Research on Inner Mongolia freight volume forecast model based on computable general equilibrium

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Abstract: Inner Mongolia Autonomous Region is a big province of energy, variety complete and reserve sufficient. However, with the continuous growth of energy freight volume, the imbalance of energy freight varieties and the unreasonable structure of energy industry in Inner Mongolia Autonomous Region are becoming more and more serious. The energy SAM table was compiled based on the latest official input-output table of Inner Mongolia, and the CGE model of regional energy freight volume and GAMS program were constructed to simulate and predict the total energy freight volume of Inner Mongolia Autonomous Region in 2025-2035. The results show that the average accuracy of the prediction model is 2.27% according to the error terms between the prediction results and the actual results. The conclusions can provide reference for stabilizing economic growth, developing regional green logistics and strengthening technological innovation and transformation.

Keywords: CGE models; Energy; Cargo volume forecast; Green development

1. Introduction

As energy consumption continues to increase, Inner Mongolia energy transportation is on a continuous growth trend. Between 2017 and 2021, more than 85% of 2021 Energy Cargo Inner Mongolia was carried in China. Less than 15% of cargo was carried by fuels such as crude oil, gas, hydropower and nuclear power. Large-scale utilization of coal resources will affect the natural environment and air quality, not conducive to sustainable development [1-4].

Looking through the existing literature, it is found that freight volume forecast has been a research hotspot. At present, the freight volume forecasting models mainly include the System dynamics models used by Lu Hua and Yuan Min, Xu Fei and Ren Shuang, the Arima model used by Alexandru-Eugen ST Tescu, the nested Logit model used by Jiao XI and the Input-output model of Amaya Johanna, etc., these models have their own characteristics, with corresponding data base, analysis methods, application scope, advantages and disadvantages. To sum up, the disadvantages can be summarized as follows: (1) Inadequate consideration of freight economic linkages; (2) Does not take into account freight transport costs; (3) Insufficient capacity to address policy impacts; (4) Weak supply-demand and logistics base; 5. Poor interaction with other passenger and freight transport models.

Taking Chongqing as an example, Yang Kunhe gives an estimation model of freight volume based on computable general equilibrium, and compares it with the actual freight volume and other data and forecast values, you can see that the expected results of the model are quite good. This paper uses the method of Yang Kun-he to construct the energy freight volume forecasting model by using the open economy dynamic CGE model.

Based on the theory of computable general equilibrium (CGE), this paper first calculates the Sam Table of the social accounting matrix from the 2017 Inner Mongolia data, constructs the CGE model, and determines the relevant parameters. Secondly, 2021 freight volume from 2017 to 2021 is verified by the actual energy freight volume. The results show that the CGE model is feasible in energy freight forecasting. Finally, the CGE model is used to forecast the Inner Mongolia energy freight volume from 2025 to 2035[5-7].

2. Sam table compilation and data sources

The whole three industries are divided into 11 departments (Table 1), the data are Inner Mongolia from the input-output tables for 2017 and the Inner Mongolia Statistical Yearbook for 2018.
Table 1: Sam Table Division of Inner Mongolia

<table>
<thead>
<tr>
<th>primary sector of the economy</th>
<th>Agriculture, forestry, animal husbandry and fishery</th>
</tr>
</thead>
<tbody>
<tr>
<td>secondary sector of the economy</td>
<td>Coal mining and washing industry</td>
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<tr>
<td></td>
<td>Oil and gas extraction</td>
</tr>
<tr>
<td></td>
<td>Petroleum Processing, coke manufacturing and nuclear fuel processing industries</td>
</tr>
<tr>
<td></td>
<td>Production and supply of electricity and heat</td>
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<td></td>
<td>Gas production and supply</td>
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<td></td>
<td>Other secondary sector of the economy departments</td>
</tr>
<tr>
<td>tertiary sector of the economy</td>
<td>Construction</td>
</tr>
<tr>
<td></td>
<td>Transportation, warehousing and postal communications</td>
</tr>
<tr>
<td></td>
<td>Wholesale and retail trade and accommodation and catering</td>
</tr>
<tr>
<td></td>
<td>Other tertiary sector of the economy departments</td>
</tr>
</tbody>
</table>

According to the methods of Lu Chunhua [8] and Yan Xingchen [9-10], the energy is divided into six kinds, as shown in the table 2 below.

