THE DYNAMIC ANALYSIS OF RAIL FREIGHT TRANSPORT PLANNING

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ABSTRACT

Shanxi province is a base of coal, heavy and chemical industry in our country, the transportation of almost all freights depends on railroad. In Shanxi, the capacity of railroad transportation is very much limited so that a lot of products are overstocked for ages, and the ratio of coal transport and other materials transport is very irrational, From coordinating the development of different branches of the national economy and rationalizing industrial structure, this paper applies dynamic analytic hierarchy process to analyse and predict freight transport structure of Shanxi in the viewpoint of systems engineering.

Based on the statistic data about 30 years, first, several curves are fitted, which are on the volume of rail freight out of Shanxi and into Shanxi, as well as the volume of several main freights transported out. Then, a hierarchy model is set, each level of which is dynamic, the model shows the relation between the gross value of industrial and agricultural output of Shanxi and the volume of rail freight. With this model, we can also predict the weights of which coal as well as other materials should be possessed in the total volume of rail freight.

1. INTRODUCTION

Shanxi province is a base of coal, heavy and chemical industry. It is rich in natural resources such as iron, copper, aluminium, especially coal. It supplies many provinces and cities with the most of its exploited coal for industry and daily life, and some is exported to other countries.

However, because of the limitation of its geographical position, there are hardly air and water transport, so rail transport becomes into a main means of freight. Besides carrying raw materials, industrial and agricultural products, it also carrie s daily necessities for people's livelihood.

Since 1949 output of coal in Shanxi has increased 40 times more than it was, but the capacity of rail transport has only raised 5 times, then the transportation becomes into the weakest link in the economical construction chain. And now, the gap between transportation and production are getting even greater and greater, on the one hand, there are a lot of overstocked coal and other products to be transported out, on the other hand , there are a lot of raw materials and daily necessities to be transported in , Not only does this slow down the development of production, but also restricts the raise of people's living standard.

In recent years, a policy of giving priority to coal transport has been made, more coal is transported, but further overstocking of other materials is caused. This irrational ratio between coal and other materials has made the production suffer heavy losses, and excerted a tremendous influence on people's daily life.

From the viewpoint of systems engineering, we should give consideration to both the development of coal and others, as well as the improvement of people' s livelihood. We must soberly know that every branch of national economy is relative and restrict each other, in order to speed up the development of our national economy, a rational production structure must be established.

It is hardly possible for us to change this tense situation of Shanxi's rail transport in a short period of time, so a long-term plan about freight transport especially a proper proportion between coal and other materials transport should be made. To develop rural economy, every district will develop industry and sideling production based on its own advantages, transportation is of great importance. For example, some materials such as gypsum, soda, chemical fertilizer and cement are of more benefit to the economy than coal, the transport of these raw materials and products will directly influence the economical benefit of Shanxi.

This paper applies dynamic analytic hierarchy process to study the relation between the gross value of industrial and agricultural output and the volume of rail freight transport within this century, and to predict the weight of coal transport in total volume of freight transport out of Shanxi.

2. DYNAMIC PRIORITIES

Analytic Hierarchy Process is a simple and practical scientific method. It is efficient in describing and analysing engineering, society and economy systems qualitatively and quantitatively. When a described system varies in properties with time, that is, in AHP, the judgement matrixes and their elements are either partly or completely the functions of time t. We have to use dynamic analytic hierarchy process to give the system an overall description.

Saaty has proved that dynamic judgement matrix is :

$$A(t)\, W(t) = \lambda_{max}(t)\;\; W(t) \qquad (1)$$

$$A(t) = (\mu_{ij}(t))_{n\times n}$$

and has already got the analytic solutions of dynamic priorities when n = 3, 4, [3]

Xu Shubo put forward to another new dynamic priority model [4],
that is ,

$$A(t) = M(t)\, A_0\, M^{-1}(t) \qquad (2)$$

where $A_0 = A(t_0)_{n\times n}$ is initial judgement matrix.
$M(t) = \mathrm{diag}\,(m_i(t)\,)$ influence multiplier matrix.
$M(t) = I$

The eigenvector of A(t) corresponding to the largest eigenvalue λ_{max} is

$$W(t) = M(t)\, W_0 \qquad (3)$$

in which W_0 is the eigenvector of A_0 for λ_{max}

The consistency test of A(t) and the basic steps of AHP are still suitable here.

