Anna Prusak[)]
Tadeusz Sikora [1)]
Magdalena Niewczas-Dobrowolska [1)]

1) Faculty of Commodity Science, Cracow University of Economics, Poland, email: anna.prusak@uek.krakow.pl

THE APPLICATION OF THE ANALYTIC HIERARCHY PROCESS IN ASSESSING THE QUALITY OF LIFE

Abstract: *The Analytic Hierarchy Process (AHP) is one of the most popular, multicriteria decision support methods. It was developed in the 70's by American professor Thomas L. Saaty as a tool for resolving complex decision problems. It is based on decomposition of multifaceted problems into single elements and their subsequent evaluation using expert judgments. The AHP consists of several steps, namely: 1) construction of hierarchical structure involving the main goal, criteria and decision alternatives, 2) pairwise comparisons using 9-point fundamental scale, 3) deriving priorities (weights), 4) testing consistency using Consistency Ratio (CR), 5) aggregating individual priorities. These steps will be explained in more details in this paper. The main objective is to demonstrate the possibility of application of the AHP method in measuring the quality of life, using the criteria proposed e.g. by the Main Statistical Office in Poland, such as material conditions of life, subjective (perceived) well-being, quality of the environment in the place of living, state and citizens' rights and activity, economic and physical safety, free time and social relations, education, health, job. The AHP model will be constructed and respective priorities will be derived. The whole methodology including specificity of data collection and analysis will be also discussed, so it can be applied to various questionnaires measuring the quality of life, such as e.g. WHO or SF-36.*

Keywords: *analytic hierarchy process, AHP, quality of life*

1. INTRODUCTION

Numerous concepts, methods and tools have been developed with potential to support decision-making processes and improve accuracy of the resultant decisions. They are necessary when decision problem is complex, requires to analyze multiple aspects and select specific priorities. In such a case, it is convenient to use so called multi-criteria decision support methods. One of the most popular decision-support methods is the Analytic Hierarchy Process (AHP) and its extension – Analytic Network Process (ANP). Both of them were developed in the 70's by the American mathematician T.L. Saaty.

They combine various concepts in both mathematics and psychology [19]. However, the history of Saaty's methods had started earlier, in the 60's of the twentieth century, when Saaty was responsible for the projects of the American Arms Control and Disarmament Agency. His team consisted of some world famous specialists in the area of game and utility theories, including Nobel Prize winners such as Gérard Debreu, John Harsanyi and Reinhard Selten. Nevertheless, Saaty was not fully satisfied with the results of his team's work. As a cause of failure, he blamed high generality of the decision models used by the researchers, and the lack of a practical, systematic approach to decision-making [15]. A few years later, he created a simple and versatile tool that would help decision-makers to make complex decisions [5].

The main advantage of Saaty's methods (especially AHP) is simplicity and affordability for the average user (including lay people, who are not educated in this field). They allow decomposition of complex decision problems,

creation of a ranking for a finite set of alternatives, and have dedicated and easy to use software (e.g. *Super Decisions*). Thus, these methods are often used by the practitioners responsible for making business and political decisions. For example, the AHP was used e.g. in IBM, Xerox, British Airways, Ford or BC Ferry Corporation [18; 5]. It was also used by the researchers to analyse decision problems regarding planning, purchasing, resource allocation, conflict resolution, evaluation, optimization, etc. [13]. Examples of numerous applications of the AHP can be found in Vaidya and Kumar [21].

The objective of the current study is to demonstrate another potential application of the AHP, which is assessing the quality of life, using criteria provided by the Main Statistical Office in Poland [2]. They include material conditions of life, subjective (perceived) well-being, housing environment, state and citizens' rights and activity, economic and physical safety, free time and social relations, education, health, job. We used these criteria to build the AHP model, and we asked experts to analyse these criteria in terms of their importance for the quality of life.

2. STAGES OF THE AHP

The AHP consists of four main stages [11]:

1. Building hierarchical model of decision problem.
2. Analysing the hierarchical model using the 9-point pairwise comparisons scale.
3. Deriving priorities (weights)
4. Calculating Consistency Ratio (*CR*).
5. Aggregating priorities from diferent respondents.

