The Optimization Model Of Subject-Proportion of Higher Education And Its Application

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I. Introduction

Education is one of the important elements of a nation. It promotes the development of the society and the economy. but it must be coordinated to maintain the relative conditions of stability in a country. To achieve such a goal, preserve stability, and coordinate the development of higher education, the society and the economy, we must rationally determine the proper mix in higher education of engineering, farming and forestry, medicine, teacher-training, liberal arts, science, economics, law, physical education and art.

In this paper, we use both a dynamic decision model of optimization subject to constraints on the proportion for a region's higher education mix, the society, and the economy in the region (province or city), and the Analytic Hierarchy Process. By applying this model, based on the particular situation of society, we have achieved the desired mix in higher education in the Shandong province in ten years. This achievement can be used as a reference for the development of other areas.

II. System Analysis and Mathematical Model

The reasonable mix of higher education in a region must consider the need of the society to develop and the economic and educational background of the region. It is clear that this is a multiple objective decision problem. The objective is to derive a rational subject-proportion under given conditions. According to the objective, to begin with, we first determine the elements which have something to do with it, then eliminate those elements that are deemed unimportant, and finally, obtain an optimum decision outcome through weighted combination. Here, the elements that are judged to have an impact are the society's demand and environmental restrictions. The process of systems analysis is shown in Figure 1.

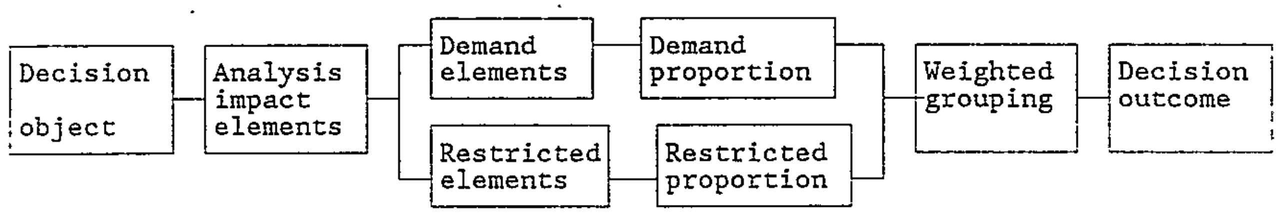

Figure 1

There are two independent subsystems that consist of demand elements and restriction elements. The demand system consists of three kinds of elements, social development, economic development and science and technology progress. Further every element can be divided into many sub-elements. The restricted subsystem is based on current status of higher education and status quo assignment or graduation (or talent in the marketplace). It needs to be pointed out that the status quo of talent in the marketplace does not reflect the overall real needs of society.

For our analysis, we developed a hierarchic structure as shown in Figure 2. This hierarchy is not complete. In addition, all the elements of B are time dependent and, therefore, the final decision outcome must also be time dependent.

