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Empirical Study on the Relationship between Export Commodity Structure and Carbon Emission in Henan Province

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Abstract: This article studied the relationship between export commodity structure and carbon emission based on VAR model and it shows that the carbon emission in Henan Province is not only subject to itself, but also to each export commodity structure factor, especially, the fluctuation of export of low value-added product has an obvious impact on carbon emission. Hence, as far as export policy is concerned, to actualize economic low-carbonization, Henan Province should accelerate the upgrading of industrial structure, intensify the research of low-carbon technology, improve environmental standard, perfect finance and taxation system and develop international cooperation.

Key words: Henan province, export commodity structure, carbon emission, VAR

INTRODUCTION

Nowadays, there has been an extensive research on the connection between trading and environmental pollution issue among the researchers from home and abroad. As for references from abroad, basically, there are three main standpoints. The first one believes that the trading and the environment are compatible which means that the liberalization of trading will contribute to the improvement of the environment. Researchers behind this viewpoint are Cole and Ragner (1997). For the second one believes just the opposite. They considers that trading and the environment are incompatible which means that international trading is the main incentive leading to the transborder pollution. The third one believes that the connection between free trading and environmental pollution cannot be simply recognized as one-way issue, there must be some threshold existing. Supporters behind this theory are Copeland and Taylor (1994, 2003, 2004), etc. As for references at home, there are also three main viewpoints. The first one is supportive of this thory that china will not become a pollution haven for free trading. The second one believes that the scale effect and the structural effect of the negative effect brought by the free trading overweighs the positive effects which implicates that it is the trade liberalization that leads to environmental deterioration. There are also ones who believe that the connection between international trading and environmental pollution are complicated.

Nevertheless, more references focus on the perspective of trade volume. In terms of theoretical and empirical research for trading pattern are relatively limited, let alone references especially for provincial economic issues which are rather less. Based on the consideration above, this essay will study the relationship between export commodity structure and carbon emission based on VAR model by taking an example of He Nan province.

METHODOLOGY

The traditional structural approaches often use economic theory to describe the relationship among variables. However, the economic theory usually cannot provide a strict definition for the dynamic relationship among variables and the endogenous variables may appear on both sides of the equation at the same time which would make estimation more complicated. In order to solve these problems, the non-structural approach in reference to multi-variable model is introduced. The VAR (Vector Auto regression) is a kind of such model which is usually applied to time-series forecasting system and the dynamic effect analysis of variables system in response

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to random disturbance. Meanwhile, this model avoids the lag of every endogenous variable which exists in Structural Approach.

As a matter of fact, VAR is a simplified Vector Autoregressive Moving Average Model (VARMA) which contains more parameter so that researchers prefer to the former one. Normally, a general mathematical expression of VAR model is as follows:

$$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + B_1 x_t + \cdots + B_r x_{t-r} + \varepsilon_t \quad (1)$$

where, y_t is the m-dimensional vector of endogenous variables and x_t is the d-dimensional vector of exogenous variables. As for $A_1 \ldots A_p$ and $B_1 \ldots B_r$, they are parameter matrix to be estimated. As to endogenous variables and exogenous variables, p-order lag and r-order lag are their respective lags. ε_t is a random disturbance term which is relative to time element, but not to hysteresis value of itself or variables on the right side of the model. This model could be known as VAR(p) model. In practical application, the lager the lag order is, the easier of the dynamic characteristics will be reflected. However, in order to solve the trade-offs between hysteresis value and variance, minimization of AIC and SC will be used, thus balanced model order will be achieved.

Main calculation procedures of this model are as follows:

- First, checkout the stationary of the time series and difference sequences. If the mean or auto covariance function change over time, then the sequence is non-stationary time series. For example: randomized procedure $\{y_t, t = 1, 2, \ldots\}$ in the equation of $y_t = \rho y_{t-1} + \varepsilon_t$, if $\rho = 1$, ε_t is a stable process and $E(\varepsilon_t) = 0$, $Cov(\varepsilon_t, \varepsilon_{t-s}) = \mu_t < \infty$, where s = 0, 1, 2,.., we consider this procedure as Unit Root Process. If any unit root exists, there can not be a direct regression, or else a spurious regression will be caused which may affect the real results of the model analysis. For this, after first difference, the unit root process get changed to be a stationary process which is $y_t - y_{t-1} = (1-B) y_t = \varepsilon_t$. The time series y_t will be reckon as first-order integrated series which is I(1). Generally, if a non-stationary time series get to become a stationary process after d-difference, it will be called as d-order integrated series which is I(d). For those variables need to be regressed, only under the condition of the same order integrated series, the regression analysis can be continued
- Second, the foundation of the VAR model. The lag order of VAR model will be determined by the criterion of AIC and SC. However, when to get the optimal lag phases under the norm of AIC and SC, inconsistency may be occurs, thus LR test will be introduced to get the final result. Under null hypothesis, LR statistics will be stayed as a asymptotic χ^2 distribution, whose variance will equal the number of the zero-bound equation of the VAR model under different orders. Besides, screening will not be carried out in the establishment of the VAR model, each lagged variable will be retained
- Third, Granger Causality Test. In order to prevent spurious regression and to confirm whether there is a causal relationship among the sequences; granger causality test will always first access the interpretation degree of the variable's own lag and then verify that the introduction of lagged values of another variable. Variables can improve the interpretation of the previous level. If possible, we will call the latter one to be the granger causes of the former one
- Fourth, Impulse Response Analysis. Add a standard deviation on any disturbance will have an impact on the current value and future value of endogenous variables and the impulse response function is used to keep track of this effect. The impulse response function can be drowned as impulse response curve which can allow us to analyze the dynamics of endogenous variables more directly. If the impulse response curve tends to 0 that indicates that a temporarily change in one variable has no lasting impact on the other variables; If it tends to be a certain value that indicates that a temporarily change in one variable has a lasting impact on the other variables; if the impulse response curve is above the zero coordinate lines that indicates that a temporary change in one variable can cause another variable change in the same direction; if the curve is located below the zero coordinate lines that indicates that a temporary change in one variable will cause another variable change in the reverse change
- Fifth, variance decomposition which was brought out by Sims in 1980. It provides a way to determine the dynamic coherence of the economic series variables. As a matter of fact, variance decomposition is an Innovation Accounting process which contributes to decompose the Mean Square Error (MSE) at different predictive period into each variable. The principal idea of variance decomposition is to decompose the fluctuation (k-step prediction mean square error) of each endogenous variable (a total number of m) emerged from the system into m-part which are associated with those equations. Thus, we could get a better understanding of the relative importance of

the endogenous variables. The variance decomposition could not only check out the causal relationship outside the sample period but also affect itself and other variables

EMPIRICAL ANALYSIS

Variable-definition: In this study, we define LnC_t as the logarithmic transformation of carbon emissions in Henan Province, where LnX_t is defined as the logarithmic transformation of gross export in Henan Province, where $LnPPX_t$ is defined as the logarithmic transformation of exports of primary products in Henan Province, where $LnMPX_t$ is defined as the logarithmic transformation of exports of industrial products in Henan Province, where $LnNIPX_t$ is defined as the logarithmic transformation of exports of natural resource-intensive products in Henan Province, where $LnLIPX_t$ is defined as the logarithmic transformation of exports of labor-intensive products in Henan Province, where $LnCTIPX_t$ is defined as the logarithmic transformation of exports of capital and technology-intensive product.

Stationary test: Check out the unit root of the level value of each variable, the first-order and second-order differential value. The test will be continued until no unit root or second-order difference sequence exists. Augmented Dickey-Fuller Test will be adopted as the testing method; the final results will be shown in Table 1.

Here, C, T, L represent the constant, time trend and lag period, * represents the critical value in the 1% confidence level, *, ** and ***each, respectively represents the critical value in the 1%, 5% and 10% confidence level

The results show that: After second-order difference, all of those non-stationary time series are changed into stable time series, which is I(2).

VAR model: Build VAR Models, respectively forLnC_t, LnX_t, LnC_t, $LnPPX_t$, $LnMPX_t$, LnC_t, $LnNIPX_t$, $LnLIPX_t$ and $LnCTIPX_t$. According to the principle of minimization of AIC, SC and the LR test, the lag period of this model will be determined. The results of the estimated parameters can be written in Eq. 2-4:

$$\begin{bmatrix} LnC_t \\ LnX_t \end{bmatrix} = \begin{bmatrix} 1.56 & -0.01 \\ 3.44 & -0.35 \end{bmatrix} \begin{bmatrix} LnC_{t-1} \\ LnX_{t-1} \end{bmatrix} + \begin{bmatrix} -0.94 & 0.02 \\ -2.16 & 0.39 \end{bmatrix} \begin{bmatrix} LnC_{t-2} \\ LnX_{t-2} \end{bmatrix} + \begin{bmatrix} 0.28 & 0.29 \\ 2.47 & 0.24 \end{bmatrix} \begin{bmatrix} LnC_{t-3} \\ LnX_{t-3} \end{bmatrix} + \begin{bmatrix} 0.19 & -0.4 \\ -0.53 & -1.33 \end{bmatrix} \begin{bmatrix} LnC_{t-4} \\ LnX_{t-4} \end{bmatrix} + \begin{bmatrix} 0.52 \\ -3.68 \end{bmatrix} \quad (2)$$

$$\begin{bmatrix} LnC_t \\ LnPPX_t \\ LnMPX_t \end{bmatrix} = \begin{bmatrix} 1.17 & 0.13 & 0.01 \\ -2.55 & -0.38 & 2.57 \\ -1.54 & -0.02 & 2.03 \end{bmatrix} \begin{bmatrix} LnC_{t-1} \\ LnPPX_{t-1} \\ LnMPX_{t-1} \end{bmatrix} + \begin{bmatrix} -0.38 & -0.24 & 0.06 \\ 3.81 & 1.2 & -1.13 \\ 3.92 & 0.71 & -1.03 \end{bmatrix} \begin{bmatrix} LnC_{t-2} \\ LnPPX_{t-2} \\ LnMPX_{t-2} \end{bmatrix} + \begin{bmatrix} -0.14 & -0.16 & 0.26 \\ -3.67 & 0.38 & -0.75 \\ -2.19 & 0.04 & -0.87 \end{bmatrix} \begin{bmatrix} LnC_{t-3} \\ LnPPX_{t-3} \\ LnMPX_{t-3} \end{bmatrix} + \begin{bmatrix} 2 \\ 10.69 \\ 0.94 \end{bmatrix} \quad (3)$$

$$\begin{bmatrix} LnC_t \\ LnNIPX_t \\ LnLIPX_t \\ LnCTIPX_t \end{bmatrix} = \begin{bmatrix} 0.51 & 0.23 & 0.35 & -0.23 \\ -0.1 & 0.63 & 0.78 & -0.37 \\ -0.62 & 0.76 & 1.41 & -0.81 \\ -0.62 & -0.39 & 1.34 & -0.32 \end{bmatrix} \begin{bmatrix} LnC_{t-1} \\ LnNIPX_{t-1} \\ LnLIPX_{t-1} \\ LnCTIPX_{t-1} \end{bmatrix} + \begin{bmatrix} 0.35 & -0.35 & 0.1 & -0.03 \\ -0.12 & -0.63 & 0.87 & -0.49 \\ 1.79 & -1.39 & 0.82 & -0.51 \\ 2.11 & -0.62 & 1.18 & -0.94 \end{bmatrix} \begin{bmatrix} LnC_{t-2} \\ LnNIPX_{t-2} \\ LnLIPX_{t-2} \\ LnCTIPX_{t-2} \end{bmatrix} + \begin{bmatrix} 0.02 \\ 2.12 \\ -4.13 \\ -8.09 \end{bmatrix} \quad (4)$$

As is showed in the three matrix above, we give more concerns about how the carbon emissions itself and those trading variables affect the carbon emissions in Henan Province. Obviously, with the increase of lag period, its impacts on current carbon emissions are fading while its direction of the influence is uncertain; The bigger of the exports trading variables lag period, the stronger of its impact on the carbon emission while its direction is uncertain; The lagged period of primary exports variable have strong influence on current carbon emission variables while its direction is uncertain; For trading exports of the manufactured goods, with its raise of the lag period, it will have a positive effect on the current carbon emission variables; The lag period of natural resource- intensive exports will have a significant impact on current carbon emissions, still the direction is uncertain; The lag variables of labor-intensive exports, capital and technology-intensive exports variables will produce positive and negative effects, respectively on the current carbon emissions.

Table 1: Stationary analysis for each variable

Variable	Difference order	ADF value	Inspection type (C, T, L)	Critical value	Consequence
LnC_t	Second	-3.86	C, 0, 0	-3.12**	Steady
LnX_t	Second	-3.84	C, 0, 0	-3.12**	Steady
$LnPPX_t$	Second	-3.45	C, 0, 0	-3.12**	Steady
$LnMPX_t$	Second	-4.62	C, 0, 0	-4.06*	Steady
$LnNIPX_t$	Second	-3.45	C, 0, 0	-3.12**	Steady
$LnLIPX_t$	Second	-5.24	C, 0, 0	-4.06	Steady
$LnCTIPX_t$	Second	-3.06	C, 0, 0	-2.7***	Steady

Granger causality test: To further illustrate the causal relationship between the two variables, Granger Causality Test needs conducting. The results are shown in Table 2.

