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The Sequencing Judgment Matrix in AHP and Their Applications

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Abstract: In this paper we propose a new dynamic queuing model for the AHP and the method to solve it.The inference is very simple and the method can be used widely in practice. Furthermore,we give a extensive analysis for the variability of the importances of the five main branches of agriculture in China(including farming,forestry, by-production, animalhusbandry and fishery).
Key words: Analytic Hierarchy Proces; Sequencing judgement matrix; Application

Agriculture(including farming,forestry,by-prodution,animal husbandry and fishery) occupies an important position in the national economy. In order to know the law of exchange of all walks of life in the countryside,we have engaged in the research of dynamic priority put forward by professor Saaty (Saaty, 1980) ,and developed a new easy algorithm.

1. THE DEFINITION OF DYNAMIC JUDGEMENT MATRIX

The analytic hierarchy process(AHP) is a branch of multi-goal decision making.It can,at last,provide priorties for making decisions. The critical step for establishing priorities using the method of AHP is to construct a judging matrix.The judging matrix shows the people's knowledge and judgement of the importance of the comparable factors involved.

The dynamic judging matrix A is usually indicated with the following formula:

$A(t)=(a_{ij}(t))_{nxn}$

Where

$a_{ij}(t)>0;\quad a_{ij}(t)=1/a_{ji}(t);\qquad i,j=1,2,\ldots,n$

In order to study the law of the development of farming, forestry, by-products, animal husbandry and fishery in Lingxian County, Shandong province, China, we analysed the relationships between them which are classified into four patterns:

- **The stable pattern**

The developing relationships between farming and forestry, animal husbandry, fishery, and the relationship between forestry and fishery are basically stable. The judgment of the relative significance between them can be indicated with a constant real number.

- **The linear changeable pattern**

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Forestry developes more rapidly than animal husbandry. By-products developes more rapidly than animal husbandry and fishery so the judgment of the relative significance between them can be indicated with linear function.

· **The slow-rapid changeable pattern**

Duing the preceding stage, animal husbandry and fishery developed almost synchronously. The developing step of animal husbandry kept pace with the development of farming. So the expontial law of development formed between them.

· **The rapid-slow changeable pattern**

From the comparision of the development in farming,forestry and by-products, we can see that by-products have a tendency to surpass farming and forestry. So the reciprocal logarithmic law of the development has formed between them.

After formulating the basic pattern, we provide,based on the statistical table of the output value in all walks of life from 1996 to 2004 in Lingxian County the elements of the upper. Triangular submatrix of the dynamic judging matrix by usingthe regression analytic method and Delphi's algorithm. The elements of the lower triangular submatrix of dynamic judging matrix can be replaced by the ratio of undetermined weights $w_i(t)/w_j(t)$.

Table 1

Dynamic Judging Matrix A(t)

	Farming	**Forestry**	**By-products**	**Animal husbandry**	**Fishery**
Farming	1	1.5	4/(1+2ln16t)	5	7
Forestry	$w_2(t)/w_1(t)$	1	19/(1+3ln18t)	0.02t+2	6
By-products	$w_3(t)/w_1(t)$	$w_3(t)/w_2(t)$	1	0.45t+0.1	0.7t+3
Animal husbandry	$w_4(t)/w_1(t)$	$w_4(t)/w_2(t)$	$w_4(t)/w_3(t)$	1	$e^{0.3t+0.2}$
Fishery	$w_5(t)/w_1(t)$	$w_5(t)/w_2$**(t)**	**$w_5(t)/w_3(t)$**	**$w_5(t)/w_4(t)$**	**1**

2. THE FUNCTION OF DYNAMIC PRIORITIES

In the dynamic judging matrix A(t),there are linear functions, logarithmic functions, exponential functions, or the reciprocais of these three functions.The reciprocal matrix $A^*(t)$ can be written by

$$A^*(t)=\begin{bmatrix} 1 & f_{12}(t) & f_{13}(t) & \cdots & f_{1n}(t) \\ w_2(t)/w_1(t) & 1 & f_{23}(t) & \cdots & f_{2n}(t) \\ w_3(t)/w_1(t) & w_3(t)/w_2(t) & 1 & \cdots & f_{3n}(t) \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ w_n(t)/w_1(t) & w_n(t)/w_2(t) & w_n(t)/w_3(t) & \cdots & 1 \end{bmatrix}$$

Where $f_{ii}(t)$ stands for the linear function,logarithmic function, exponential function,or the reciprocals of these three functions.

