are on the left side of the "threshold value", which means the resource abundance do not have a negative impact on the economic growth rate. The future outlook depends on the changes in the global economic development model and in the resource status. If the importance of resource has been in the rising channel, it does not rule out that more countries will fall into "resource curse trap". Technological progress occupies an important position in the economic growth of the world, especially of those developed countries, but global economy on the whole has not yet leaped over the resource-driven phase, the deepening and development of the international division of labor especially in the global value chain, and the increasing contribution to the world economy of the extensive economic growth in the developing countries may be an important reason for the rising importance of global resource since the beginning of the new century. The transformation of the economic development mode in the global sense is a long and arduous task.

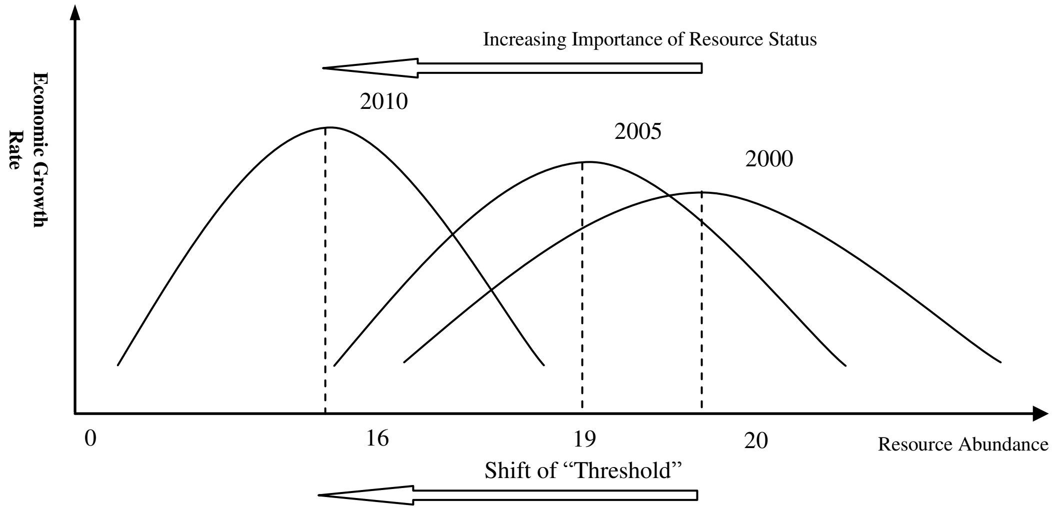

Fig. 1. Dynamic change of global resource status and resource curse threshold.

IV. CONCLUSION

This paper uses the panel data of 90 countries from 1972 to 2017 to empirically test the non-linear relationship between natural resource and economic growth, the existence of resource curse threshold, especially the impact of changes in resource status to economic growth, and draws some main conclusions as follows:

- There is an inverted U-shaped relationship between natural resource and economic growth, and there is a "threshold value" for the impact of resource on a country's economic growth. When the level of resource abundance is lower than the "threshold value," resource are favorable to economic growth. However, this promotion will diminish as the negative effect of resource increases. When a country's resource abundance exceeds the threshold, the resource will have a curse effect on the economic growth of a country.
- The resource status depending on the global economic development mode has a significant impact on the relationship between natural resource and economic growth. With the rise of the resource status in the world economy as a whole, the inverted U-shaped curve shifts to the left. The impact of resource on economic growth becomes even stronger, the resource curse effect intensifies, and the "threshold" decreases, which may have more countries, fall into the resource curse trap, or vice versa.
- Of the 90 sample countries that we examined, the resource abundance of a few countries such as Kuwait and Qatar exceeded the "threshold value" of the curse in some years. For most countries, natural resource is still conducive to their economic growth. However, the rising trend of the resource elements status in recent years has given us reason to worry that more countries will be plagued by resource curses in the future. The specific evolution will depend on the changing pattern of global economic development.

The above research results have at least the following implications for us to understand and handle resource issues:

- Natural resource is a double-edged sword for economic growth. When using resource, it is necessary to recognize that resource can bring economic dividends, as well as negative effects such as rent-seeking behavior and inducing laziness. Each country can guide the rational use and resource allocation optimization by strengthening the construction of relevant natural resource laws and regulations, establishing a scientific and clear natural resource property rights system, improving the price and trading mechanism of natural resource, and coordinating with the government's macroeconomic regulation and control.
- All countries should formulate resource and industrial policies based on their own level of natural resource. For countries with rich resource, attention should be paid to preventing over-reliance on resource, actively

guiding the diversified development and transformation of industries, and making full use of the dividends of resource industries to increase education and infrastructure investment to lay the foundation for long-term economic development. For countries with relatively scarce resource, the development of resource industries should be strengthened, encouraging technological innovation in this field as well as exploring international channels actively to ensure stable external supply.

- All countries should strengthen cooperation and work together to promote the transformation of the global economic development mode. The relationship between a country's resource and economic growth is not only related to its own situation, but also constrained by the global economic development mode, that is, the resource status. Therefore, changing the mode of economic development is an important way to weaken the negative effects of resource and reduce the risk of resource curses. Countries should strengthen cooperation in various fields such as the environment, climate and production capacity, and jointly promote the transformation of the global economic development mode.

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