AN OVERVIEW OF REASEARCHES AND APPLICATIONS OF THE ANALYTIC HIERARCHY PROCESS IN JAPAN

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ABSTRACT

This note is to overview researches and applications of the Analytic Hierarchy Process in Japan since it was introduced in 1984.

HOW AND WHEN AHP STARTED IN JAPAN

The Analytic Hierarchy Process has been paid much attention in Japan since Thomas Saaty's visit and his talks in Japan in November 1984. Until then his books and papers were known among some researchers, but only two groups, as far as I know, had used AHP: K. Tsuji(1985), Osaka University and H. Konno(1985), Tokyo Institute of Technology.

Thomas Saaty was invited to the International Conference on Economics and Management held in Tokyo, Japan, sponsored by the O.R. Society of Japan (ORSJ) and some other firms and organizations. His lecture at the plenary session was a kind of debut of AHP in Japan. This talk and his lecture in Osaka to the audiences from industries and universities sponsored by the local chapter of ORSJ and Kansai Institute of Management Systems(KIMS) attracted many people to the power of AHP.

The good acceptance of Saaty's lecture by the audience at Osaka made KIMS ask the present author who arranged the lecture to write a tutorial paper for IE Review, the journal of Japanese Institute of Industrial Engineering and the article appeared in March 1985 (Manabe 1985). (KIMS was acting as the local chapter office of JIIE.) This article was the first printed material in Japansese which introduced the method and applications of AHP and hundreds Xerox copies of this have been circulated until now as a handout for seminars and lectures in industries and universities.

Another lecture which affected Japanese operations researchers was delivered by K. Tone of Saitama University. He was invited to talk at the plenary session of the Spring National Meeting of ORSJ in May 1985.

Tone was one of organizers of the international conference in Tokyo and invited Saaty to the conference in the previous year. He showed small but good examples to attract people, and interested the audience in the AHP.

In addition, he wrote an introductory book of AHP in Japanese and published it in January 1986 (Tone 1986), which is a compact and good introduction to decision makers as well as to operations researchers.

Tone and Manabe made several lectures since 1986 in several cities at the convention of quality control managers, Operations Research training courses for people in industries, local chapter meetings of ORSJ, and so on. Manabe gave a two-day seminar for decision makers in Osaka in June 1986 sponsored by KIMS.

In May 1987 with some members of ORSJ I have founded the AHP Research Interest Group within ORSJ. We have about 50 persons in our mailing list and ten to twenty of them get together every month for half a day to hear the talks on AHP and relateted topics.

Operations Research has been apt to deal with well-structured rather than ill- or fuzzy-structured problems, quantitative problems rather than qualitative ones, and single-objectives rather than multi-objectives. But AHP can deal with problems which OR has not yet or cannot solved and it supplements conventional OR techniques. We think AHP would be a vehicle which penetrate operations research into top management who had paid little attention to O.R.

THEORETICAL AND METHODOLOGICAL RESEARCHES

Some academics have made research on the fundamentals of AHP such as Kameyama et al.(1987), Ichihashi & Tanaka(1987), Takeda and some others. And most theoretical contributions made in the last one year in Japan will be presented at this conference. Let me overview these works.

Takahashi(1988), and Takeda and Yu(1988) deals with the comparison process of AHP. When the large number of elements are to be compared at one level Takahashi(1988) partitions the comparison matrix into the submatrices by using the theory of balanced incomplete block design such that each pair of elements is included in one and only one submatrix and no pairs are repeated in any submatrices. By this partition, we can compare a small and equal number of elements in each submatrix and we are

able to consuruct a comparison matrix of the size larger than the magic number, 7 ± 2.

During the pairwise comparison process, the decision makers may have some pairs which he has little confidence in judging and make an incomplete matrix. Takeda and Yu(1988) proposes a procedure to obtain the eigenvalue weights in this case.

Masuda(1988) studies the effect of the change in a priority value at a certain level to the overall priority by setting up the overall priority matrix including all elements on the hierarchy chart, which he calls a reachability matrix. He calculates changes in the overall priority using this matrix.

Kamayama et al.(1988) used AHP for quantitative analysis of fault tree. They tried to obtain the priorities for the elements at the end of the fault tree, that is, the leaves. They also considers sensitivity of some elements to others.

