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Decomposition of Influencing Factors of Carbon Dioxide Emission in Qinghai Transportation Industry

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Abstract*:* Based on the methods of IPCC, this paper used the "top-down" method to calculate the total CO2 emission of energy consumption in Qinghai province from 2005 to 2016. On this basis, the LMDI model will transport carbon dioxide emissions of Qinghai province factorization for transportation economies of scale, transportation, industry, transportation, energy efficiency growth industry economic efficiency, transportation structure effect, population scale effect, the structure of the transportation industry energy consumption effect these six factors, for each influence factors on the transportation industry in Qinghai province and the role of carbon dioxide emissions and contribution value are analyzed. The results show that during the study period, the total amount of carbon dioxide emissions from energy consumption increased, but the growth rate decreased. Among the incremental factors of carbon dioxide emissions of Qinghai transportation industry, population size, transportation scale and energy consumption structure of transportation industry promote carbon dioxide emissions of Qinghai transportation industry, while transportation structure inhibits carbon dioxide emissions of Qinghai transportation industry.

Keywords Qinghai province; transportation industry; carbon dioxide emissions; influencing factors decomposition

INTRODUCTION

Due to its unique climate characteristics, geographical location, diverse ecosystems and rich biological resources, the Qinghai-Tibet plateau has become an important ecological security barrier in China and a regulator of climate change in Asia and even the whole northern hemisphere. Due to the fragile ecological environment of the plateau, the global warming trend has produced a series of negative effects on the natural ecosystem of the Qinghai-Tibet plateau. Located in the northeastern part of the Qinghai-Tibet plateau, Qinghai province is the birthplace of the Yangtze, Yellow river and Lancang river. Therefore, Qinghai province is facing enormous pressure of economic development. How to ensure the stable economic growth of the region while reducing carbon dioxide emissions and protecting the ecological security of the Qinghai-Tibet plateau has become the primary consideration in economic development. In the implementation plan of Qinghai province's 13th five-year plan for controlling greenhouse gas emissions, it is clearly proposed that by 2020, carbon dioxide emissions per unit of GDP will be reduced by 12% compared with 2015, and the total carbon dioxide emissions in various fields will be effectively controlled. Fully integrated into the national carbon dioxide emissions trading market. Establish and improve the greenhouse gas statistical accounting and evaluation system. Carbon sequestration capacity has been significantly enhanced. Low-carbon pilot projects and demonstrations have been deepened, and the synergy of pollution reduction and carbon reduction has been further enhanced.

The transportation industry is not only the basic supporting industry of the whole national economy, but also, together with industry and power generation, constitutes the main source of carbon dioxide emissions of energy consumption in a country. From a global perspective, the energy consumption of transportation industry accounts for 1/3 of the total global energy consumption, and has become the second largest energy consumption industry, only second to industry. From 2005 to 2016, the carbon dioxide emissions of Qinghai's transportation industry grew rapidly, with an average annual growth rate of 18%. Transportation industry has become a key industry for Qinghai province to achieve the overall goal of energy conservation and emission reduction. Therefore, it is of great practical significance to explore the energy consumption characteristics of the transportation industry in Qinghai province and analyze the influencing factors of the change of carbon dioxide emission in the transportation industry in Qinghai province, so as to achieve various energy-saving and emission reduction targets in Qinghai province.

LITERATURE REVIEW

Up to now, more and more domestic and foreign researchers have started to study the carbon dioxide emission of the transportation industry. ERGAS C, CLEMENT M, MCGEE J (2016) positioned the city as a driver of environmental destruction and a place for environmental protection. The traditional binary view of city is both harmful and beneficial. We took a closer look at cities, looking at the internal and external metabolic effects of carbon dioxide emissions from road transport at the county level in the continental United States between 2002 and 2007. KRISHNAN V, MCCALLEY J D (2016) believes that bioenergy and biofuels are promising alternative energy sources. They studied their role in long-term U.S. national energy and transportation portfolio planning, and considered competition among other energy options. They presented a modeling framework for a system to integrate biomass pathways with energy and transportation systems, and also captured geographic differences in raw material supply and costs across the United States. LI h-r (2016) believes that with the acceleration of urbanization, urban traffic congestion becomes increasingly severe, and the contradiction between population, resources and environment becomes increasingly prominent. Through a systematic analysis of the green traffic development experience of international metropolises in the process of traffic development, they determined the problems faced by Beijing's green traffic and put forward countermeasures and Suggestions to improve Beijing's green traffic system and advocate green travel. MINDELL J, RUTTER H (2016) believed that transportation has a broad impact on health. Many of them are beneficial, whether through activities such as work, education, leisure and social contact, or by providing physical activity opportunities through walking and cycling. But transportation also has many harmful effects, including recognized health effects such as the consequences of injuries and air pollution, community demobilization, and the long-term effects of greenhouse gas emissions. These positive and negative effects of transport are experienced differently throughout society, with health and affluence experiences as well as poor, young and old people having adverse effects that tend to be experienced. Shifting patterns away from cars in favour of walking, cycling and public transport (transport) can reduce traffic hazards and enhance personal, social and environmental benefits. SONG M, ZHANG G, ZENG W (2016) believed that railway is one of the most effective and environmentally friendly ways to transport people and goods. They used non-radial DEA to measure the environmental efficiency of 30 regions in China and proposed a group beta regression model with fixed effects to simulate the impact of railway transportation on environmental efficiency. The results showed that the environmental efficiency increased slowly from 2006 to 2011, with great regional differences. The eastern region had the highest environmental efficiency, while the western region had the lowest. In addition, we also find that railway transport has a significant positive impact on improving environmental efficiency. SONG M, ZHANG G and ZENG W (2016) argued that with the rapid development of China's economy and the advancement of urbanization, the increasingly large urban transportation system has led to increasingly serious resource and environmental problems in China. They combined a measurement model of excess efficiency slack (including poor output) with a window data envelopment analysis model of management panel data to calculate the environmental efficiency of road transportation systems in China.AZIZALRAHMAN H, HASYIMI V (2019) illustrate the impact model of urbanization on carbon dioxide emissions by providing a breakdown of emission drivers in the urban sector (residential, commercial and industrial) to illustrate the dynamics of variable interactions.GARC a-olivares A, SOL J, OSYCHENKO O (2017) reviewed the technologies and systems proposed or demonstrated from A technical and energy perspective as alternatives to fossil-based transport and their prospects for entering the end-stage of carbon dioxide emissions. Estimate the energy cost of transitioning from the current transport system to 100% global renewable transport and the electricity required to operate the new renewable transport sector. The analysis concluded that 100% renewable transportation is feasible, but it does not necessarily mean an infinite increase in resource consumption. Major material and energy constraints and obstacles in each transport sector during this transition were also analysed.LI N and CHEN W (2018) developed a 30-province energy system optimization model (China times-30p) to simulate three low-carbon scenarios, including PEAK2030 (peak emissions 2030), PEAKA (peak emissions 2030) and WBD2 (far below 2 degrees). According to PEAK2030, PEAKA and WBD2 scenarios, low-carbon development will lead to a reduction in coal transport to 1114,728 and 653 Mtce by 2050 (48%, 66% and 69% lower than the reference scenario). At the same time, the overall coal transport model will be simplified and centralized. According to the PEAK2030, PEAKA and WBD2 scenario, this will lead to a corresponding reduction in freight turnover in 2050 to 1,337,887,787 billion TKM (44%, 63%, 67% lower than the reference value). In addition, the low-carbon transformation will also promote the transformation of power generation structure. Under the scenario of PEAK2030, PEAKA and WBD2, the emissions per unit cargo turnover of coal transportation in 2050 will be reduced to 3.00,1.61, 0.52kt CO2 / BTKM.QIU G, SONG R, HE S (2019) established a panel data model to examine the impact of urban construction, transportation facilities and economic development on urban air quality.SALEHI M, JALALIA (2017) discussed the issue of integrated green truck transport scheduling and driver assignment. They proposed a two-objective mixed integer nonlinear programming (MINLP) model to minimize total transport-related costs (TTC) and total carbon dioxide emissions (TCE).SIM J (2017) focuses on four carbon dioxide emissions reduction targets recently proposed by the south Korean government as they relate to the trucking industry, which is a sub-sector of the large transport industry. With truck freight volume expected to continue to grow, the system dynamics modeling tool was also used to develop a carbon dioxide emissions reduction plan model to measure the emission reduction required by the Korean trucking sector from 2015 to 2015.WANG B, SUN Y, CHEN Q (2018) used LMDI (log-mean Divisia Index) method to decompose the factors affecting China's passenger transport and carbon dioxide emissions. The results show that :(1) carbon dioxide emissions from passenger and cargo transportation increased from 1990 to 2015; (2) the per capita GDP and population increase the carbon dioxide emission of passenger and cargo transportation, and the transportation structure promotes the increase of carbon dioxide emission of freight transportation. Economic factors contributed the most; (3) activity intensity restrains the increase of carbon dioxide emission and transportation structure, and restrains the increase of carbon dioxide emission of passengers.XIE R, FANG J, LIU C (2017) used the improved STIRPAT model to examine the panel data of 283 cities from 2003 to 2013 to explore the impact of transportation infrastructure on urban carbon dioxide emissions. The results show that the transportation infrastructure increases the carbon dioxide emissions and intensity of the city. In addition, although the population scale effect of transportation infrastructure is conducive to reducing carbon dioxide emissions, the economic growth and technological innovation effect of transportation infrastructure increases carbon dioxide emissions. The results also show that in large and medium-sized cities, the construction of transportation infrastructure increases carbon dioxide emissions. In smaller cities, this relationship is not important. Robustness testing supports all findings. These results suggest that effective carbon reduction policies need to examine the impact of transport infrastructure.

