Research on carbon emission reduction based on the optimization of transportation structure under VAR model

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Abstract. In the process of rapid economic development, protecting the environment has become an important task. As the world's second largest greenhouse gas emission sector, the transport sector's emission reduction situation is not optimistic. Based on the theoretical mechanism analysis of the impact of transportation structure on carbon emissions, this paper studies the impact of transportation structure change on carbon emissions, as well as the duration, degree and response direction of transportation structure optimization and carbon emissions. Based on the empirical results, the dynamic interaction mechanism between structural factors and transportation carbon emissions is discussed in the hope of contributing to environmental protection.

1. Introduction
Economic development and environmental protection is an important task facing all countries, the transportation is one of the fastest growth in CO2 emissions. A 2007 study published in the proceedings of the national academy of sciences by the Oslo center for international research on climate and environment found that gases released from fuels used in cars, ships, planes and trains are one of the leading causes of global warming. According to the report, global emissions have increased by 13 percent over the past 10 years, while emissions from transportation have increased by 25 percent. It is expected that by 2050, the carbon emission of global transportation will increase by 30% to 50% compared with the current level. It is not difficult to see from the international community's discussions and agreements on environment-related issues that carbon emission reduction has become an important issue in the affairs of governments. From the international practical situation, the carbon emission of transportation is the key industry. No matter developed country or less developed area, transportation carbon emission ranks first. In recent years, global carbon emissions have continued to increase, and the growth rate of carbon emissions from transportation has exceeded the total carbon dioxide emissions. In the process of our country economy develops ceaselessly, change development mode, undertake structural adjustment already became our country transportation industry future development direction. Therefore, the research on low-carbon development of China's transportation system, especially the research on carbon emission reduction based on structural optimization, is more important.
2. Literature review
It has been recognized by many researchers at home and abroad that transportation structure can influence carbon emission. In foreign countries, Mazzarino believed that the optimization of transportation structure could effectively promote carbon emission reduction, and the optimization of Italian structure promoted the carbon emission reduction of Italian transportation by 25% from 1980 to 1995[1]. Jeff Kenworthy studied the greenhouse gas emission of passenger transport structure in 87 cities around the world in 2003[2]. Poudenx analyzes the carbon emission factors that affect the structure of passenger transport, and analyzes the main factors and emission reduction possibility of carbon emission from the perspective of action mechanism[3]. Tapio studied the decoupling between the economic growth of the transportation industry in Europe from 1970 to 2001 and the transport volume and greenhouse gases, and believed that the 15 EU countries were in a state of negative decoupling of growth on the whole during the 1990s[4]. Greaves developed a modeling tool for assessing carbon emissions from transport to assess the effectiveness of carbon emissions from the transport sector[5]. Bristow et al. conducted policy simulation for the carbon emission reduction path of road passenger transport in the UK in the future[6]. In China, zhang Ming believes that from 1991 to 2006, China's transportation structure played a significant role in the increase of transportation energy consumption[7]. Chang shiyuan et al. believed that the transportation structure played a significant role in promoting the energy consumption growth of China's inter-urban passenger transport from 2000 to 2005, and the carbon emissions generated under its influence accounted for about 20% of the total energy consumption change in the same period[8]. Zhang shuwei et al. believed that the transportation structure played a continuous role in promoting the increase of energy consumption from 1980 to 2001[9]. Xu yanan et al. calculated the total carbon emission and carbon emission intensity of China's transportation industry from 1995 to 2008, and focused on analyzing the effects of population and economic factors on the carbon emission of the transportation sector[10]. According to the IPCC inventory guide report, wu kaiya et al. calculated the change trend of energy consumption carbon emission, carbon emission per capita and carbon emission intensity of Shanghai's transportation industry from 2000 to 2010[11]. Xue into based on each department such as fuel consumption multiplied by the departments for CO₂ emissions coefficient of carbon emissions, the results show that during 1980-2007 China transportation emissions increased 5 times[12]. Based on the above domestic and foreign studies, the research on the impact of transportation structure on carbon emissions focuses on static data analysis, that is, the influence measurement of historical data, and lacks dynamic research on the impact of transportation structure on carbon emissions. The research conclusions obtained have certain historical limitations. The interpretation of the future development and change trend of the relationship between the two is limited.