According to Table 2, when the significance level is set to be 25%, all trading variable Granger cause the carbon emission except for the variable of exports of manufactured goods and export of primary products has the most significant influence on it.

Table 2: Results of granger causality test

Model No.	Null hypothesis	Lag	F-statistic	p-value
1	$LnX_t \nrightarrow LnC_t$	3	1.80488	0.2464
2	$LnPPX_t \nrightarrow LnC_t$	2	3.31069	0.0836
	$LnMPX_t \nrightarrow LnC_t$	2	0.55459	0.5928
3	$LnNIPX_t \nrightarrow LnC_t$	4	2.55752	0.2332
	$LnLIPX_t \nrightarrow LnC_t$	4	3.12960	0.1879
	$LnCTIPX_t \nrightarrow LnC$	4	4.86029	0.1124

Impulse response analysis: Impulse response function is used to measure the impact of Standard deviation pulse from the random disturbance term to the current and future value of the Endogenous variables. In Eviews, the VAR output can be drawn as Fig. 1.

According to Fig. 1, each carbon emission has a strong effect on their own standard deviation innovation; For the export trade, the standard deviation innovation has almost no response on its first three period which however has a strong positive and negative responses on the fourth periods; For the exports of primary products and manufactured goods trade, the standard deviation innovation has almost no response on its first eight stages which however begin to gradually increase from the ninth stage and more intense responses are recorded