At the same time, the research on carbon dioxide emission of regional transportation industry is gradually enriched. Song Mei and xu-guang hao (2018) refer to the IPCC, the method of measuring the 2005-2015 Beijing municipal transportation fossil energy consumption and CO2 emissions, and using logarithmic mean di's decomposition model (LMDI) will the Beijing transportation emissions factor decomposition for the effect of population, economic growth, industry scale, energy intensity and energy structure of five factors.Zhuang ying and xia bin (2017) used LMDI decomposition method (logarithmic average index method) to analyze the factor decomposition of carbon dioxide emissions from guangdong transportation. The results show that the carbon dioxide emissions of the transportation industry is the main part of the carbon dioxide emissions of the transportation industry in guangdong. Zhang shiqing, wang jianwei and zheng wenlong (2017) used ESDA method to study the spatial and temporal distribution pattern of transport carbon dioxide emissions, and found that the spatial clustering characteristics of transport carbon dioxide emissions in China's provincial regions changed little with time from 2000 to 2013. The influence factors of carbon dioxide emissions are less different in neighboring regions. Among them, urbanization rate and transportation structure are the main driving factors, while energy intensity plays a key inhibiting role.Shi zhaohui (2017) based on STIRPAT model combined with partial least squares regression method to study the influences from 1997 to 2014, the Beijing municipal traffic factors of carbon dioxide emissions, mainly research the economic level, demographic factors, technical factors and related parameters of traffic data, the results showed that the economic level and population expansion is to promote the Beijing traffic emissions increased the most important two factors, civil the increase of car ownership will lead to the number of people travel by bus in China, further increased the amount of traffic emissions. The increase of passenger and freight turnover both promotes the increase of the total carbon dioxide emissions of transportation, but passenger turnover plays a more significant role. The increase of energy price reduces the total amount of carbon dioxide emissions from transportation in Beijing. The impact of its change on the carbon dioxide emissions from transportation is only second to the per capita GDP and population size. The increase of energy price has a significant negative effect on the increase of carbon dioxide emissions from transportation in Beijing. The research results show that the decrease of energy intensity actually promotes the increase of carbon dioxide emissions from transportation, but its influence is not significant.Wang wei (2017) studied the carbon dioxide emissions of freight transportation, conducted econometric analysis on the status quo of freight transportation and energy consumption in the city belt of Wan-Jiang, and studied and analyzed the development status and existing problems of freight transportation in the city belt of Wan-Jiang.FAN F and LEI Y (2016) believe that in the rapid development and urbanization of Beijing, determining the potential factors of carbon dioxide emissions in the transportation sector is an important prerequisite for controlling carbon dioxide emissions. He developed a multivariate generalized Fisher index (GFI) decomposition model based on the extended Kaya equation to measure the impact of energy structure, energy intensity, output per unit of traffic flow, transport intensity, economic growth and population size on carbon dioxide emissions. The results show that the major positive factors of carbon dioxide emissions in the transportation sector include economic growth, energy intensity and population size. The negative drivers are transport intensity and energy mix, and transport intensity is the main factor limiting transport carbon dioxide emissions. The energy structure shows a certain inhibitory effect, but its inhibitory effect is not obvious.JAMNONGCHOBA, DUANGPHAKDEE O, HANPATTANAKIT P (2017) estimated the co2 emission of tourism transportation energy consumption in Suan Phueng, Thailand. Through questionnaire survey, we observed the bottom-up method to calculate the carbon dioxide emissions of tourism transportation.AGARANA M C, BISHOP S A, AGBOOLA OO (2018) believes that one of the main reasons for the increase in greenhouse gas pollution is transportation. They believe sub-saharan Africa, which produces less greenhouse gases, will suffer more from the effects of climate change in the coming years if necessary measures are not taken now. They used a linear programming model to simulate the current situation in Lagos, Nigeria. The analysis shows that if the current transport carbon dioxide emissions situation is not contained, it will bring serious health problems to local residents, such as respiratory diseases, and negative impact on the economic development of these cities.CHANG c-c, CHUNG c-l (2018) analyzed the Taiwan government's greenhouse gas emission reduction and regulation act (GGRMA), which stipulates that greenhouse gas emissions in 2050 should be reduced to half of 2005 greenhouse gas emissions. By 2050, they explore three potential policy options. The results show that :(1) if the use of vehicles is allowed to increase, it is impossible to achieve the goals of GGRMA only through the use of carbon quota allocation and the use of alternative fuels. (2) it is possible to achieve the government's carbon dioxide emissions target for 2050 by encouraging the use of PHEV and keeping the increase in vehicle use to zero through carbon subsidy allocation. (3) if we can actually reduce the use of vehicles, we can achieve 1.30-5.18% lower carbon dioxide emissions than the 2050 target. The use of alternative fuels has proven to be a reliable way to reduce carbon dioxide emissions. Encouraging the use of public transport can also reduce carbon dioxide emissions.CHEN W and LEI Y (2017) used path analysis model to estimate the direct, indirect and total impacts of driving factors on carbon dioxide emissions of Beijing traffic, and studied the causal relationship between variables. The results show that reducing energy intensity and transportation intensity are the key factors to control the increase of carbon dioxide emission from transportation. Population has the greatest positive impact on carbon dioxide emissions, as population growth leads to increased energy consumption and the number of motor vehicles.WANG Y, XIE T, YANG S (2017) calculated the carbon dioxide emissions coefficient of conventional energy covered by jiangsu statistical yearbook (JSY) in detail by combining the 2006 national greenhouse gas inventory index of the intergovernmental panel on climate change (IPCC) and the coefficient of China's calorific value. On this basis, the carbon dioxide emissions of transportation in jiangsu province from 1995 to 2012 was estimated. In the case of electric power, the decoupling relationship between economic growth of transportation and carbon dioxide emissions in jiangsu province is studied. The results show that the carbon dioxide emissions of electric power is significant and has no effect on the overall decoupling state. Since the 11th five-year plan, transport has made great achievements in reducing pollution and carbon dioxide emissions in jiangsu province and done a better job in terms of low-carbon development potential. But achieving low-carbon transport is still a big step forward.