3. Research design and model construction
3.1. Research framework
Research framework as shown in figure 1, this paper studies the transportation structure optimizing ability of carbon reduction. First of all to transport structure theory analysis of the mechanism of carbon emissions influence. Then using dynamic research, impulse response analysis based on VAR model, impulse response analysis and variance analysis, the study of transportation structure and carbon system, under the interaction of the two analog pulse transportation structure change direction on its carbon emissions, influence and continuous cycle, simulation of transport structure optimization of carbon emission reduction effect. Finally combining the above mechanism research and empirical analysis, comprehensive analysis.
3.2. theoretical analysis of influence mechanism

Transportation structure refers to the share of total transportation turnover of a country or region in different transportation modes. The influence mechanism of transportation structure on its carbon emission can be summarized as follows:

(1) The energy intensity of different transportation modes varies greatly. Transportation modes are divided into four kinds: road transport, rail transport, water transport and air transport, road transport energy intensity is 0.5959 tce/ton-km, railway energy intensity is 0.0995 tce/wan ton-km, waterway transportation energy intensity is 0.0540 tce/ton-km, air transport energy intensity is 6.5069 tce/ton-km.[13] Therefore, transportation modes may structure changes of energy intensity of the industry have a significant impact.

(2) The carbon emission intensity of transportation mainly depends on its energy intensity. The carbon emission of transportation mainly comes from fuel combustion, which is mainly dependent on energy intensity and is slightly affected by engine and combustion technology. Therefore, the change in energy intensity of the industry caused by structural change can be quickly transmitted to carbon emission intensity and has a significant impact on the carbon emission of the industry.

3.3. Build VAR model

Since static factor decomposition analysis can only decompose historical data, dynamic interaction between China’s transportation structure and carbon emissions cannot be analyzed dynamically. In order to study the change of transportation structure and carbon emissions between dynamic effect, this article to build VAR model for impulse response analysis and variance decomposition analysis. The structure of the VAR model principle is that each of the endogenous variable as a function of the system in all endogenous variable lag value to construct the model, so as to avoid the structure modeling method in the need for the system of each endogenous variable of all the modeling of endogenous variable lag value[14]. At the same time, because the transportation system as the subsystem of the social economic system, Therefore, Cobb-Douglas production function is adopted as the design basis of the model, and its variant is used to construct the regression model of the influence of structural factors on the carbon emission of transportation:

\[ C = \varepsilon \times S_t^\beta \]  

In formula (1), is the transportation structure, which is expressed by the proportion of the sum of railway transportation and water transportation turnover in the total transportation turnover. Since the
carbon emission intensity of railway transportation and water transportation is small, the transportation structure studied in this paper also represents the low-carbon degree of the transportation structure. Is the elasticity of carbon emission to transportation structure; T is the year; Is the error term of the regression model. In order to eliminate heteroscedasticity and non-stationary factors without changing the original properties of the data, logarithm is taken from both sides of equation (1)

\[
LnC = A + \beta \times LnS_i
\]  

In equation (2), A is a constant term. Equation (2) is VAR regression basic model.

4. Empirical research

4.1. Data sources

The research data adopted in this paper are mainly from China statistical yearbook, China statistical bulletin of highway and waterway development, China traffic yearbook, etc. For the missing data of some indicators in this paper, refer to relevant literature for repair.

4.2. Impact response analysis

According to ADF test data stationarity, the logarithmic lnC and lnS of carbon emission and structural time series data are all one-order single integrated series at 5% significance level. According to akachi information criterion (AIC), schwarz information criterion (SC) and LR(Loglikelihoodratio) statistics, the optimal lag time is determined to be 2, and Johansen test shows that there is a co-integration relationship. The VAR model was established. The overall fitting degree of the model was 0.901, and all the characteristic roots of the VAR model were located in the unit circle. The model structure was stable and the fitting degree was good. The VAR model is shown in equation (3):

\[
\begin{bmatrix}
\Delta LnC \\
\Delta LnS
\end{bmatrix}
= \begin{bmatrix}
-0.095908 & -0.058352 & -0.051792 \\
-0.095908 & 0.051254 & 0.119051
\end{bmatrix}
\begin{bmatrix}
\Delta LnC(-1) \\
\Delta LnS(-1)
\end{bmatrix}
\begin{bmatrix}
-0.113801 & -1.583178 & \Delta LnC(-2) \\
-0.028174 & 0.123428 & \Delta LnS(-2)
\end{bmatrix}
+ \begin{bmatrix}
\gamma_i \\
\gamma_i
\end{bmatrix}
\]  