Table 2: Specific energy categories

<table>
<thead>
<tr>
<th>The energy sector</th>
<th>Energy</th>
</tr>
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<tbody>
<tr>
<td>Coal mining and processing industry</td>
<td>Raw coal</td>
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<tr>
<td>Oil extraction</td>
<td>Crude oil</td>
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<tr>
<td>Natural gas extraction</td>
<td>Natural gas</td>
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<tr>
<td>Coking Industry</td>
<td>Coke</td>
</tr>
<tr>
<td>Petroleum and nuclear fuel processing industries</td>
<td>Oil products</td>
</tr>
<tr>
<td>Gas production and supply</td>
<td>Gas</td>
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<tr>
<td>Production and supply of electricity and heat</td>
<td>Electricity</td>
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</table>

Production and supply of Electricity and heat Electricity uses the 2017 Inner Mongolia input-output tables, the 2018 Inner Mongolia Statistical Yearbook and the 2018 China Fiscal Yearbook to construct the energy Sam Tables. The SAM table data used in this paper can be obtained by referring to the “Social accounting matrix of the Chinese economy” compiled by Li Shantong et al. of the development research center of the State Council, as well as relevant literature such as Wang Jun and Su Limin. Although the SAM content built for different problems is not exactly the same, its data source and basic structure are the same.

Table 3: Inner Mongolia Energy Sam balance sheet in 2017(100 million yuan)

<table>
<thead>
<tr>
<th>sec1</th>
<th>sec2</th>
<th>sec3au</th>
<th>sec3</th>
<th>com1</th>
<th>com2</th>
<th>com3au</th>
<th>com3</th>
<th>lab</th>
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Since the SAM tables based on data sources such as the input-output tables, the statistical yearbook and the financial yearbook are usually unbalanced (i.e. the total value of the rows in the tables does not equal the total value of the columns), it is therefore necessary to level the SAM table so that its totals in the same row are equal. There are different methods for balancing the SAM table, such as the least square cross-entropy method of Tu tao-tao [11-13], the direct cross-entropy method of Zhang Yang [14] and the Gras method of Godfrey Ho and Liu Lanjuan [15]. In this paper, the initial Sam Table of the total difference is less, so the use of manual adjustment method.

The balanced Sam Table (see table 3) is used as the basis for the CGE model.
3. Freight volume forecasting model based on computable general equilibrium theory

3.1 Model assumptions

In the equation of CGE model, the uppercase of letters denotes endogenous and exogenous variables, and the general exogenous parameters are denoted by lowercase symbols. The set of production activities and products is defined as follows: \( A = \{ \text{production activities} \}; \ an = \{ \text{non-energy production activities} \}; \ AE = \{ \text{energy production activities} \}; \ F = \{ \text{elements} \}; \ C = \{ \text{commodities} \}; \ CN = \{ \text{non-energy commodities} \}; \ CE = \{ \text{energy commodities} \} \).

Based on the viewpoint of Yang Kun River, the model assumes that cross-regional commodity logistics forms logistics. The volume of freight traffic studied is the flow of goods (as shown in Figure 1):

![Figure 1: CGE model of open area commodity flow process](image)

3.2 Model building

3.2.1 Production module

The total output of production mainly includes the total amount of value-added part and the total amount of intermediate input, the value-added part consists of capital input and labor input, and the total amount of intermediate input consists of the individual amounts of intermediate input in various industries, where \( C \) is a collection of goods. In this paper, a dynamic CGE model is developed to predict Inner Mongolia energy freight volume. The CGE model built in this paper mainly includes the following

![Figure 2: Production structure of enterprise](image)
modules, as shown in Figure 2.

The first level is the CES production function; it describes the total output $QA$ for each manufacturing enterprise:

$$QA_a = \alpha_a^{\delta_a QVA_a^\rho_a} + (1 - \delta_a)QINTA_a^\rho_a, a \in A$$ (1)

$$PVA_a = \frac{\delta_a^{\rho_a}}{1 - \delta_a} QVA_a, a \in A$$ (2)

$$PA_a * QA_a = PVA_a * QVA_a + PINTA_a * QINTA_a$$ (3)

In this part, according to the model of Yang kun-he, $\alpha_a$ is the scale parameter of the total output, $\delta_a$ is the share parameter of the value-added part; $\rho_a$ is the elastic parameter of the total output, $QVA_a$ is the total quantity of input of the value-added part; $QINTA_a$ is the total quantity of intermediate inputs, $PVA_a$ is the total value of value-added components, and $PINTA_a$ is the total value of intermediate inputs.