METHODS AND DATA SOURCES

Carbon dioxide emission decomposition model for transportation industry

Transportation industry carbon dioxide emissions estimated according to the IPCC national greenhouse gas emissions in 2006 listing guide (IPCC refers to the intergovernmental panel on climate change), mobile source (transportation industry) CO_2 emissions accounting methods can be divided into two categories: one is the "top-down", namely the statistics calculation based on the means of transport fuel consumption; The second is "bottom-up", which is based on different types of transportation models, holding amount, driving distance, fuel consumption per driving distance and other data. Because China is different in model structure, range and energy consumption per unit mileage data are difficult to obtain, so using the calculation method of "top-down", comprehensive industry of road transportation, water transport, rail transport terminal energy consumption data, to estimate the co2 emissions of China's transportation industry.

$$C^t = \sum_{i,j} C_{ij}^t = \sum_{i,j} (E_{ij}^t F_j) \frac{44}{12} \quad (1)$$

where C^t represents the carbon dioxide emissions of the transportation industry in year t. C_{ij}^t represents the carbon dioxide emission generated by the ith mode of transportation and the j mode of energy consumption. Where, i =1,2,3, representing road transportation, water transportation and railway transportation respectively; j=1,2,3,4,5,6,7, respectively, representing coal, gasoline, diesel, kerosene, fuel oil, natural gas and electric power. E_{ij}^t represents the JTH energy consumption of the ith mode of transportation. F_j represents the carbon dioxide emissions coefficient of the JTH energy source.

$$C^t = \sum_{i,j} C_{ij}^t = \sum_{i,j} \left(\frac{E_{ij}^t}{E^t} \frac{E^t}{gdpt^t} \frac{gdpt^t}{T^t} \frac{T^t}{T_i^t} \frac{T_i^t}{P^t} P^t F_j\right) \quad (2)$$

where E^t represents the total energy consumption of the transportation industry in year t. $gdpt^t$ represents the GDP added value of transportation industry in year t. T^t represents the total transportation turnover of various transportation modes in year t. T_i^t represents the transport turnover of mode I in year t. P^t represents the population in year t.

Suppose $Ee_j{}^t = \sum_i \frac{E_{ij}^t}{E^t}$ represents the energy consumption structure of the transportation industry. $Eg^t = \frac{E^t}{gdpt^t}$ Represents the energy efficiency of the transportation sector. $Gt^t = \frac{gdpt^t}{T^t}$ represents the economic efficiency of the transportation industry. $Tt^t{}_i = \frac{T^t}{T_i^t}$ represents the transport structure of the transport industry. Due to the need of LMDI model modeling, this paper USES the reciprocal of the proportion of the transport turnover of the ith transport mode in the total transport turnover to represent the transport structure of the industry. $Tp^t{}_i = \frac{T_i^t}{P^t}$ represents the transportation scale of the ith mode of transportation, i.e., the transportation turnover of the ith mode of transportation accounted for by average person; □ □ said population scale, namely the population. Thus, equation (2) can be simplified into:

$$C^t = \sum_{i,j} C_{ij}^t = \sum_{i,j} (Ee_j{}^t Eg^t Gt^t Tt^t{}_i Tp^t{}_i P^t F_j) \tag{3}$$

At this point, the change of carbon dioxide emissions can be decomposed into six influencing factors: energy consumption structure, energy use efficiency, industrial economic efficiency, transportation structure, transportation scale and population. Assuming that carbon dioxide emissions change fromC^0in base year to C^t in t year, LMDI addition decomposition formula can be obtained:

$$\Delta C^t = \Delta C_{Ee}^t + \Delta C_{Eg}^t + \Delta C_{Gt}^t + \Delta C_{Tt}^t + \Delta C_{Tp}^t + \Delta C_P^t \tag{4}$$

$$\Delta C_{Ee}^t = \sum_{i,j} \frac{C_{ij}^t - C_{ij}^0}{\ln C_{ij}^t - \ln C_{ij}^0} \ln\left(\frac{Ee_j{}^t}{Ee_j{}^0}\right) \tag{5}$$

$$\Delta C_{Eg}^t = \sum_{i,j} \frac{C_{ij}^t - C_{ij}^0}{\ln C_{ij}^t - \ln C_{ij}^0} \ln\left(\frac{Eg^t}{Eg^0}\right) \tag{6}$$

$$\Delta C_{Gt}^t = \sum_{i,j} \frac{C_{ij}^t - C_{ij}^0}{\ln C_{ij}^t - \ln C_{ij}^0} \ln\left(\frac{Gt^t}{Gt^0}\right) \tag{7}$$

$$\Delta C_{Tt}^t = \sum_{i,j} \frac{C_{ij}^t - C_{ij}^0}{\ln C_{ij}^t - \ln C_{ij}^0} \ln\left(\frac{Tt^t{}_i}{Tt^0{}_i}\right) \tag{8}$$

$$\Delta C_{Tp}^t = \sum_{i,j} \frac{C_{ij}^t - C_{ij}^0}{\ln C_{ij}^t - \ln C_{ij}^0} \ln\left(\frac{Tp^t{}_i}{Tp^0{}_i}\right) \tag{9}$$

$$\Delta C_P^t = \sum_{i,j} \frac{C_{ij}^t - C_{ij}^0}{\ln C_{ij}^t - \ln C_{ij}^0} \ln\left(\frac{P^t}{P^0}\right) \tag{10}$$