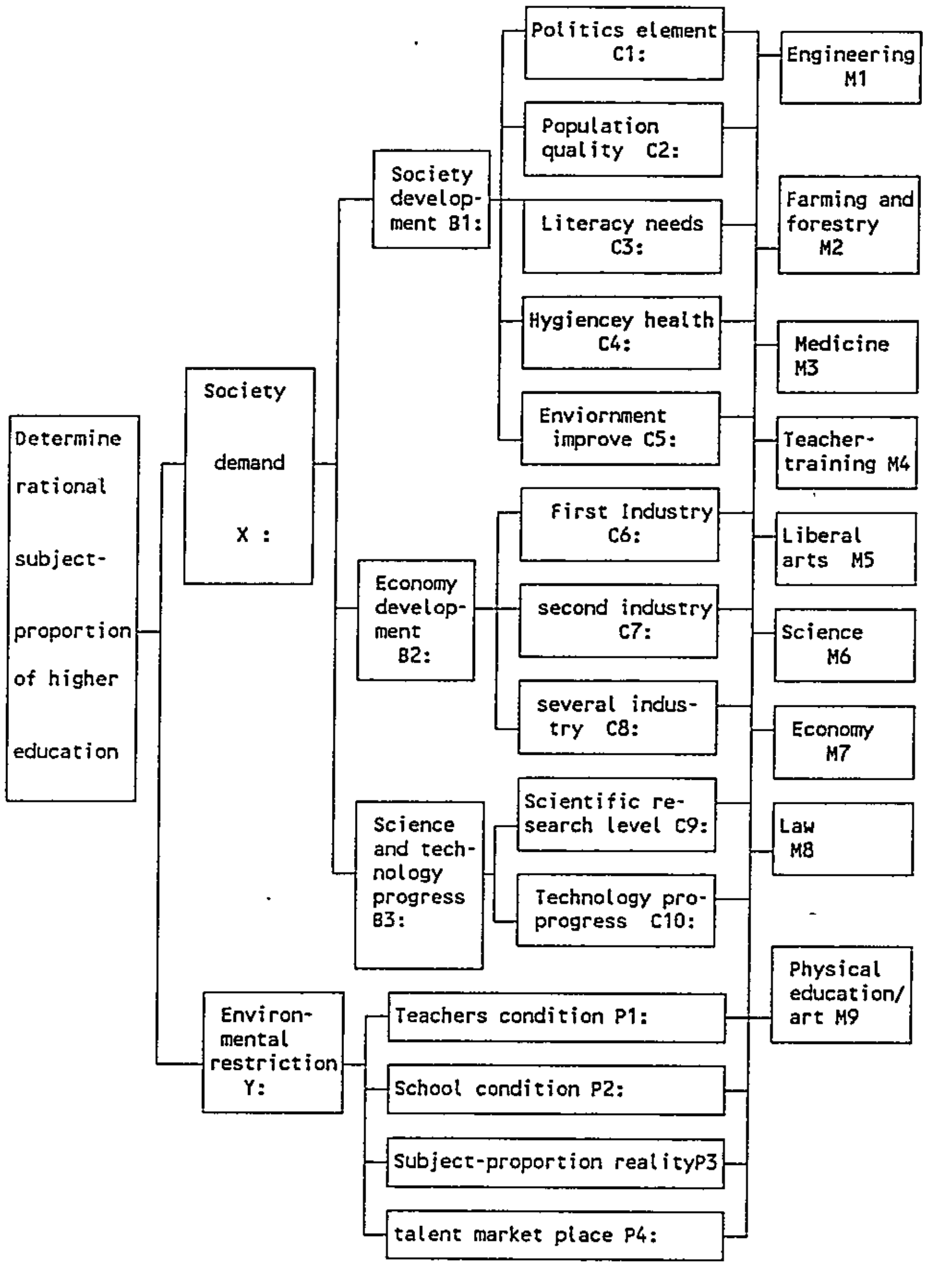

Figure 2

The mathematical model we use is given by:

$$\left| (C_k(t) \right| = \begin{vmatrix} C1 & 0 & 0 \\ 0 & G(t) & 0 \\ 0 & 0 & C2 \end{vmatrix} \cdot F_i(t) \qquad (1)$$

$$m_i(t) = m \cdot C_k(t) \quad (2)$$
$$n_i(t) = N(t) \cdot P \quad (3)$$
$$M_i(t) = k_1(m_i(t)-n_i(t))+n_i(t) \quad (4)$$
$$(k = 1,2,...10,\ i = 1,2,...9,\ j = 1,2,3,\ l = 1,2,3)$$

where $C_k(t)$ is the weight of the C_k elements. $C1=(c_1, c_2 \cdots c_5)^t$ is the weight of the sub-elements of B1; $G_j(t)=(g_1(t),g_2(t),g_3(t))^t$ is the weight of the sub-elements of B2; $C2=(c_9,c_{10})^t$ and C1 have the same meaning; $F_i(t)=(f_1(t), f_2(t), f_3(t))^t$ is the weight of all elements of B correspond to X; $m_i(t)$ is the weight of the proportion of demand, Mi, corresponding to X. $M=(m_{ij})$ is a matrix of demand of dimension 9x10. It consists of the weights of the elements in C_k. By the same principle, $n_i(t)$ is called the proportion of restrictions; N(t) is called the matrix of restrictions; and $P=(p_1, p_2, p_3, p_4)^t$ is called the weight of the restricted elements.

Because the restrictions are discrete variables and change year after year, N(t) may be obtained through statistics every year. M_i =(t) is the decision outcome that is obtaied through the weighted grouping of $m_i(t)$ and $n_i(t)$. k_1 is weight value of X. If kl is the weight of Y, then k2=1-kl and we have:

$$M_i(t) = k_1m_i(t)+k_2n_i(t)=k_1m_i(t)+(1-k_1)n_i(t)=k_1(m_i(t)-n_i(t)).$$

III. Application example

Using the model described above we have predicted the subject-proportion of higher education and the demand proportion for 1991-2000 in the Shandong province. The data of this paper have been obtained through pairwise comparisons and statistical material of the society and the economy, and also through the analysis of the development of the society, the economy and the higher education in this region.