The next level refers to Wang Jia [16], that is, the value-added part of the formula and the middle part of the formula. The production parameters of value-added part $QVA_a$ are CES function, mainly composed of $QLD_a$ of labor input and $QKD_a$ of capital input, whose values are $WL$ and $WK$ in turn.

$$QVA_a = \alpha_a^{\delta_a QLD_a^{\rho_a}} + (1 - \delta_a)QKD_a^{\rho_a}, a \in A$$ (4)

$$WL = \frac{\delta_a^{\rho_a}}{1 - \delta_a} QLD_a, a \in A$$ (5)

$$PVA_a * QVA_a = WL * QLD_a + WK * QKD_a$$ (6)

In Chinese formula, $\alpha_a^{\delta_a}$ is the scale parameter of added value, $\delta_a$ is the share parameter of labor input in added value, and $\rho_a$ is the elastic parameter of added value.

The formula for the intermediate input part of $QINTA_a$ is as follows:

$$QINT_a = ica_a * QINTA_a, a \in A, c \in C$$ (7)

$$PINTA_a = \sum_{c \in C} ica_a * PQ_c$$ (8)

In the formula, $ica_a$ is the direct consumption coefficient of input-output of intermediate input, $QINT_a$ is the quantity of intermediate investment $C$ required for production activity $a$, $PQ_c$ is the total value of commodity $C$ in the local market, $PINTA_a$ is the total value of the intermediate inputs.

### 3.2.2 Trade module

The product $QA$ of production activities in this region is divided into two parts: QDA of sales in this region and QE of sales out of this region. The substitution relation is represented by CET production function:

$$QA_a = \alpha_a^{\delta_a QDA_a^{\rho_a}} + (1 - \delta_a)QE_a^{\rho_a}, a \in A$$ (9)

In the formula, $\alpha_a$ is a scale parameter, $\delta_a$ is a share parameter and $\rho_a$ is an elastic parameter.

The QDA price for products manufactured and sold in the area is $PDA$. The price of goods sold outside the production area is $PE$. Relative changes in $PDA$ and $PE$ affect relative sales within and outside the region, depending on the primary conditions of optimization.

$$PDA_a = \delta_a^{\rho_a} QDA_a, a \in A$$ (10)

$$PE_a = pwe_a * (1 - \eta_a)$$ (12)

In the formula, $PDA_a$ is the user price of the outside area, $\eta_a$ is the ad valorem rate of the goods, indicating the freight cost per unit of the goods. As you can see, $PE$ can be
determined as long as $p_{wea}$ and $\eta_a$ are given by the outside world. Thus the price $PD$ can be calculated in $PA$.

The quantity of commodity $C$ available on the market in the region is represented by $QQ_c$. In the open economy, $QQ_c$ includes the production and sales part of $QDC_c$ for the area of $PDC_c$ at a certain price, and the production and sales part of $QM_c$ for the area of $PM_c$ at a certain price. Regional markets provide products that consumers, companies and government departments need. In addition to the final requirements described above, intermediate input requirements for product activities must also be addressed. $QQ_c$ in the region of the formation of supply and supply outside the region can be replaced with each other (although not necessarily completely replaced). The Armington condition illustrates these substitutions, which were originally used to describe substitutions of domestic and overseas products:

$$QQ_c = \alpha^c_c \left[ \delta^c_c QDC_c + (1 - \delta^c_c) QM_c \right]^{1/p^c_c}, \ c \in C \quad (13)$$

$$\frac{PDC_c}{PM_c} = \frac{\delta^c_c}{1 - \delta^c_c} \left( \frac{QM_c}{QDC_c} \right)^{1 - p^c_c}, \ c \in A \quad (14)$$

In the formula, $\delta^c_c$ is a scale parameter, $\rho^c_c$ is a share parameter and $\rho^c_c$ is an elastic parameter.