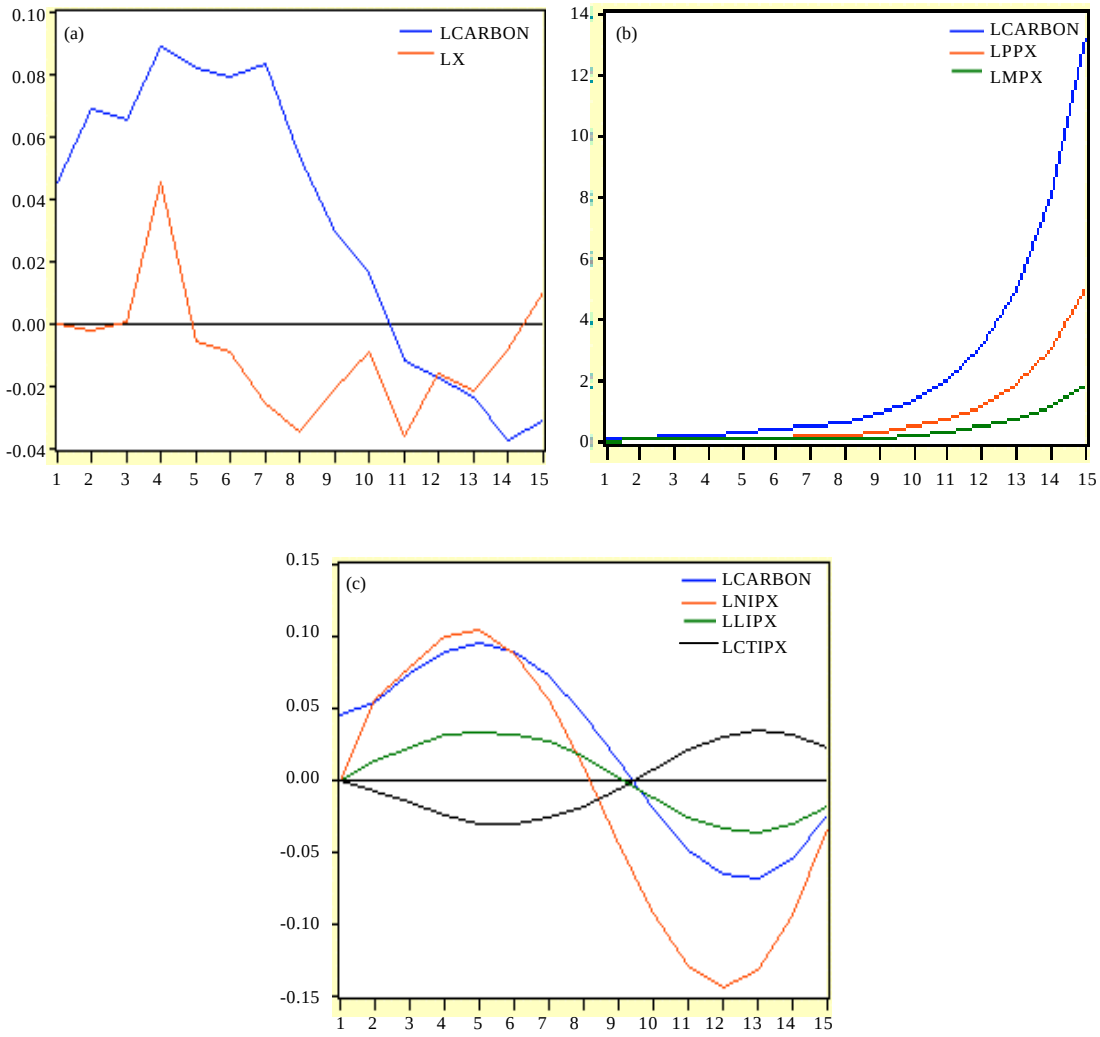

Fig. 1(a-c): Response to standard deviation innovation from different models

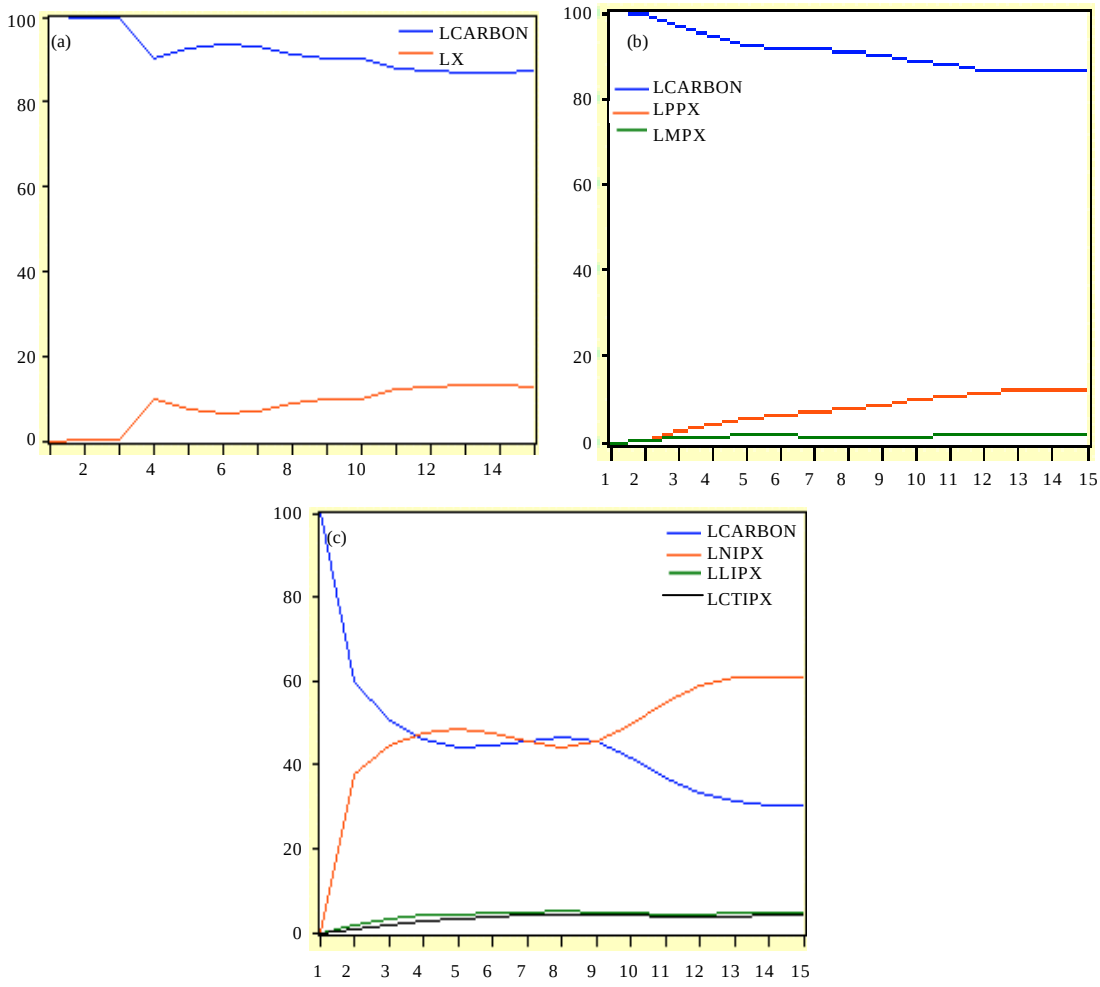

Fig. 2(a-c): Variance decomposition from different models

from the former; For the factor-intensive exports, the standard deviation innovation has almost no response on its first phase which however has a strongly alternating positive and negative responses on the second periods and responses sharply to the natural resource-intensive exports while roughly have the same magnitude response on the labor-intensive exports and capital and technology-intensive exports.

Variance decomposition: We will use variance decomposition model to further study the dynamic characteristics. In Eviews, the decomposition results are shown in Fig. 2.

According to Fig. 2, the volatility of carbon emissions will only get affected by itself in the first stage; Afterwards, the effects from itself are declining by varying degrees while those from the trade variables volatility shocks are increased to varying degrees, of which the total export trade, export volume of primary products, manufactured goods trade, trade and labor-intensive exports of capital and technology-intensive products, the impact of fluctuations in the export trade Impact is more limited, but for natural resource-intensive exports, the effect becomes more obvious from the second stage. Thus, the variance decomposition is consistent with the above conclusions.

CONCLUSION

In short, except by their own inertia effects, the carbon emission will also be affected by the main factor which is the structural factors of exports. Especially for the exports of low value-added products which have more obvious role on the carbon emission. Therefore, in order

to fulfill low-carbon economic development in Henan Province, some export trade policies must be achieved from the following aspects:

First, in order to achieve low-carbon export trade, we must accelerate the industrial upgrading. In order to solve the pollution problems, some measures are conducted which mainly embodied in the scale effect, structural effect and technical effects, where the structure effect has a positive effect on the reduction of trade pollution. As a natural upgrade in industrial structure, the carbon pollution intensive sectors will gradually be eliminated; low-carbon sector will gradually become the main supportive economic entities which would bring inhibition to the exacerbating carbon emissions in Henan Province. Therefore, accelerating industrial upgrading, promoting the low-carbon technology to realize the low-carbon economy.