3, THE DYNAMIC PRIORITIES OF THE COAL AND OTHER MAIN MATERIALS IN RAIL FREIGHT TRANSPORT OUT OF SHANXI

The development of coal industry of Shanxi is concerned with the development of our energy resource and national economy. With the building of rail in Shanxi, the volume of coal transport will be certainly on the increase. But at the same time, we should take account of the coordinate development of all branches in whole economy and the requirement of people's livelihood, and keep the volume of coal and other materials transport remaining a proper proportion. This is a complicated dynamic systen, therefore we can analyse and predict it with dynamic analytic hierarchy process.

First, set up a hierarchy model with four levels A,B,C,D (shown as fig. 1). In Fig. 1, each level of A,B,C,D is dynamic.

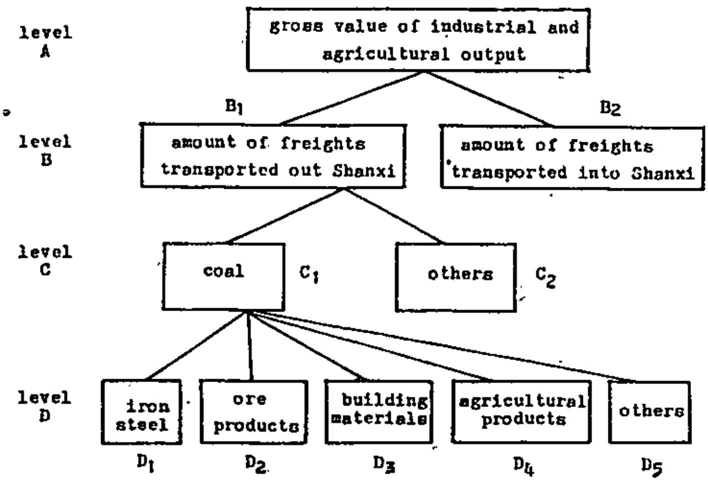

fig. 1 Hierarchy Model

A-B,

$$A_0 = \begin{pmatrix} 1 & 4 \\ 1/4 & 1 \end{pmatrix}$$

$$W_0 = \begin{pmatrix} 0.8 \\ 0.2 \end{pmatrix} \qquad \lambda_{max} = 2, \quad CR = 0$$

$$M_B(t) = \mathrm{diag}\,(\, m_1(t),\ m_2(t)\,)$$

in which

$$m_1(t) = 1 - 0.0181t + 0.0075t^2$$
$$m_2(t) = 1 + 0.1525t + 0.0024t^2$$

so,

$$W_{AB}(t) = M_B(t)\, W_0$$

$$= \begin{pmatrix} m_1(t) & \\ & m_2(t) \end{pmatrix} \begin{pmatrix} 0.8 \\ 0.2 \end{pmatrix} \qquad t_0 = 1951$$

B_1-C_1

$$A_0 = \begin{pmatrix} 1 & 5 \\ 1/5 & 1 \end{pmatrix}$$

$$W_0 = \begin{pmatrix} 0.8333 \\ 0.1667 \end{pmatrix} \qquad \lambda_{max} = 2, \quad CR = 0$$

$$Mc(t) = \mathrm{diag}\,(\, m_3(t),\ m_4(t)\,)$$

in which

$$m_3(t) = 1 - 0.0146t + 0.0078t^2$$
$$m_4(t) = 1 - 0.0277t + 0.0063t^2$$

so,

$$W_{B_1C}(t) = \begin{pmatrix} m_3(t) & \\ & m_4(t) \end{pmatrix} \begin{pmatrix} 0.8333 \\ 0.1667 \end{pmatrix} \qquad t_0 = 1951$$

overall priority A-B_1-C_1

$$W_{AC}(t) = 1/\Delta_t \begin{pmatrix} 0.8333\, m_3(t) & 0 \\ 0.1667\, m_4(t) & 0 \end{pmatrix} \begin{pmatrix} 0.8m_1(t) \\ 0.2m_2(t) \end{pmatrix}$$

$$\Delta_t = 0.8333\, m_3(t) + 0.1667\, m_4(t)$$

The influence weights of coal transport on the gross value is shown as Fig. 2. And the ratio between coal transport and other materials in the total volume of freight transport out of Shanxi is shown as Fig. 3.

Besides coal, the transportation of iron and steel, ore products, building materials, agricultural products and others is also very important.