The price of a product on the market, $PQ_c$, is a Weighted mean of both:

$$PQ_c = \frac{PDC_c \ast QDCC_c}{QQ_c} + \frac{PM_c \ast QMc_c}{QQ_c}, \ c \in C \quad (15)$$

The above formula (13) $-$ (15) can form the optimal condition of supply allocation based on the price of $PQ$, $PDC$ and $PM$, and on the basis of $QQ$, $QDC$ and $QM$. The selling price of the imported goods $PM$ is determined according to the selling price in the foreign market (the price of the foreign user $PWM$ and $\eta_a$ from the market price rate).

$$PM_c = pwm_c \ast (1 + \eta_a), \ c \in C \quad (16)$$

$pwm_c$ is used in the production of goods in the outer region of the price.

Because economic activity corresponds to the number of goods, that is, $QDC_c$ and $QDA_a$, $PDC_c$ and $PDA_a$ are the same thing, can represent the same number of goods. However, since this article uses a tool for the Integrated Application Model System (GAMS), it is necessary to distinguish between product names representing different defined regions of the same variable in Gams. However, because the program accepts only the last variable and the region it defines. So, to accommodate the GAMS program, we used a different name, and they can be mapped one by one in the following ways:

$$QDC_c = \sum_a IDENT_{ac} QDA_a \quad (17)$$

$$PDC_c = \sum_a IDENT_{ac} PDA_a \quad (18)$$

The $IDENT_{ac}$ is the identity matrix.

The 18 equations described above describe the relationship between the activities contained in the production module and the goods.

### 3.2.3 Revenue and Expenditure Module

The principal institutions of an open economy include residents, governments, and other regions (rows) in addition to businesses. Residents' income consists of three parts: labor income, capital income and government transfer income.

$$YH = WL \ast QLS + WK \ast shif_{hk} \ast QKS + transfr_{hgov} \quad (19)$$

$QLS$ is the total supply of labor; $transfr_{hgov}$ is the transfer payment of the government to the residents; $QKS$ is the total supply of capital; and the capital factor income is distributed to both the residents and the companies, the $shif_{hk}$ represents the total share of capital element income distributed to the population. The disposable income ratio is $YH(1 - ti_h)$, in which $ti_h$ is the basic income tax rate of urban residents, and the MPC determines the amount of consumption and the saving beyond consumption. The influence function is the cobb-douglas function, from which the consumer demand for product $C$ is derived:

$$PQ_c \ast QH_c = shrh_c \ast mpc \ast (1 - ti_h) \ast YH, \ c \in C \quad (20)$$

In Yent, the tax revenue of enterprise in capital input includes the transfer expenditure of state finance
to enterprise capital. This model focuses only on the former.

\[ \text{YENT} = \text{shif}_{\text{ent}} \times \text{WK} \times \text{QKS} \]  
\( (21) \)

In the formula, \( \text{shif}_{\text{ent}} \) is the share of capital element income distributed to the enterprise.

Corporate tax rate is income tax \( \text{ti}_{\text{ent}} \) corporate savings is equal to corporate income minus income tax:

\[ \text{ENTSAV} = (1 - \text{ti}_{\text{ent}}) \times \text{YENT} \]  
\( (22) \)

The government revenue only considers the individual income tax levied by residents and the enterprise income tax levied by enterprises. The government revenue is as follows:

\[ \text{YG} = \text{ti}_{h} \times \text{YH}_{h} + \text{ti}_{\text{ent}} \times \text{TENT} \]  
\( (23) \)

The government expenditure in this model includes commodity consumption and transfer expenditure to residents. Suppose that government demand for goods is determined by external variables:

\[ \text{EG} = \sum \text{PQ}_{c} \times \text{QG}_{c} + \text{transfr}_{\text{hgov}} \]  
\( (24) \)

Government revenue and expenditure are government net savings \( \text{GSAV} \). If it is a positive sign, it is a fiscal surplus; if it is a negative, it is a fiscal deficit. \( \text{GSAV} \) endogenously:

\[ \text{GSAV} = \text{YG} - \text{EG} \]  
\( (25) \)