For VAR model impulse response analysis. The impulse response function can describe the system within a one standard deviation of the endogenous variables impact on the dynamic effect of the whole system. Specifically, an endogenous variable in the model after a one standard deviation impact, affected all the endogenous variables in the model, the current and future impact to respond to different periods respectively. Impulse response figure to visual indicators of the endogenous variable response under the impact of positive and negative direction information, adjust delay, stable process, etc. Under the impact of transportation structure in our country, traffic transportation structure of carbon emissions and response is shown in figure 1. Visible, Transportation structure of a standard deviation from its own information in the first period immediately produced a short-term positive response, suggesting that if a standard deviation of the transportation structure optimizing, to make the transportation structure in the first phase of ascension optimization degree about 7% the effect reduced to about 1% from the second phase of the start, then gradually converge to 0. Transport carbon emissions and the shock response of the transportation structure in stage 1 and 2 is very weak, (3) the rapid change of 11%, means that influenced by structure optimization, the stage of transport carbon emissions can be reduced by 11% then effect is abate, After the 5th phase, it gradually converges to 0. It can be seen that the optimization of China's transportation structure can not only promote its own further optimization, but also be more conducive to the carbon emission reduction of transportation.
Figure 2. Impulse response of China's transportation structure optimization to carbon emission of transportation and transportation structure.

Table 1 shows the variance decomposition results of transport carbon emissions, can reflect the structure and carbon emissions their own contribution to the carbon changes. Visible, transportation structure to a larger impact on transport emissions, although the current impact of 0, but 2 affects up to 17.01%, since the beginning of the third period, influence gradually stability, at the end of up to 62.43%.

| Period | Standard deviation | Δ lnC | Δ lnS |
|--------|--------------------|-------|-------|
| 1      | 0. 088484          | 100. 0000 | 0. 000000 |
| 2      | 0. 088729          | 99. 82988 | 0. 170118 |
| 3      | 0. 143293          | 38. 27760 | 61. 72240 |
| 4      | 0. 144824          | 37. 67612 | 62. 32388 |
| 5      | 0. 144906          | 37. 69595 | 62. 30405 |
| 6      | 0. 145101          | 37. 59929 | 62. 40071 |
| 7      | 0. 145153          | 37. 57455 | 62. 42545 |
| 8      | 0. 145163          | 37. 57080 | 62. 42920 |
| 9      | 0. 145166          | 37. 56894 | 62. 43106 |
| 10     | 0. 145167          | 37. 56843 | 62. 43157 |

From of transportation structure and the dynamic interaction between carbon emissions, the transportation structure optimization can effectively promote the transportation in our country carbon emissions. Impulse response function, according to the transportation structure optimization in China not only can effectively promote the transport carbon emissions, but also to the transportation structure optimizing themselves play a significant and sustainable contribution. At the same time, variance decomposition analysis shows that our country transportation structure on the influence of transport carbon emissions, of about 63.73%.

5. Conclusion
Overall, China's transport structure has a positive and negative impact on transport carbon emissions, transportation structure factors become a contributor of transport carbon emissions growth. Because of the economic development and people's living standards improve, lead to the upgrade of traffic demand. More and more traffic participants to have the ability for quick, convenient, comfortable high carbon traffic patterns to pay higher fees, thus from objectively led to the deterioration of the transportation structure in our country, and it is also a transportation structure in our country is in extensive development for a long time, the lack of appropriate planning and management.
With the increasing aggravation of environmental pollution in China, the development of green transportation has become the focus of national development. Therefore, it is an effective way to reduce environmental pollution to dig deeply into the emission reduction capacity of transportation structure factors, optimize the transportation structure scientifically and rationally, and reduce the energy consumption of transportation. In a word, China still has a long way to go in terms of carbon emission reduction. In order to achieve China's overall emission target, China must constantly optimize its transportation structure, so as to respond to the call of The Times, protect the ecological environment and achieve sustainable development.

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