Where ΔC^t represents the change of carbon dioxide emissions in transportation industry. ΔC_{Ee}^t represents the impact of the change of energy consumption structure on carbon dioxide emissions in the transportation industry. ΔC_{Eg}^t represents the impact of energy efficiency changes on carbon dioxide emissions in the transportation industry. ΔC_{Gt}^t indicates the impact of economic efficiency change on carbon dioxide emissions in transportation industry. ΔC_{Tt}^t represents the impact of transportation structure change on carbon dioxide emissions. ΔC_{Tp}^t represents the impact of the change in transportation size on carbon dioxide emissions. ΔC_P^t represents the impact of changing population size on carbon dioxide emissions. According to the zero value processing method in LMDI mentioned by b. w. ANG et al., all the zero values involved in equation (5) -- (10) are replaced by [10] ^(-20). The data required for this article and their sources are shown in table 1. In this paper, passenger turnover is converted into freight turnover for calculation. The conversion turnover calculation formula is shown in formula 11, and the conversion coefficient of passenger and freight is shown in table 2.

Conversion turnover = passenger turnover×Turnover conversion coefficient+ Freight turnover.

Table1 Description of indicators in the model

indicators	unit	The data source
Energy consumption of railway transportation in Qinghai province	Ten thousand tons	Qinghai statistical yearbook
Energy consumption of road transportation in Qinghai province	Ten thousand tons	Qinghai statistical yearbook
Water transport energy consumption in qinghai	Ten thousand tons	Qinghai statistical yearbook
The population of qinghai province	Ten thousand people	Qinghai statistical yearbook
The added value of qinghai's transportation industry	One hundred million yuan	China transportation statistical yearbook

Table 2 Conversion coefficient of passenger and freight turnover

Railway transportation	Highway transportation	Water transportation
1	0.1	1

In this paper, the top-down approach of IPCC was adopted to calculate CO2 emissions, that is, statistical data of energy consumption were used for calculation, and the formula was as follows:

$$I_t = \sum_{i=1}^{n} E_i^t F_i \quad (11)$$

I_t represents CO2 emission in year t. E_i^t represents the end consumption standard amount of the ith energy in year t. F_i Represents the carbon dioxide emission coefficient of the ith energy. The carbon dioxide emission coefficient and standard coal coefficient of major energy are shown in table 4. (Data of carbon dioxide emissions coefficient are from guidelines for compiling provincial greenhouse gas inventory, and data of standard coal coefficient are from China energy statistical yearbook.)

Table 3 CO2 emission coefficient and equivalent standard coal measure of each energy source

Energy type	Carbon dioxide emissions coefficient /（kg CO2/kg standard coal）	Conversion coefficient of standard coal /（kg standard coal/kg）
Raw coal	1.9003	0.7143
Crude oil	3.0202	1.4286
Gasoline	2.9251	1.4714
Kerosene	3.0179	1.4714
Diesel	3.0959	1.4571
Fuel oil	3.1705	1.4286
Natural gas	2.1622	1.3300
electric power	0.977	0.1229

The energy consumption structure of Qinghai's transportation industry

The energy consumption of Qinghai's transportation industry from 2005 to 2016 is shown in figure 1. From 2005 to 2016, the total energy consumption of Qinghai's transportation industry increased continuously. In 2005, the total energy consumption of Qinghai's transportation industry was 372,000 tons of standard coal, and in 2016, it reached 1,794,100 tons of standard coal.

Oil of Qinghai province transportation industry energy consumption accounted for the largest energy, increase sharply in 2005-2016, but its proportion in total energy consumption in the transportation industry down after rising first, in 2005 in Qinghai oil consumption of 209500 tons of standard coal transportation industry, accounting for 56.31% of the national transportation industry energy consumption, 2010 up to 914800 tons of standard coal, and oil consumption accounted for 82.75%, increased to 1.3813 million, 2016 tons of standard coal, accounting for 76.99% of the transportation industry energy consumption of Qinghai province. 2005-2016, transportation industry in Qinghai province natural gas consumption continues to increase, but in the Qinghai province transportation industry energy consumption accounts for more than the first decreases, the overall change is small, the coal consumption accounted for more than 2011, 2005 in Qinghai gas consumption of 62500 tons of standard coal transportation industry accounted for 16.8% of the national transportation industry energy consumption, increase to 282000, 2016 tons of standard coal accounts for 15.72% of the energy consumption in the transportation industry of China. From 2005 to 2016, the power consumption of Qinghai's transportation industry increased continuously, and the proportion of power in the energy consumption of Qinghai's transportation industry also increased continuously. In 2015, the proportion of power consumption exceeded that of coal, reaching 4.9%. In 2005, the power consumption of Qinghai transportation industry was 11,300 tons of standard coal, accounting for 3.04% of the national energy consumption of transportation industry. In 2016, it increased to 83,200 tons of standard coal, accounting for 4.64% of the national energy consumption of transportation industry. The proportion of coal in the energy consumption of the transportation industry in Qinghai province keeps decreasing. In 2005, the coal consumption of the transportation industry in Qinghai province was 88,700 tons of standard coal, accounting for 23.84 percent of the energy consumption of the transportation industry in Qinghai province. In 2016, the coal consumption of 47,600 tons of standard coal accounted for 2.66 percent of the energy consumption of the transportation industry in Qinghai.

The decrease of coal consumption, the decrease of oil consumption and the increase of electricity consumption are the obvious characteristics of energy consumption in the transportation industry of Qinghai province.