Study matrix of n row and one colume of the characteristic equation:

$$\begin{bmatrix} 1 & f_{12}(t) & f_{13}(t) & \dots & f_{1n}(t) \\ w_2(t)/w_1(t) & 1 & f_{23}(t) & \dots & f_{2n}(t) \\ w_3(t)/w_1(t) & w_3(t)/w_2(t) & 1 & \dots & f_{3n}(t) \\ \dots & \dots & \dots & \dots & \dots \\ w_n(t)/w_1(t) & w_n(t)/w_2(t) & w_n(t)/w_3(t) & \dots & 1 \end{bmatrix} \begin{bmatrix} w_1(t) \\ w_2(t) \\ w_3(t) \\ \dots \\ w_n(t) \end{bmatrix} = \lambda_{max} \begin{bmatrix} w_1(t) \\ w_2(t) \\ w_3(t) \\ \dots \\ w_n(t) \end{bmatrix}$$

$$nw_n(t)= \lambda_{max} w_n(t)$$

Since $w_n(t)$ is a nonzero vector, $\lambda_{max}=n$; therefore the eigenvector corresponding the largest eigenvalue of matrix $A^*(t)$ is $W(t)=(w_1(t),w_2(t),\dots,w_n(t))^T$,such that

$$A^*(t)W(t)=nW(t)$$

So we get the following recurrence formula:

$$w_i(t)=1/(n-i)(\sum_{j=i+1}^{n} f_{ij}(t)w_j(t))$$

i=1,2,…,n-1.

If we put the element of the dynamic judging matrix A(t) into the formula above,then we get the following results:

$w_1(t)=(((81t+18)/(160+480\ln 18t)+(9t+2)/(40+80\ln 16t)+0.0025+1.5)e^{0.3t+0.2}+(63t+270)/(80+240\ln 18t)+7t+30)/(20+40\ln 16t)+2.5)w_5(t)$

$w_2(t)=(((27t+6)/(20+60\ln 18t)+(t+100)/150)e^{0.3t+0.2}+(21t+90)/(10+30\ln 18t)+2)w_5(t)$

$w_3(t)=((0.225t+0.05)e^{0.3t+0.2}+0.35t+1.5)w_5(t)$

$w_4(t)=e^{0.3t+0.2}w_5(t)$

Where $w_5(t)$ is a known function.

3. ANALYSIS OF THE NUMERICAL RESULTS

Having the dynamic priority function,and calculated by computer, we acquired the ratio of the five walks of life (farming,forestry,animal husbandry,by-products,fishery) in the output value of agriculture from 1996 to 2014, Lingxian County,Shandong Province.

At the same time, by using the computer we also draw a picture of the function of the dynamic priofity the five walks of life in Lingxian County.

Year	Farming	Forestry	By-products	Animal husbandry	Fishery
1996	0.3819	0.2956	0.1500	0.1074	0.0651
1997	0.3702	0.2792	0.1777	0.1194	0.0536
1998	0.3590	0.2674	0.2023	0.1285	0.0428
1999	0.3483	0.2581	0.2251	0.1352	0.0333
2000	0.3380	0.2505	0.2466	0.1394	0.0255
2001	0.3282	0.2445	0.2668	0.1414	0.0191
2002	0.3189	0.2398	0.2858	0.1404	0.0142
2003	0.3100	0.2360	0.3036	0.1399	0.0104
2004	0.3017	0.2331	0.3203	0.1374	0.0076
2005	0.2939	0.2308	0.3358	0.1341	0.0055
2006	0.2866	0.2289	0.3502	0.1304	0.0039
2007	0.2798	0.2274	0.3636	0.1264	0.0028
2008	0.2734	0.2261	0.3761	0.1223	0.0020
2009	0.2675	0.2250	0.3877	0.1183	0.0015
2010	0.2621	0.2241	0.3985	0.1143	0.0010
2010	0.2569	0.2232	0.4086	0.1105	0.0007
2011	0.2521	0.2224	0.4180	0.1069	0.0005
2012	0.2477	0.2217	0.4268	0.1034	0.0004
2013	0.2435	0.2210	0.4351	0.1001	0.0003
2014	0.2395	0.2204	0.4429	0.0970	0.0002

The above results of caculation indicates the developing tendency of farming, forestry, by-products, animal husbandry and fishery in Linxian County, ShandongProvince, China, and also shows their proportional relation. This provides the county with a scientific basis to regulate the industrial structure in the countryside and to work out a plan for agricultural development.

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