3.2.4 Equalization module

In this model, the supply (inflow) and demand (outflow) of out-of-region products are endogenous variables. Under CET, exports are determined by the previous output model, which in Armington is one of the determinants of imports. Assume that the business is in the market economy of full competition. The state of supply and demand of products in a given region is that the products supplied on the regional market are equal to the products needed in that region:

\[ \text{QQ}_{c} = \sum \text{QINT}_{ca} + \text{QH}_{c} + \text{QINV}_{c} + \text{QG}_{c}, c \in C \]  
\( (26) \)

Factor market clearing, factor demand equals supply:

\[ \sum \text{QLD}_{a} = \text{QLS} \]  
\( (27) \)

\[ \sum \text{QKD}_{a} = \text{QKS} \]  
\( (28) \)

In macroscopically closed neoclassicism, factors are exploited. For example, if the actual supply of labour is fully employed, factor supply equals factor endowment:

\[ \text{QLS} = \overline{\text{QLS}} \]  
\( (29) \)

\[ \text{QKS} = \overline{\text{QKS}} \]  
\( (30) \)

In an open national economy, a net savings account is needed to adjust the foreign exchange balance. This model is an open economy at the regional level, which does not take into account exports and imports but only the external balance of payments outside the region:

\[ \sum \text{pwm}_{c} \times \text{QM}_{c} = \sum \text{pwe}_{a} \times \text{QE}_{a} + \text{FSAV} \]  
\( (31) \)

In the model, \( \text{FSAV} \) is the net balance of regional trade as an endogenous variable. Then there is the investment-savings balance:

\[ \text{EINV} = (1 - \text{mpc}) \times (1 - \text{ti}_{h}) \times \text{YH} + \text{ENTSAV} + \text{GSAV} + \text{FSAV} \]  
\( (32) \)

The 32 equations (1) to (32) form a common part of the CGE model for the open economy. There are 32 internal variables that can be untangled.

3.3 Parameter assignment

In this paper, we use Yang Kun-he, Hu Ming [17] and Freire-gonzález Jaume [18] for reference to assign the elastic parameters involved in the model. The elastic parameters of the production function, CET function and Armington condition function need to be given by the outside world, the production function parameters are as follows Table 4:
### Table 4: Production function parameter assignment

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</tbody>
</table>

The remaining parameters are assigned as follows:  \(P_A(a)=1;\ P_V A(a)=1;\ P_INT_A(a)=1;\ P_D A(a)=1;\ P_D C(c)=1;\ P_E(a)=1;\ P_M(c)=1;\ P_Q(c)=1;\ W K=1;\ W L=1.\)

### 3.4 Model predictions

According to the basic assumption of the model, there are \(Q_E, Q_M, Q_D\) data in the end, in which \(Q_E\) indicates the quantity of goods produced and \(Q_M\) the quantity of goods attracted. \(Q_D\) is the rate of movement of goods in an area. Because the calculation results of CGE model are based on the SAM table in value form, the \(Q_E, Q_M, Q_D\) all in value form, here we can use the following method to obtain the characteristic weight form of freight volume \(H_Y L_W_t\):

\[
H_Y L_W_t = \frac{H_Y L_W_b H_Y L_V_t}{H_Y L_V_b} \quad (33)
\]

\(H_Y L_W_b\) represents the quantity of goods in the form of social weight in the base year, \(H_Y L_V_b\) represents the quantity of goods in the form of social value in the base year, and \(H_Y L_V_t\) represents the sum of \(Q_E, Q_M, Q_D\) representing the quantity of goods in the form of social value in the characteristic year, the most direct output for the CGE mode, such as:

\[
H_Y L_V_t = Q_E + Q_M + Q_D \quad (34)
\]

### 4. Analysis of model results

Taking Labor (labor remuneration) and capital (the sum of net production tax, fixed asset depreciation and operating surplus) as the main exogenous factors, this paper simulates the change trend of energy freight volume in Inner Mongolia after 2017. Trends in the dynamic and exogenous data obtained in the statistical data relative to the base period are shown in table 5.