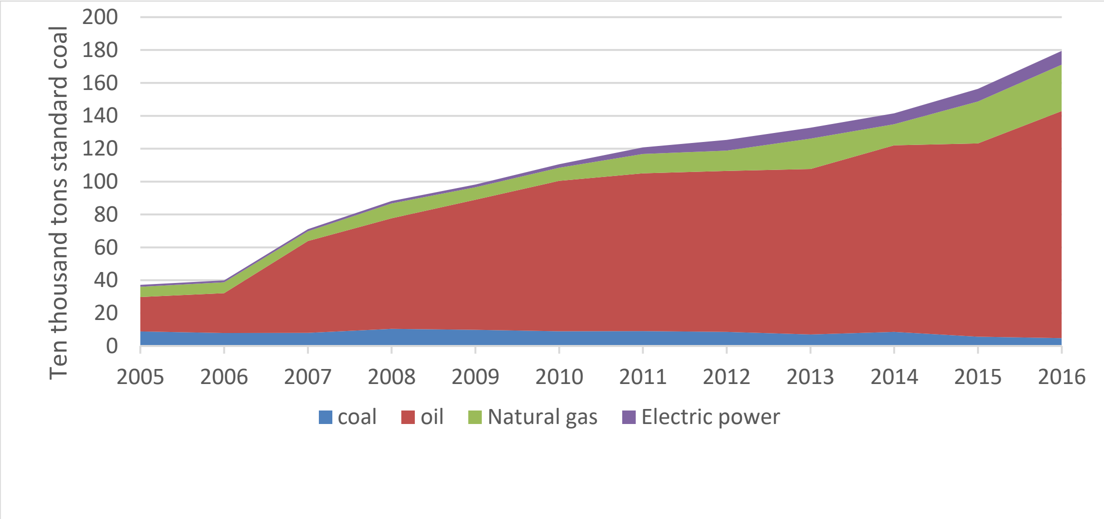

Fig.1. Energy consumption in Qinghai's transportation sector

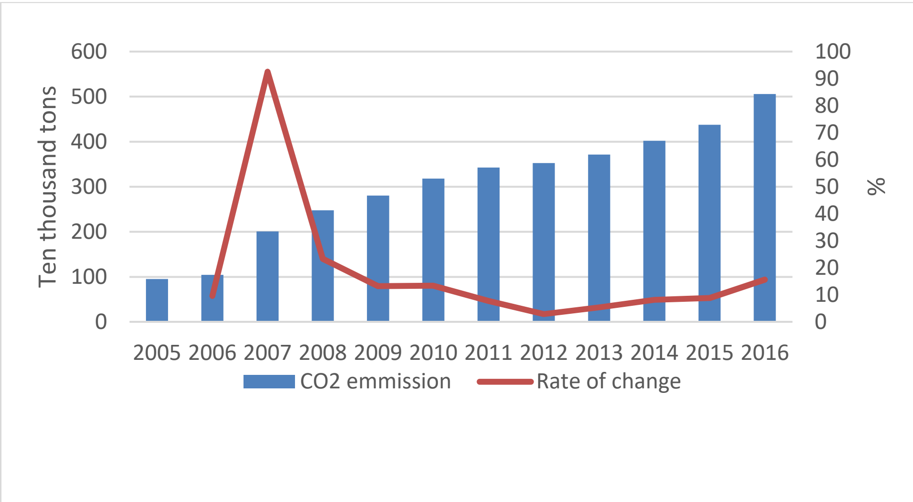

Fig.2. CO2 emissions from Qinghai's transportation sector

Current situation of carbon dioxide emissions in Qinghai transportation industry

After calculation, the total amount of CO2 emission from 2005 to 2016 in the transportation industry of Qinghai province was obtained, as shown in figure 2. The CO2 emission of the transportation industry in Qinghai province continued to increase from 2005 to 2016, and the change rate was continuously reduced before 2012 and then increased. In 2005, the CO2 emission of Qinghai's transportation industry was 952,000 tons, and in 2016, the CO2 emission of Qinghai's transportation industry was 505.75 tons. From 2005 to 2016, the annual change rate of carbon dioxide emissions from transportation in Qinghai province was 18.25%, among which the annual change rate from 2006 to 2007 was the largest, reaching 92.51%. In 2012, the annual rate of change dropped to the lowest, 2.92%.

RESULTS AND DISCUSSION

Decomposition of carbon dioxide emission factors in Qinghai transportation industry

Table 4 shows the decomposition results of influencing factors of carbon dioxide emissions in the transportation industry of Qinghai province. It can be seen that from 2005 to 2016, the carbon dioxide emission of Qinghai's transportation industry has been on the rise, with different annual growth rates. From 2005 to 2016, under the combined action of the six influencing factors, the carbon dioxide emission of Qinghai's transportation industry increased by 4.087 million tons.

The transportation scale made the largest cumulative contribution to the increase of carbon dioxide emission in Qinghai's transportation industry, which was 3,055,100 tons. The cumulative contribution of energy utilization efficiency to the increase of carbon dioxide emission in Qinghai transportation industry was the second, which was 830,300 tons. The cumulative contribution of transportation structure to the increase of carbon dioxide emission in Qinghai transportation industry is

-529,000 tons. The cumulative contribution of the economic efficiency of the transportation industry to the growth of carbon dioxide emissions in Qinghai was 342,800 tons. The cumulative contribution of population size to the increase of carbon dioxide emission in Qinghai's transportation industry was 273,900 tons. The cumulative contribution of the energy consumption structure of the transportation sector to the growth of carbon dioxide emissions in Qinghai was 35,700 tons.

From the perspective of cumulative contribution, four factors, namely, transportation scale, energy efficiency of transportation industry, population scale, and energy consumption structure of transportation industry, play a promoting role in carbon dioxide emission of Qinghai's transportation industry. The contribution value of transportation scale is the highest, while the contribution value of energy consumption structure of transportation industry is the lowest. The transportation structure can restrain the carbon dioxide emission of Qinghai transportation industry. The cumulative contribution of the economic efficiency of the transportation industry was -352,800 tons from 2005 to 2014, 409,500 tons from 2005 to 2015, and 342,800 tons from 2005 to 2016. This indicates that the cumulative effect of economic efficiency of the transportation industry on the carbon dioxide emission of the transportation industry in Qinghai province during the period from 2005 to 2008 is inhibitory, but it does not always exert an inhibitory effect on the carbon dioxide emission of the transportation industry in Qinghai province.

Table 4 Decomposition results of influencing factors of carbon dioxide emissions in Qinghai transportation industry

Year	ΔC_P	ΔC_Tp	ΔC_Ee	ΔC_Tt	ΔC_Eg	ΔC_Gt	ΔC
2005-2006	0.91	1.77	0.07	-0.12	-3.01	7.5	7.12
2005-2007	1.97	35.73	0.79	-1.05	59.45	-4.62	92.25
2005-2008	2.78	185.48	1.26	-33.67	108.62	-123.5	140.96
2005-2009	4.2	207.85	1.53	-33.78	86.6	-96.68	169.73
2005-2010	7.41	263.8	1.87	-44.38	57.12	-80.45	205.37
2005-2011	10.32	308.82	2.14	-44.44	54.14	-96.14	234.83
2005-2012	13.37	329.88	2.25	-44.62	45.51	-98.42	247.97
2005-2013	16.51	279.31	2.43	-52.52	54.39	-31.47	268.65
2005-2014	19.83	317.07	2.63	-52.73	42.06	-35.28	293.57
2005-2015	23.4	280.22	2.93	-52.84	40.94	40.95	335.6
2005-2016	27.39	305.51	3.57	-52.9	83.03	34.28	400.87