C_2-D_1

$$A_0 = \begin{pmatrix} 1 & 1/3 & 1/2 & 2 & 1/4 \\ 3 & 1 & 3/2 & 5 & 2/3 \\ 2 & 2/3 & 1 & 4 & 1/2 \\ 1/2 & 1/5 & 1/4 & 1 & 1/7 \\ 4 & 3/2 & 2 & 7 & 1 \end{pmatrix}$$

$$W_s = \begin{pmatrix} 0.0967 \\ 0.2731 \\ 0.1933 \\ 0.0515 \\ 0.3854 \end{pmatrix}$$

$$\lambda_{max} = 5.000411$$
$$CR = 0.000918 \qquad (t_0 = 1976)$$

In fluence multiplier matrix is

$$M_s(t) = \begin{pmatrix} m_1(t) & & & & \\ & m_2(t) & & & \\ & & m_3(t) & & \\ & & & m_4(t) & \\ & & & & m_5(t) \end{pmatrix}$$

in which

$$m_1(t) = 1 + 0.5254t$$
$$m_2(t) = 1 + 0.1711t$$
$$m_3(t) = 1$$
$$m_4(t) = 1 + 0.9154t$$
$$m_5(t) = 1 + 0.2339t$$

the weights matrix,

$$W_{C,D}(t) = M_s(t)\, W_s = [W_i]^T$$

When to = 1976, we will get

$$m_6'(t) = 1 + 0.0683t + 0.0014t^2$$
$$m_7'(t) = 1 + 0.0677t + 0.0015t^2$$

B_1-C ,

$$A_s = \begin{pmatrix} 1 & 6.5 \\ 1/6.5 & 1 \end{pmatrix}$$

$$W_s = \begin{pmatrix} 0.8667 \\ 0.1333 \end{pmatrix}$$

$$\lambda_{max} = 2 \qquad CR = 0$$

$$W_x(t) = \begin{pmatrix} 0.8667m_6'(t) \\ 0.1333m_7'(t) \end{pmatrix} \qquad (t_0 = 1976)$$

$$\Delta_2 = 0.8667m_6'(t) + 0.1333m_7'(t)$$

the overall priority B_1-C_2-D_2

$$W_{B,D}(t) = 1/\Delta_1\, W_{C,D}(t) \cdot 1/\Delta_2\, 0.1333m_7'(t)$$

$$\Delta_1 = \sum_{i=1}^{5} W_i\, m_{i+1}(t)$$

The influence weights of iron and steel, ore products, building materials agriculteral products and others except coal in the total volume of freight transport out of Shanxi is shown as Fig. 4.

4. CONCLUSION

According to the results, although the volume of coal transport will continuously increase with the building of railroad, its weight in total volume of freight transport should remain 86.5 percent. So that we can make all branches develop balancedly. They also show that coal transport is of great importance to the rational economy of Shanxi Province.

Certainly, if our energy policy or the requirement for coal of other provinces varies, the weight predicted will vary too . although the rail transport of Shanxi has been much developed for many years, yet there are a lot of materials overstocked. It is impossible to expect a great change in a short time.

REFERENCES

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A-B1-C

	(C_1)	(C_2)		(C_1)	(C_2)
1951	.833	.167	1986	.866	.134
1952	.835	.156	1977	.866	.134
1953	.837	.163	1978	.866	.134
1954	.840	.160	1979	.866	.134
1955	.843	.157	1980	.866	.134
1956	.845	.155	1981	.866	.134
1957	.848	.152	1982	.866	.134
1958	.850	.150	1983	.866	.134
1959	.853	.147	1984	.866	.134
1960	.855	.145	1985	.866	.134
1961	.857	.143	1986	.866	.134
1962	.858	.142	1987	.866	.134
1963	.859	.141	1988	.866	.134
1964	.861	.139	1989	.865	.135
1965	.862	.138	1990	.865	.135
1966	.862	.138	1991	.865	.135
1967	.863	.137	1992	.865	.135
1968	.864	.136	1993	.865	.135
1969	.864	.136	1994	.865	.135
1970	.864	.136	1995	.865	.135
1971	.865	.135	1996	.865	.135
1972	.865	.135	1997	.865	.135
1973	.865	.135	1998	.865	.135
1974	.865	.135	1999	.865	.135
1975	.865	.135	2000	.865	.135