2.1. Building hierarchical model

A multifaceted problem should be decoposed into hierarchy consisting of goal (top level of hierarchy), criteria that are assessed for their importance with respect to the goal, and decision alternatives (variants) that are evaluated for how preferred they are with regard to each criterion. Criteria can be divided into sub-criteria. A general schema of a four-level hierarchy is shown in **Figure 1** and is used to structure most of the decision problems.

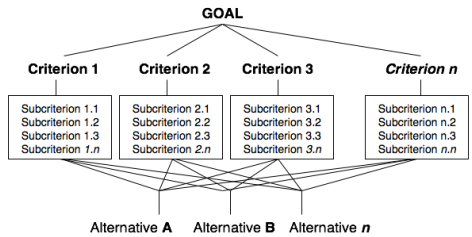

Figure 1. *The four-level AHP hierarchical model*

2.2. Analysing the hierarchical model

Having constructed a hierarchical model, it is necessary to obtain the source data (judgments) to determine priorities. The judgments are expressed by the relevant experts as pairwise comparisons of the elements within particular clusters of the hierarchical model. They reflect opinions, knowledge, feelings, preferences etc. of the experts on the analyzed part of the decision problem. Comparisons are used to express dominance (advantage) of one element over another. Saaty proposed a 9-point pairwise comparisons scale, known as the fundamental scale. If one uses a verbal scale, the degree of dominance must indicated by the respondent be transposed into numerical values [17]:

- A and B have equal importance ("1", middle of the scale),
- A is slightly more important than B or B is slightly more important A ("3" on the left or the right side of the scale),
- A is moderately more important than B, or B is moderately more important than A ("5"),
- A is much more important than B, or B is much more important than A ("7"),
- A is extremely more important than B, or B is entirely more important than A ("9").

If the respondent's judgments lie between the main categories („1", „3", „5", „7", „9"), they are represented by even numbers ("2", "4", "6", "8"), reflecting their indecision. The values are then introduced to a pairwise comparison matrix A (PC matrix *nxn*), which is the basis for deriving priorities.

2.3. Deriving priorities and calculating CR

From PC matrix, priorities can be derived using several procedures. For example, Choo and Wedley [4] described 18 methods for calculating weights from PC matrix. However, only four of them are used in practice, namely [20]: 1) right eigenvector method, 2) least square method, 3) logarythmic least square method, also called geometric mean, 4) normalized columns method, also called arithmetic mean method. The eigenvector method was proposed by Saaty, who recommend it as the only correct way of obtaining priorities in the AHP [16]. Geometric mean method is most frequently used due to its simplicity. Unlike in the eigenvector method, priorities can be calculated "by hand" and their values are close to those obtained by the eigenvector [7].

2.4. Calculating Consistency Ratio

It is necessary to check whether priorities are consistent. One of the principles of obtaining judgments by pairwise comparisons is that each element must be compared with each other located in the same group of hierarchical structure. It causes their redundancy in relation to the minimum number of judgments necessary to obtain weights. This redundancy allows measuring the degree of consistency of judgments, using special measure called *Consistency Ratio* (*CR*), which should not exceed *0,10*, otherwise the AHP matrix is inconsistent and it is necessary to reject such matrix or repeat the judgments. The way of calculating *CR* and its mathematical basis can be found in many publications, so it will not be explained here [14]. Difficulty to obtain an adequate level of consistency is one of the major problems of the AHP [1].

2.5. Aggregating priorities from different respondents

Complex and important decisions are rarely taken individually. They are always made in the group settings, involving people from various disciplines. The literature usually discusses two approaches to synthesize the AHP results: aggregation of individual judgments (AIJ) and aggregation of individual priorities (AIP) [6].

3. QUALITY OF LIFE MODEL

The concept of the quality of life is not easy to define, despite numerous works to define its terminology and measurement.

The WHP developed several widely used research questionnaires pertaining to the quality of life, which were developed cross-culturally and in many different languages [2]. The WHO instruments include: WHOQOL, WHOQOL-BREF and EUROHIS-QOL. The WHOQOL measures include six domains; each of them has specific facets [8]:

1) Physical health,
2) Psychological,
3) Level of independence,
4) Social relationships,
5) Environment,
6) Spirituality.