Table 5 shows the contribution rate of each influencing factor of carbon dioxide emission in Qinghai's transportation industry. From 2005 to 2016, the cumulative contribution of transportation scale to the change of carbon dioxide emissions in Qinghai's transportation industry was the largest, at 60.3%. The accumulative contribution rate of energy utilization efficiency to carbon dioxide emission in Qinghai transportation industry was 16.39%. The cumulative contribution rate of transport structure to the change of carbon dioxide emission in Qinghai transportation industry is -10.44%. The cumulative contribution rate of the economic efficiency of the transportation industry to the change of carbon dioxide emission in Qinghai transportation industry was 6.77%. The cumulative contribution of population size to the change of carbon dioxide emission in Qinghai transportation industry was 5.41%. The energy consumption structure of the transportation industry contributed 0.7% to the carbon dioxide emission of the transportation industry in Qinghai province. With the continuous expansion of the scale of railway transportation and road transportation in Qinghai province, the cumulative contribution rate of transportation scale to the change of carbon dioxide emissions in Qinghai province is increasing. The energy use efficiency of the transportation industry does not change obviously, so the contribution rate of energy use efficiency of the transportation industry to the carbon dioxide emission change of Qinghai province is decreasing. The proportion of road transportation increased first and then decreased; the proportion of railway transportation decreased first and then increased. During the study period, the economic efficiency of the transportation industry did not change significantly, so the cumulative contribution rate of the economic efficiency of the transportation industry to the change of carbon dioxide emissions in Qinghai province was continuously reduced. With the expansion of population size, the cumulative contribution of population size to the change of carbon dioxide emission of transportation industry in Qinghai province decreased first and then increased. In the energy consumption structure of Qinghai's transportation industry, oil, natural gas and electric power consumption account for an increasing proportion, while coal consumption continues to decrease. The cumulative contribution of energy consumption structure of the transportation industry to the change of carbon dioxide emissions of Qinghai's transportation industry is increasing, but its contribution rate is always low, less than 1%.

Table 5 Contribution rate of each influencing factor of carbon dioxide emission in Qinghai transportation industry

Year	ΔC_P	ΔC_Tp	ΔC_Ee	ΔC_Tt	ΔC_Eg	ΔC_Gt
2005-2006	6.82	13.25	0.49	-0.88	-22.5	56.06
2005-2007	1.9	34.48	0.76	-1.02	57.37	-4.46
2005-2008	0.61	40.74	0.28	-7.4	23.86	-27.12
2005-2009	0.98	48.26	0.36	-7.84	20.11	-22.45
2005-2010	1.63	57.97	0.41	-9.75	12.55	-17.68
2005-2011	2	59.85	0.41	-8.61	10.49	-18.63
2005-2012	2.5	61.77	0.42	-8.36	8.52	-18.43
2005-2013	3.78	63.97	0.56	-12.03	12.46	-7.21
2005-2014	4.22	67.52	0.56	-11.23	8.96	-7.51
2005-2015	5.3	63.5	0.66	-11.97	9.28	9.28
2005-2016	5.41	60.3	0.7	-10.44	16.39	6.77

Analysis on the annual carbon dioxide emissions effect of factors influencing carbon dioxide emission in Qinghai transportation industry

The annual carbon dioxide emissions effect of factors influencing carbon dioxide emission in Qinghai's transportation industry is shown in figure 3. The total effect of each factor was positive and showed a decreasing trend from 2006 to 2012, and an increasing trend from 2012 to 2016, which indicated that under the joint action of the six influencing factors, the increase of carbon dioxide emission in the transportation industry of Qinghai province decreased from 2006 to 2012, and increased from 2012 to 2016.

The variation of each influencing factor is shown in table 6. Before 2012, the continuous expansion of the railway and road transport scale in Qinghai province promoted the carbon dioxide emission of the transport industry in Qinghai province. From 2005 to 2008, the carbon dioxide emissions effect of the transport scale increased continuously, reaching 1.4975 million tons from 2007 to 2008. After 2012, the scale of railway transport and road transport in Qinghai province did not increase significantly, so the carbon dioxide emissions effect of the scale of transport began to decline or even have negative effects after 2012, which were -505,700 tons from 2012 to 2013 and -368,400 tons from 2014 to 2015, respectively.

Table 6 Development of each influencing factor

Year	Population	Energy consumption per unit of GDP	Added value of unit transport turnover	Railway transport turnover ratio	Highway transport turnover ratio	Water transport turnover ratio	Rail transport turnover per capita
	Ten thousand people	Tons of standard coal	Ten million yuan	%	%	%	Ten thousand ton-km
2005	543	11669	1.87049	68.929	29.5701	1.50091	0.21635
2006	548	11321.6	2.01676	67.2901	30.7015	2.00847	0.21475
2007	552	17376.8	1.85581	72.3265	26.3548	1.31867	0.28877
2008	554	21654.9	1.09001	48.8978	51.0865	0.01569	0.32973
2009	557	19919.6	1.2068	50.249	49.7277	0.02332	0.36869
2010	563	18047.5	1.27419	50.4474	48.3579	1.19467	0.4308
2011	568	17885.1	1.21500	51.3007	47.4278	1.27152	0.50199
2012	573	17446.6	1.20705	50.8515	48.1929	0.95563	0.52841
2013	578	17880.3	1.45257	59.5059	40.4671	0.0271	0.52611
2014	583	17317.8	1.43832	57.9009	42.0782	0.0209	0.56413
2015	588	17271.5	1.72615	56.7866	43.1957	0.01771	0.50662
2016	593	18887.4	1.70185	56.8171	43.1398	0.04307	0.53479

The carbon dioxide emissions effect of the transportation scale of each transportation mode is shown in figure 4. Among them, the highway transportation scale has the most significant promotion to the carbon dioxide emission of the transportation industry in Qinghai province, followed by the railway transportation scale. Before 2011, due to the expansion of road transport scale, the carbon dioxide emissions effect of road transport scale was continuously enhanced, reaching 182,800 tons in 2010-2011. After 2011, the carbon dioxide emissions effect of road transport scale began to weaken. In 2012-2013 and 2014-2015, due to the reduction of road transport scale, the carbon dioxide emissions effect of road transport scale also appeared negative effect. The carbon dioxide emissions effect of road transport scale from 2012-2013 was -492,600 tons, and the carbon dioxide emissions effect of road transport scale from 2014-2015 was -112,100 tons. Before 2011, the scale of railway transport in Qinghai province was also expanding, and the carbon dioxide emissions effect of the scale of railway transport was increasing, reaching 259,000 tons from 2010 to 2011. After 2011, the carbon dioxide emissions effect of the railway transport scale began to weaken. In 2012-2013 and 2014-2015, due to the reduction of the railway transport scale, the carbon dioxide emissions effect of the railway transport scale also appeared negative effect, among which the carbon dioxide emissions effect of the railway transport scale in 2012-2013 was 0.94 million tons, and the carbon dioxide emissions effect of the railway transport scale in 2014-2015 was -256,100 tons. On the one hand, this phenomenon is caused by the obvious expansion of road transport scale; on the other hand, it is caused by the fact that road transport and railway transport occupy a large proportion in Qinghai's transport industry. From 2005 to 2016, the carbon dioxide emissions effect of water transport scale in Qinghai province was always low, less than 10,000 tons.