The results are calculated as follows:

$$F_I(t) = \delta_1(0.106+0.0194t,\ 0.634-0.166t,\ 0.260+0.004)^T$$

where
$$G_j(t) = \delta_2(0.299e^{-0.042t},\ 0.482e^{0.042t},\ 0.219e^{0.003t})$$

$$\delta_1 = \left[\sum_{I=1}^{3} f_i^I(t)\right]^{-1} = (1+0.0068t)^{-1}$$

$$\delta_2 = \left[\sum_{j=1}^{3} g_j^I(t)\right]^{-1} = 0.299e^{-0.042t}+0.482e^{0.042t}+0.219e^{0.003t-1}$$

$C_1=(0.082,\ 0.371,\ 0.122,\ 0.031,\ 0.094)^T$ and $C_2=(0.25,\ 0.75)^T$.

Substituting $F_i(t)$, $G_j(t)$, C_1, C_2 into equation (1) we obtain:

$$C_k(t)=\delta_1(\begin{array}{l} 0.0016t+0.0087, \\ 0.0072t+0.0393, \\ 0.0024t+0.0129, \\ 0.0064t+0.351, \\ 0.0018t+0.001, \\ \delta_2(-0.005t+0.1896)e^{-0.0412t}, \\ \delta_2(-.008+0.3056)e^{0.042t}, \\ \delta_2(-0.0036t+0.1388)e^{0.03t}, \\ 0.001t+0.065, \\ 0.003t+0.195 \end{array})^T$$

The matrix of demand M is given by:

$$
\begin{bmatrix}
0 & 0 & 0 & .091 & .561 & .101 & .552 & .32 & .053 & .704 \\
0 & 0 & 0 & 0 & .213 & .517 & .104 & 0 & .053 & .102 \\
0 & .07 & 0 & .818 & 0 & 0 & 0 & .048 & .269 & .052 \\
.043 & .466 & .064 & 0 & 0 & .203 & .126 & .108 & 0 & 0 \\
.424 & .179 & .267 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & .091 & .119 & .101 & .126 & .034 & .624 & .142 \\
.146 & .03 & 0 & 0 & .054 & .051 & .126 & .359 & 0 & 0 \\
.272 & .042 & 0 & 0 & 0 & .027 & .03 & .024 & 0 & 0 \\
.115 & .213 & .699 & 0 & .054 & 0 & 0 & .108 & 0 & 0
\end{bmatrix}
$$

The calculation of $m_i(t)$ is shown in Table 1.

Table 1
1991-2000 subject-proportion of demand of higher education of Shandong

	M1	M2	M3	M4	M5	M6	M7	M8	M9
1991	.3894	.1458	.0709	.1163	.0192	.144	.0659	.225	.0265
1992	.3884	.1364	.0766	.1158	.0216	.1429	.0663	.0226	.0303
1993	.3871	.1278	.0822	.1149	.0238	.142	.0663	.0228	.0338
1994	.3852	.1198	.0088	.1144	.0263	.1407	.0664	.0229	.0374
1995	.3831	.1124	.0932	.1141	.0287	.1397	.0661	.0229	.0408
1996	.3806	.1057	.0987	.1136	.031	.1385	.0657	.0232	.0442
1997	.3779	.0995	.1039	.1135	.0331	.1376	.0651	.0231	.0472
1998	.3747	.0939	.10992	.1133	.0354	.1365	.0643	.0233	.0504
1999	.3712	.0887	.1143	.1132	.0376	.1356	.0634	.0234	.0536
2000	.3675	.0838	.1193	.1133	.0399	.1347	.0626	.0235	.0566

Using the same principle, we obtain the restricted proportion based on statistics on education for the province of Shandong (1988,1989). We have:

$$n_i(t_o)=(o.303,\ 0.032,\ 0.177,\ 0.213,\ 0.027,\ 0.057,\ 0.14,\ 0.025,\ 0.026)^T$$

$n_i(t_o)$ is the restricted proportion value for the years 1990 and 1991. We now use it to compute the higer-education mix for 1990 and 1991. Setting kl equal to 0.7, 0.5 and 0.3, we have:

Table 2
1991 optimum subject-proportion of higher education of Shandong

kl	M1	M2	M3	M4	M5	M6	M7	M8	M9
0.7	.0635	.1117	.1027	.1453	.0215	.1179	.0881	.0233	.0264
0.5	.3462	.0889	.124	.1647	.0231	.1005	.103	.0238	.0263
0.3	.3289	.0661	.1452	.184	.0247	.0831	.1178	.0243	.0262

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