Second, in order to fulfill the low-carbon export trade, we must enhance learning the low-carbon technologies which include carbon reduction technologies at the target of emission reduction, non-carbon technologies based on the renewable resources and carbon-based processing technology based on carbon capture and sequestration of carbon. At present, most of those core technologies are mastered by the developed counties while the developing countries can largely rely on independent innovation to develop the low-carbon technologies. Thus, at the guidance of scientific concept of development, Henan Province should be continuously improving its low-carbon technology innovation system. At the same time, build some projects in a planned way and take full account of the comparative advantages, so as to provide technical support for carbon trading.

Third, in order to achieve low-carbon export trade, we have to improve the environmental standards. The typical characteristics of the traditional mode of economic development are at the sacrifice of the wasting resources and environmental degradation. In the background of the harmonious development of man and the natural environment, Henan Province must transform its concept and development models actively, by increasing production of export goods, environmental standards, For one hand, it will effectively prevent the foreign capital regarding the locality as a "pollution haven"; For the other hand, it can also force the domestic foreign trade enterprises to accelerate technical innovation to meet the demanding environmental standards, thereby enhancing its competitiveness in trading competition.

Fourth, In order to achieve low-carbon export trade, the tax system has to be improved. Modern economics consider that it is the system that affects the growth of economic significantly. For any economic phenomena, we can find out its institutional roots. Thus an effective system leads to high efficient economic, whereas improper system leads to low efficient or even inefficient economic. Therefore, for the development of low carbon export trade, Henan Province will need a relatively comprehensive institutional platform (especially the taxation system) to be guided, to fulfill the low-carbon objective by fiscal policy constraints and incentives.

Fifth, in order to achieve low-carbon export trade, we must develop the international cooperation. In view of the absolute advantages in developing countries on low-carbon economy, Henan Province should introduce more international cooperation, digesting and utilizing the advanced experiences and focus on developing high value-added export industries. In the meantime, the government should also take advantage of the Clean Development Mechanism (CDM) and seek win-win situation. Practice shows that the global climate problem can only be effectively solved on the basic of the framework of global cooperation while the export trade is the important link among the world. Only by the mutual understanding and support, a high degree of coordination from the different countries and regions can the low-carbon economic be achieved.

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