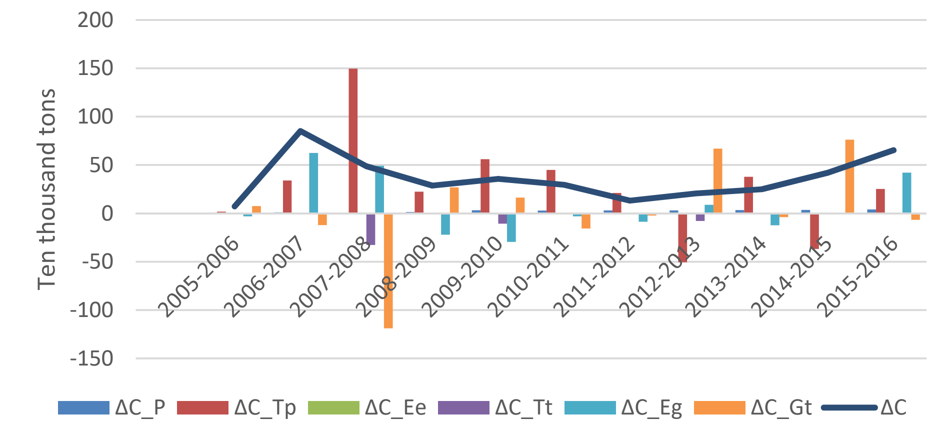

Fig.3. The CO2 emission effect of each influencing factor in Qinghai's transportation sector

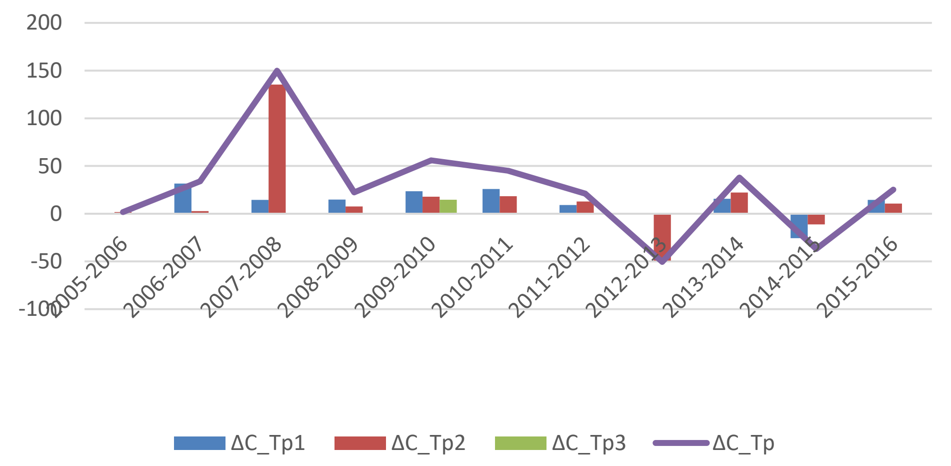

Fig.4. Carbon effect of transportation scale

Before 2008, the energy utilization efficiency of the transportation industry in Qinghai province was continuously decreasing and the energy consumption per unit of GDP was continuously increasing. After 2008, the energy utilization efficiency of the transportation industry in Qinghai province was not significantly changed. Transportation industry energy efficiency of the transportation industry carbon dioxide emissions effect before 2007 is positive effect and increasing, 2006-2007 to reach 624600 tons, after 2007 began falling, in 2008-2015 show the negative effects, it shows that in 2008-2015 in Qinghai province transportation industry to enhance the efficiency of energy utilization suppresses the carbon dioxide emissions increase the transportation industry. From 2015 to 2016, with the decrease of energy utilization efficiency in the transportation industry, the carbon dioxide emissions effect of energy utilization efficiency in the transportation industry became positive again, at 421,000 tons.

The economic efficiency of the transportation industry in Qinghai province decreased continuously from 2005 to 2008, and increased gradually from 2008 to 2016. From 2005 to 2008, the carbon dioxide emissions effect of the economic efficiency of the transportation industry was negative and increased continuously, reaching -1.1888 million tons in 2007-2008, which indicates that the decrease of the economic efficiency of the transportation industry in Qinghai province inhibited the increase of carbon dioxide emission in the transportation industry in 2005-2008. After 2008, with the improvement of the economic efficiency of the transportation industry, the carbon dioxide emissions effect of the economic efficiency of the transportation industry also changed into a positive effect, and was continuously enhanced. It reached a maximum of 762,300 tons in 2014-2015.

Each transportation mode of transportation of the structure of the carbon dioxide emissions effect as shown in figure 5, the transportation structure of Qinghai province from 2005 to 2016, the trend changes, 2007-2008 in Qinghai province turnover accounted for 23.43% less than of railway transportation, road transportation turnover ratio increased by 24.73%, 2012-2013 in Qinghai province railway transport turnover ratio increased by 8.65%, highway transport turnover accounted for 7.73% less than. On the whole, the carbon dioxide emissions effect of the transportation structure in Qinghai province is negative and the absolute value is small. This indicates that the transportation structure has been playing an important role in the carbon dioxide emission of the transportation industry in Qinghai province, but its inhibitory effect is weak. Except for 2007-2008, 2009-2010 and 2012-2013, the carbon dioxide emissions effect of transportation structure is all less than 10,000 tons, with -320,200 tons, -106,100 tons and -79,000 tons respectively.

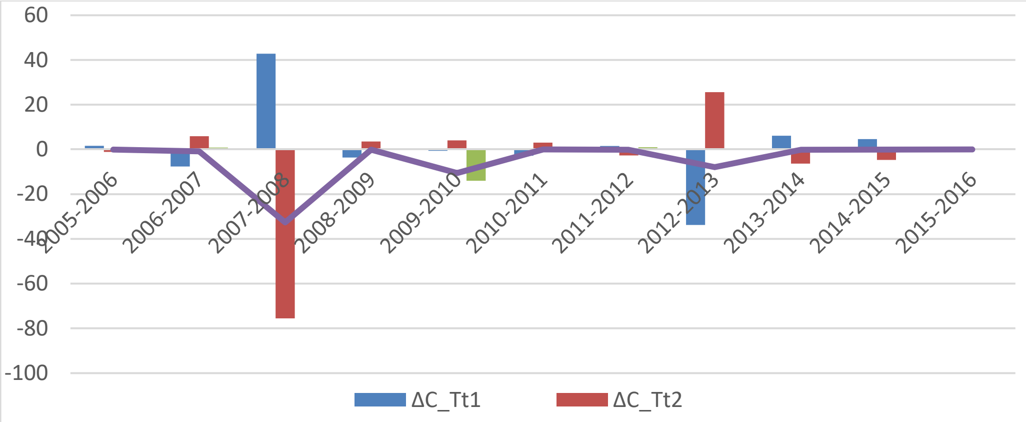

Fig.5. Carbon emission effect of transportation structure

From 2005 to 2016, the population scale of Qinghai province expanded continuously. During the study period, the population size promoted the carbon dioxide emission of the transportation industry, and the promotion effect became stronger year by year with the expansion of the population size. In 2005-2006, the carbon dioxide emissions effect of population size was 0.91 million tons, and in 2015-2016, the carbon dioxide emissions effect of population size was 39,900 tons.