### Table 5: Dynamic exogenous variables

<table>
<thead>
<tr>
<th>Year</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remuneration for workers (billion million)</td>
<td>7734.11</td>
<td>7682.84</td>
<td>8061.86</td>
<td>8205.96</td>
<td>8352.63</td>
</tr>
<tr>
<td>Ratio of labor remuneration to base year</td>
<td>1</td>
<td>0.993</td>
<td>1.042</td>
<td>1.061</td>
<td>1.080</td>
</tr>
<tr>
<td>NET production tax (billion yuan)</td>
<td>2725.66</td>
<td>2779.98</td>
<td>2995.74</td>
<td>3141.84</td>
<td>3295.07</td>
</tr>
<tr>
<td>Depreciation of fixed assets (billion yuan)</td>
<td>2148.89</td>
<td>2156.75</td>
<td>2282.46</td>
<td>2353.15</td>
<td>2426.04</td>
</tr>
<tr>
<td>The operating surplus in GDP (billion yuan)</td>
<td>3487.55</td>
<td>3521.43</td>
<td>3872.47</td>
<td>4084.29</td>
<td>4307.71</td>
</tr>
<tr>
<td>Capital Input (billion yuan)</td>
<td>8362.10</td>
<td>8458.16</td>
<td>9150.67</td>
<td>9579.29</td>
<td>10028.82</td>
</tr>
<tr>
<td>Ratio of capital investment to base year</td>
<td>1.000</td>
<td>1.011</td>
<td>1.094</td>
<td>1.146</td>
<td>1.199</td>
</tr>
</tbody>
</table>

Input and output processing using GAMS program, parameter calibration and dynamic simulation procedures are not detailed. The output is the forecast data in table 6.

### Table 6: Forecasts of regional energy freight volume (value form)

<table>
<thead>
<tr>
<th>Year</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forecast Regional Energy Freight Volume QD</td>
<td>5968.197</td>
<td>5961.932</td>
<td>6364.351</td>
<td>6563.399</td>
<td>6764.301</td>
</tr>
<tr>
<td>QM of attraction forecast</td>
<td>181.073</td>
<td>180.456</td>
<td>116.092</td>
<td>98.654</td>
<td>86.723</td>
</tr>
<tr>
<td>The quantity of QE is predicted</td>
<td>7.47</td>
<td>7.48</td>
<td>13.249</td>
<td>16.581</td>
<td>20.035</td>
</tr>
<tr>
<td>Forecast total freight volume</td>
<td>6156.74</td>
<td>6149.868</td>
<td>6493.692</td>
<td>6678.634</td>
<td>6871.059</td>
</tr>
</tbody>
</table>

According to the output results, combined with the actual freight volume, through comparison and analysis, the characteristic annual energy freight volume and regional energy freight volume are obtained.
As can be seen from the error term of figure 3, the average prediction error is -2.27%, the maximum error is -11.01%, and the result is very reliable. It is proved that CGE model can be applied to regional energy freight volume.

The following use of this model forecast Inner Mongolia in 2025, 2030 and 2035 total energy freight, as shown in Figure 4.

Using the growth rate relationship, compensation and capital input from 2025 to 2035 is calculated, and its ratio to the base period is compiled into GAM software. The CGE model is used to forecast the total Inner Mongolia energy freight volume. Visible, Inner Mongolia future energy freight volume will continue to grow, and a higher rate of increase[19-22].

5. Summary

From the process and result of the model prediction, we can draw the following conclusions: 1 the average prediction error is -2.27%, the maximum error is -11.01%, the result is very reliable. It is proved that the CGE model is feasible in the forecast of energy freight transport, and the integration of economics and freight logistics is explored effectively. 2 forecast: Inner Mongolia Energy freight volume will continue to grow in the next decade, and the rise is high. The average growth rate every five years reached 45.56%, showing a rapid growth state.

According to the above situation, this paper puts forward the following suggestions: 1 according to the regional characteristics of Inner Mongolia, we should establish a complete energy logistics transportation network and build the corresponding logistics center. Establish and improve the green logistics management system to promote the integrated development of Green Logistics Energy. During the epidemic, we should also promote toll roads free or reduced to reduce transport costs, and promote green transport flow. 2 firstly, Inner Mongolia Energy Transport Company must give priority to developing green transportation, and combine modern transportation modes such as rail transportation and aviation, through scientific and reasonable planning of transportation channels with high efficiency and less pollution, carry out reasonable planning of transportation. Second, energy transport companies...
must research and introduce advanced means of transport, such as driverless vehicles, new energy vehicles and unmanned aerial vehicles, to reduce pollution and business costs, and jointly improve the quality of energy transmission.

References