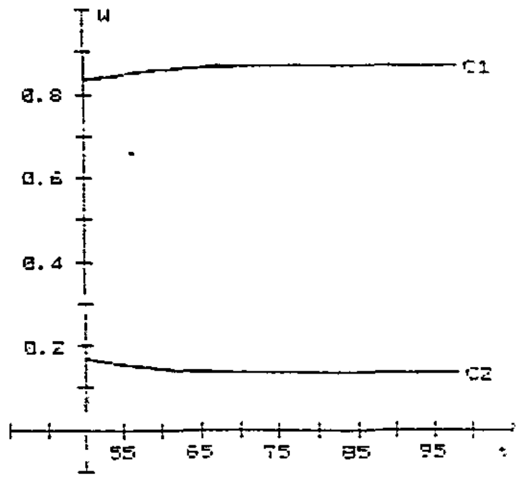

Fig.2 The weight of coal in the gross value

B1-C

	(C_1)	(C_2)		(C_1)	(C_2)
1951	.833	.167	1976	.866	.134
1952	.835	.165	1977	.867	.133
1953	.838	.162	1978	.867	.133
1954	.841	.159	1979	.867	.133
1955	.843	.157	1980	.867	.133
1956	.846	.154	1981	.867	.133
1957	.849	.151	1982	.867	.133
1958	.852	.148	1983	.866	.134
1959	.854	.146	1984	.866	.134
1960	.856	.144	1985	.866	.134
1961	.858	.142	1986	.866	.134
1962	.859	.141	1987	.866	.134
1963	.861	.139	1988	.866	.134
1964	.862	.138	1989	.866	.134
1965	.863	.137	1990	.866	.134
1966	.864	.136	1991	.866	.134
1967	.864	.136	1992	.866	.134
1968	.865	.135	1993	.866	.134
1969	.865	.135	1994	.866	.134
1970	.866	.134	1995	.866	.134
1971	.866	.134	1996	.866	.134
1972	.866	.134	1997	.866	.134
1973	.856	.134	1998	.866	.134
1974	.866	.134	1999	.866	.134
1975	.866	.134	2000	.866	.134

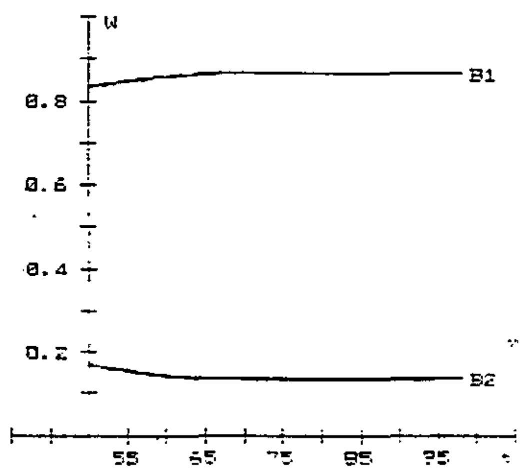

Fig.3 The weights of coal and other materials in the volume of freight transport out

B_1-C_2-E

	(D_1)	(D_2)	(D_3)	(D_4)	(D_5)
1976	.013	.037	.026	.077	.025
1977	.016	.035	.021	.011	.052
1978	.018	.033	.018	.013	.052
1979	.020	.032	.015	.015	.052
1980	.021	.032	.013	.017	.052
1981	.022	.031	.012	.016	.052
1982	.022	.031	.011	.019	.052
1983	.023	.030	.010	.019	.052
1984	.023	.030	.009	.020	.052
1985	.024	.030	.008	.020	.052
1986	.024	.030	.008	.021	.052
1987	.025	.029	.007	.021	.052
1988	.025	.029	.007	.022	.052
1989	.025	.029	.006	.022	.052
1990	.025	.029	.006	.022	.051
1991	.025	.029	.006	.022	.051
1992	.026	.029	.005	.023	.051
1993	.026	.029	.005	.023	.051
1994	.026	.029	.005	.023	.051
1995	.026	.028	.005	.023	.051
1996	.026	.028	.005	.023	.051
1997	.026	.028	.004	.024	.051
1996	.026	.028	.004	.024	.051
1999	.026	.028	.004	.024	.051
2000	.027	.028	.004	.024	.051

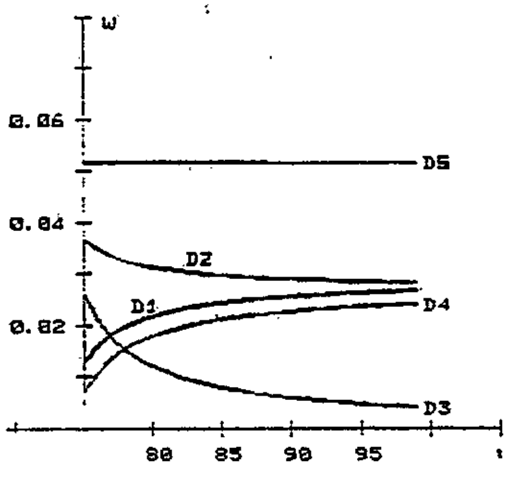

Fig.4 The weights of five kinds of materials in the volume of freight transport out