The carbon dioxide emissions effect of the main energy consumption structure of the transportation industry in Qinghai province is shown in figure 6. From 2005 to 2016, the energy consumption structure of the transportation industry promoted the carbon dioxide emission of the transportation industry in Qinghai province, but the promotion effect was weak. Between 2005 and 2016, the annual carbon dioxide emissions effect was less than 10,000 tons. As the main energy required by the transportation industry, oil consumption accounts for the most significant carbon dioxide emissions effect. After 2010, with the increase of transportation industry in Qinghai province natural gas consumption, gas consumption and further increase, resulting in gas consumption accounted for the effects of carbon dioxide emissions after 2010 become more evident, 2014-2015, natural gas consumption accounted for carbon dioxide emissions effect than oil consumption accounted for carbon dioxide emissions effect, 02600 tons. As the total and proportion of coal consumption in the energy consumption of the transportation industry in Qinghai province continues to decrease, the carbon dioxide emissions effect of coal consumption is also shown as a negative effect. However, due to the relatively low proportion of coal consumption in the energy consumption of the transportation industry in Qinghai province, its carbon dioxide emissions effect is also weak. As the total and proportion of electricity consumption in the energy consumption of the transportation industry in Qinghai province is increasing, the carbon dioxide emissions effect of the proportion of electricity consumption is positive. However, because the proportion of electricity consumption in Qinghai's transportation industry is still low, the carbon dioxide emissions effect of the proportion of electricity consumption is also weak.

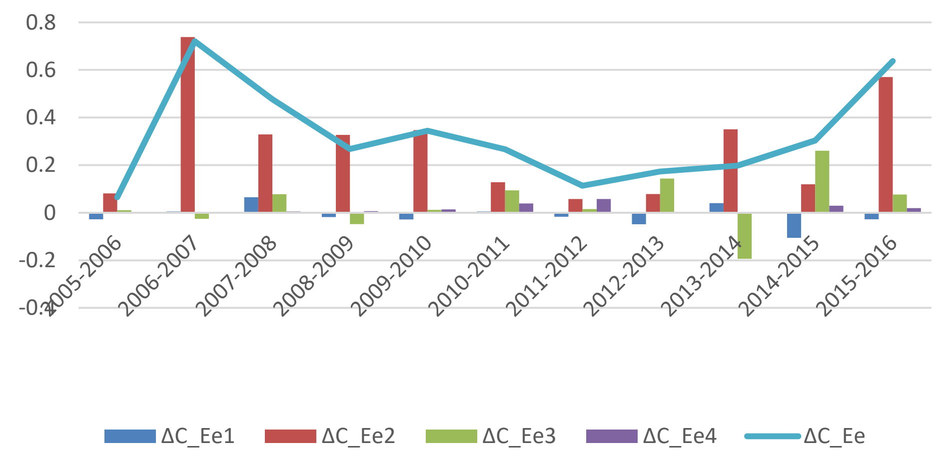

Fig.6. Carbon emission effect of energy consumption structure

The annual carbon dioxide emissions contribution rate of the influencing factors of carbon dioxide emission in the transportation industry of Qinghai province is shown in figure 7. Among them, the annual contribution rate of energy utilization efficiency, transportation scale and economic efficiency of the transportation industry is high, while the annual contribution rate of other influencing factors is low. Energy efficiency in the transportation sector contributes an average of 23.58 percent of annual carbon dioxide emissions. The average annual carbon dioxide emission contribution of transportation scale is 41.62%. The average annual contribution of carbon dioxide emissions to the economic efficiency of the transportation industry is 28.15%. The average annual contribution of population size is 3.8%. The average annual carbon dioxide emission contribution of the transportation structure is 2.47%. The average annual carbon dioxide emission contribution of the transportation structure is 0.38%. Therefore, it can be considered that energy utilization efficiency, transportation scale and economic efficiency of transportation industry are the main influencing factors of carbon dioxide emission of transportation industry in Qinghai province.

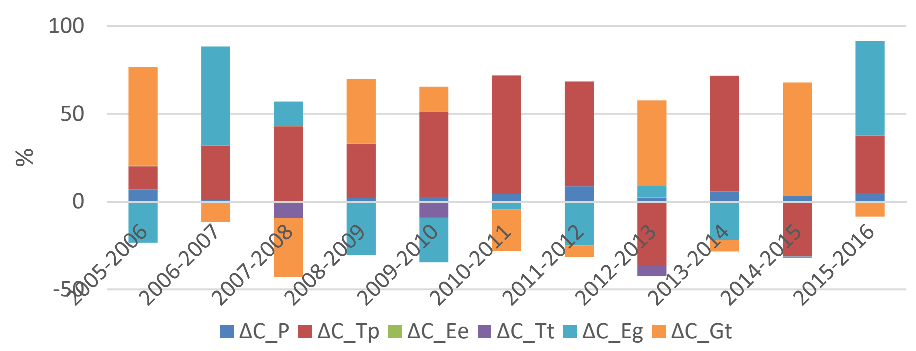

Fig.7. The cumulative contribution rate of CO2 emission from transportation industry in Qinghai province

CONCLUSIONS AND RECOMMENDATIONS

According to the research results, the following conclusions can be drawn. Under the combined action of the six influencing factors selected in this paper, the carbon dioxide emission of Qinghai's transportation industry increased continuously from 2005 to 2016. In six factors, population scale, the scale of transportation, transportation industry energy consumption structure of Qinghai province transportation industry plays a role of promoting carbon dioxide emissions, transportation structure inhibition effect to the transportation industry co2 emissions of Qinghai province, the transportation industry energy use efficiency and economic efficiency during the study period of transportation industry to transport industries in Qinghai province showed both carbon dioxide emissions, also showed inhibitory effect. From six kinds of influence factors of the annual average carbon contribution rate, the scale of transportation for transportation industry in Qinghai province carbon dioxide emissions of the main factors that influence the economic efficiency of the transportation industry influence weaker than transport scale effect, the transportation industry energy efficiency the influence of the weak effect on the economic efficiency of the transportation industry, the effects of population scale for weak impact in the transportation industry of energy efficiency, the influence of transportation structure effect of weak in population size. From the perspective of the cumulative carbon dioxide emissions contribution rate, the cumulative carbon dioxide emissions contribution rate of the transportation scale increases year by year, respectively surpassing the economic efficiency and energy utilization efficiency of the transportation industry, and becoming the influencing factor with the highest cumulative contribution rate.

Based on the conclusions of this paper, the following Suggestions are proposed:

(1) Effectively control the transportation scale and prevent the further expansion of the transportation scale.

The transportation scale has become the most important promoting factor of carbon dioxide emission in the transportation industry of Qinghai province. The local government can control the transportation scale by controlling the annual transportation turnover of railways and highways, so as to control the growth of carbon dioxide emissions.

(2) Further improve the energy utilization efficiency of Qinghai's transportation industry.

the energy efficiency of transportation industry in Qinghai province in the country is relatively backward, energy consumption per unit GDP also well below the industry average transportation, so it is necessary to further improve the energy efficiency, transportation industry can be achieved by policies to guide the way to make more energy efficient use of transportation in transportation industry.

(3) Further improving the energy consumption structure.

In the energy consumption of the transportation industry in Qinghai province, the use proportion of energy with lower carbon dioxide emissions coefficient, such as electricity and natural gas, is lower. Therefore, the carbon dioxide emission of the transportation industry can be further controlled by increasing the consumption proportion of such energy.

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