While we talk introducing AHP, we are often asked how AHP is different from the conventional weighing methods such as described by the classical textbook of Operations Research by Churchman, Ackoff and Arnoff. Ohmae(1988) compared AHP with Churchman's weighing menthod and Scheffe's pairwise comparisons and answers to this question. His answer is for AHP.

Takahashi (1988b) shows the interesting results when binary judgments are made in pairwise comparisons, that is, $a_{ij} = \theta$ if i wins j and $a_{ij} = 1/\theta$ otherwise. He shows additional results for ternary comparisons.

Data Envelopment Analysis (DEA) is also being paid attention as another way of making decisions under multiple criteria environments. Tone (1987) shows the structural similarities between cost-benefit analysis through AHP and DEA.

APPLICATIONS IN JAPAN

Applications in an early stage were to select one from many alternatives under multiple criteria. Tsuji(1985) reported his application at the Energy Conference and Konno presented his case at the Fall Meeting of ORSJ, 1985 (Konno 1985). They coincidentally evaluated alternative energy sources in urban planning or housing. Tsuji's group applied AHP

also to evaluate proposals to the mass-transit system to be constructed in the newly developed residential and campus area and to other problems. J. Nomura and his team of Matsushita Denko reported at the ORSJ Meeting in Spring, 1986 (Nishikawa 1986) that they evaluated alternative proposals when they installed a workstation at their laboratory. They showed the result of evaluation to the budget control and facility planning departments. Their request to purchase the new facility was approved easier. E. Kinoshita used the AHP to analyse the people's bahavior in selecting the best way among alternative mass-transit routes (Kinoshita 1986, Kinoshita and Sasaki 1988). S. Katayama (1987) evaluated the Japanese word-processing softwares for the personal computers.

At the Spring Meeting of ORSJ in 1986 five cases used AHP were presented. Since then papers on theory and applications of AHP were presented at every meeting of ORSJ, which is held twice a year, in spring and fall.

The Communications of ORSJ, monthly journal of the society in Japanese, published the special issue on AHP in August 1986. I was the guest editor for this issue and wrote an introductory tutorial. Five papers on applications were contributed. Saaty also wrote a short paper describing several remarks in using AHP. Tsuji and Konno also joined with the above cases. Tone and his two graduate students(Tone et al. 1986) examined the taxation system in Japan. I can say that they extended a kind of thought experiments to quantitative analysis through AHP. Terano and his colleagues(Terano et al. 1986) at Central Research Institute of Electric Power Industry contributed a paper on AHP used in a expert system, which will be remarked later. M. Takizawa(1986) of Yamaha Motors wrote how AHP is used in product planning process. Many people learned AHP for the first time by this issue and wanted to use AHP to their problems.

The AHP Group of ORSJ have been collecting applications by inviting those who actually used AHP to talk at the group meeings.

A new and distinguished application is found in designing Expert Systems. Terano reported that they used to help describe the expert men's knowledge in constructing the expert system for diagnosing the defects of reservoir gates for hydro power plants (Terano et al. 1986). Terano wrote another paper for this symposium (Terano 1988). And Ohhashi of Toshiba also did the similar work in developing an expert system (Ohhashi et al. 1988).

A staff of Japan Vocational Ability Development Association reported at the meeting of AHP Research Group that he used AHP to standardize the exam problems to test the vocational ability. This association gives the exams to workers of more than one hundred and thirty kinds of jobs to evaluate the vocational ability every year at the cities all over Japan. The evaluation of the exams are required to be fair among the examiners in all cities. And the problem of one year are required to be as easy or difficult as that of other years. He made a hierarchy of the requirements of the problems, and allocated the points to each requirement.

AHP SOFTWARES IN JAPAN

Some of those who used the AHP wrote personal computer programs for their own uses in BASIC, C, or macros on a Lotus 1-2-3 spreadsheet.

Besides home made programs, Sumitomo Computing Service, Inc. rewrote Expert Choice developed and distributed by Decision Support Softwares, for the Japanese personal computers, NEC's PC-9801 series and IBM Japan's 5550.

