REDUCING THE NUMBER OF EXPERT PAIR-WISE COMPARISONS DURING DECISION SUPPORT USING AHP

ABSTRACT

Studies on the reduction of the number of expert pair-wise comparisons during decision support using AHP is extremely relevant, because they allow expert session organizers to save time and reduce the cost of experts' work. Analysis of results of theoretic research of psychophysiological constraints of human mind, that influence credibility of expert estimates, demonstrated the impact of the order of pair-wise comparisons, performed by experts, upon expert session results. We suggest the respective ways of reduction of the number of expert pair-wise comparisons during decision support using AHP, which, at the same time, maintain the required level of expert information credibility.

Keywords: decision-making support, analytic hierarchy process, expert, pair comparisons, weakly structured domain, intangible factors.

1. Introduction

Expert estimation is widely used during decision-making support in weakly-structured subject domains. Examples of such domains include sustainable development, strategic management, defining social tension level, information operations research etc. Hiring of experts results in substantial costs and, at the same time, requires dealing with errors, caused by psychophysiological limitations of human mind, and subjectivity (heuristic nature) of expert estimation process. Thus, reduction of the number of times the experts are addressed in the process of decision-making is a relevant issue.

2. An approach to reduction of the number of expert pair-wise comparisons during decision support using AHP

One of the ways to improve the accuracy of expert estimation is to reduce the number of expert pair-wise comparisons [Wedley, 2009]. Related experimental research was focused on the so-called "tangible factors" [Saaty, 2010]: length of finite lines, square of figures etc. It has been demonstrated that if n alternatives are compared with each other, then, after we achieve the minimum necessary number of comparisons ($n-1$) (build one spanning tree), consistency level is gradually decreasing, while the level of accuracy is growing and then declining. In these experiments the order of pair-wise comparisons is not taken into account.

In addition to the approach, suggested by [Wedley, 2009], we propose to use the method of expert pair-wise comparisons, which takes the order, in which alternatives are compared (see section 4), into consideration, and, thus, increase the level of estimation accuracy, while reducing the number of pair-wise comparisons.

3. Influence of the order of alternative comparisons upon credibility of expert session results

Let us consider the psychological aspects of how the order of alternative comparisons influences the credibility of expert session results during estimation. Here we should mention the experimental studies, featuring comparisons of objects according to length, heaviness, brightness, loudness, duration, and other criteria [Stevens, Galanter, 1957]. These studies demonstrate the following patterns: dependance of subjective estimates on objective measures is not a linear one; respondents, usually, tend to overestimate the degree of the estimated quality of the object. The smaller the average value of this measure across the set of compared object, the larger this overestimation is. This allows us to suggest that by presenting the pairs of objects to the expert for comparison in a certain order we can influence (increase/decrease) the credibility of the estimation result.

4. A method of expert pair-wise comparisons, taking the order of comparisons into consideration

Let us assume, that we already know the non-strict ranking of *n* alternatives, and we need to obtain their expert pair-wise comparisons in order to rate them according to relative weights. Based on the phenomenon, mentioned in section 2, we suggest using a certain order when presenting alternatives to the experts for pair-wise comparisons.

Let alternatives be numbered according to their ranks:

$$a_1 \geq a_2 \geq \cdots \geq a_n ,$$

where: a_i is the alternative number *i*, $i = \overline{1, n}$, *n* is the total number of alternatives.

We suggest the following order of alternative pairs in order to improve the accuracy of judgments (preference values) obtained through pair-wise comparisons:

1st turn: (a_1, a_n);

2nd turn: (a_1, a_{n-1}) or (a_2, a_n);

3rd turn: (a_1, a_{n-2}) or (a_2, a_{n-1}) or (a_3, a_n);

…

n-1 turn: (a_1, a_2) or (a_2, a_3) or … or (a_{n-1}, a_n).

Within each turn, all alternative pairs have the same priority, so the order of comparisons within the turn can be arbitrary. The number of “turns” equals maximum alternative rank minus 1. Thus, first the expert is presented alternative pairs from turn # 1, then from turns #2, #3, ... , #(*n*-1).

Within the experiments of [Stevens, Galanter, 1957] objects were compared according to "tangible factors". However, expert estimation is used to evaluate objects, mostly, according to "intangible factors" [Saaty, 2010], that have no metrical units to compare the objects to. That is why we conducted a separate experimental research of how the order of pair-wise comparisons influenced the credibility of expert session results. In this research we deliberately focused on “intangible factors”. We used subjective preferences of each of the respondents as benchmarks. Similar approach was used in [Tsyganok, Kadenko, Andriichuk, 2015] and [Tsyganok, Kadenko, Andriichuk 2016]. According to the approach, after pair-wise comparison session, the expert/respondent is shown histograms (charts) with ratings (relative weights) of alternatives. (S)he is requested to select the chart that most adequately represents his(her) preferences in the issue under consideration.

Within the experimental research every respondent performed 3 rounds of pair-wise comparisons. Each round featured different sequences (*A*, *B* and *C*) of individual expert pair-wise comparisons of criteria used in the AHP model. Sequence *A* was formed based on the suggested method, taking the order of criterion pairs into account. Sequence *B* was formed based on random order of expert pair-wise comparisons of criteria. Sequence *C* was formed based on the order of criterion pairs, that was opposite to the order from sequence A (i.e. to the one suggested in the method).

According to the experiment results, sequence *A* was the leader in 56% of cases, sequence *B* – in 26% of cases, while sequence *C* – in 18% of cases, respectively (i.e. respondents preferred the respective charts). This result empirically validates the method of expert estimation, taking the order of comparisons into account, and proves that it can and should be applied to decision-making support as part of the AHP. Application of the method will increase the quality of initial expert data and the adequacy of subject domain models. As a result, decision-makers will get better recommendations as to decision variant selection. Finally, the approach makes the pair-wise comparison number reduction procedure, suggested by [Wedley, 2009], more targeted and efficient.

5. Conclusions

The paper presents an approach to reduction of the number of pair-wise comparisons during decision support using AHP. Application of the suggested approach allows expert session organizers to save time and resources, as the amount of required expert information is reduced, while sufficient level of expert recommendations' credibility is retained.

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7. Key References

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