JUSE, Inc. developed a software for AHP under the supervision by K. Tone for NEC's PC 9801 series and sells it under the name, "Nemawashi-Kun", which means in Japanese to lay the groundwork informally.

CONCLUDING REMARKS

Many academics show their interests in AHP and more researches will be made for using AHP effectively in actual decision making.

The special issue on AHP of the Communications of ORSJ published in August 1986 was most effective to spread AHP in Japan. Another special issue of the Communication or Journal is being planned to publish in the near future. And the Research Interest Group of AHP is going to sponsor one day symposium for the members of ORSJ at large in Spring next year on the previous day of the National Meeting of ORSJ. Those activities will continue to attract much audience to using AHP.

It usually takes time before a new method in management is understood and used in Japanese firms and organizations, especially, at the higher management levels. Our activities have been aimed at encouraging

decision makers, chiefly at the middle management or operations research staff, to use AHP in their actual decision making situations. And they have been effective. But more strong chances are required to stimulate the top management to look at us, understand and recognize the power of AHP.

REFERENCES

(References proceded by ‡ are in Japanese.)

‡Ichihashi, H. and H.Tanaka (1987), "AHP Using the Non-additive Weights," Spring Meeting, ORSJ, Preprints, pp.215-216.

‡Kameyama, Y. et al. (1987), "Numerical Expression of the Relative Importance for Analytic Hierarchy Process and it's Consistency," Proceedings of the 30th Joint Conference on Automatic Control in Japan, pp.137-142.

Kameyama, Y. et al. (1988), in this preprints.

‡Katayama, S. (1987), "Quality Evaluation by Way of Quality Development & AHP," The 7th Symposium for Quality Control in Software Production, Proceedings, pp.53-60.

‡Kinoshita, E. (1986),"On Selecting a Traffic Route Using AHP," Transportation and Economics, 46, 6, pp.64-73.

Kinoshita, E. and T. Sasaki (1988), in this preprints.

‡Konno, H. (1985), "Evaluation of the New Energy System by AHP," Fall Meeting, ORSJ, Preprints, pp.96-97, also (1986), Communucation of ORSJ, 31, 8, pp.482-487.

‡Manabe, R. (1985), "A New Desicion Making Method: AHP," IE Review, JIIE. 26, 1, pp.33-36.

Masuda, T. (1988), in this preprints.

‡Nishikawa, Y. et al. (1986), "Application of AHP in Selecting a Workstation," Spring Meeting, ORSJ, Preprints pp.166-167.

‡Ohhashi, A. et al.(1987),"Expert System Utilizing the Analytic Hierarchy Process (AHP)," National Meeting, Japan Association for Artificial Intelligence, Preprints, pp.331-334.

‡Ohmae, Y. (1987),"Comparison of AHP with Conventional Weighing Methods," 1987 Fall Meeting, ORSJ, Preprints, pp.190-191.

Ohmae, Y. (1988), in this preprints.

Takahashi, I. (1988), in this preprints.

Takahashi, I. (1988b), "AHP Applied to Binary and Ternary Comparisons," Draft, (Monthly Meeting, AHP Res. Group, ORSJ, May 20, 1988).

Takeda, E. and P. Yu (1988), in this preprints.

‡Takizawa, M. (1986), "AHP in Product Planning," Communucations of ORSJ,

31, 8, pp.505-510.

‡Terano, T. et al. (1986), "Application of AHP in developing an Expert Systems for diagnosing the Dam Gates," Spring Meeing of ORSJ, Preprints, pp.164-165. Also in Communications of ORSJ, 31, 8, pp. 500-504.

Terano, T. et al. (1988), in this preprints.

‡Tone, K. (1986), Desicion Making Using AHP, JUSE Publishing Inc.

‡Tone, K. et al. (1986), "A Study on Taxation Structures," Communications of ORSJ, 31, 8, pp.494-499.

Tone, K. (1987), "A Comparative Study on AHP and DEA," Research Report No. 87-B-7, Institute of Policy Science, Saitama Univ., also (1988) in this preprints.

‡Tsuji, K. et al. (1985),"Evaluation of Energy Systems through AHP," Res. Assoc. for Energy and Resources, preprints. pp140-145(in Japanese).

Yahagi, S. (1988), in this preprints.