The EUROHIS-QOL measure is the simple 8-item index developed for economic screening and consisting of the following questions [14]:

1) How would you rate your quality of life,
2) How satisfied are you with your health,
3) Do you have enough energy for everyday life,
4) How satisfied are you with your ability to perform your daily activities,
5) How satisfied are you with yourself,
6) How satisfied are you with your personal relationships,
7) Have you enough money to meet your needs,
8) How satisfied are you with the conditions of your living place.

This was validated across Europe and in Israel, showing internal consistency, and discriminated well between healthy individuals and those with chronic diseases.

The quality of life measurement proposed by the Main Statistical Office in Poland consists of nine criteria [2]:

1) Material conditions of living,
2) Self-assessed well-being,
3) Quality of the environment in the place of living,
4) State, citizens' rights and civic activity,
5) Economic and physical safety,
6) Free time and social relations,
7) Education,
8) Health,
9) Job or main activity.

Each criterion has several attributes. For example, the "health" was measured by 7 indicators, including:

a) percentage of people who assessed their health status positively,
b) percentage of people who assessed their health status negatively,
c) percentage of the population aged 15 years or more with overweight and obesity,
d) percentage of people who smoke every day,
e) percentage of people who had to give up a visit to a doctor due to long waiting list,
f) percentage of people who had to give up a visit to a doctor due to financial reasons,
g) percentage of the population with limited ability to cope with daily activities.

In this paper, we demonstrate how to derive priorities in the measurement of the quality of life using the AHP method. Due to space constraints, we will only present ranking of importance of general criteria and health-related indicators (local and global priorities). However, the complete model should take into account other subcriteria, which are reported elsewhere. With no doubt, the quality of life is a multidimensional concept and so multicriteria methods such as the AHP are suitable for the analysis.

4. ANALYSIS AND RESULTS

The judgments (by pairwise comparisons) were performed by the university experts who have knowledge on the quality of life and related subjects. First they were asked to compare the criteria according to the question: *Which criterion is more important with respect to the quality of life?* As there were 9 criteria to compare, they had to perform 36 combinations of comparisons (*J*), accoding to the following formula:

$$J = \frac{n(n-1)}{2}.$$

It shows that *J* increases with the number of elements being compared (*n*). The research showed that the larger number of comparisons the more difficult is to keep consistency of judgments [10]. It has been discussed frequently in the literature and has roots in so called "magic number 7+/-2" by Miller [9], who stated that on average, a respondent is not able to process effectively (consistently) more than 9 pieces of information at once.

To analyse judgments, we used online BPMSG AHP Online System [3]. The priorities are shown in **Table 1** below.

Table 1. Priority values for 9 criteria x

	Category	Priority	Rank
1	Material conditions of living	9.6%	5
2	Self-assessed well-being	8.0%	6
3	Environment in the place of living	3.7%	8
4	State, citizens' rights, civic activiy	10.8%	4
5	Economic and physical safety	13.0%	3
6	Free time and social relations	1.8%	9
7	Education	6.9%	7
8	Health	**32.9%**	**1**
9	Job or main activity	13.4%	2
CR=8,1%			

The Consistency Ratio (CR) was 8,1% (CR≤0,10), which is quite well considering the large number of comparisons. "Health" received the highest priority value (32,9%), which indicates its highest importance for the quality of life. The next important criteria were "Job or main activity" and "Economic and physical safety". The least important one was "Free time and social relations".

In the next step, experts were asked to compare 7 health indicators (in the AHP terminology, these are called "subcriteria"), and priorities are shown in **Table 2**.

Within the "Health" category, percentage of the population with limited ability to cope with daily activities was the most important indicator of the quality of life (39,1%), followed by the percentage of people who had to give up a visit to a doctor due to financial reasons and those who suffer from overweight and obesity. Each criterion can be analysed in such a way using its own indicators.

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Table 2. Priority values for health indicators

	Category	Priority	Rank
1	% who assess health positively	4.0%	7
2	% who assess their health negatively	5.3%	6
3	% of >15 years old overweight/obese	10.4%	3
4	% of people who smoke every day	7.5%	5
5	% of people not visiting a doctor due to long waiting list	10.0%	4
6	% of people not visiting a doctor due to lack of money	23.7%	2
7	% of people with limited ability to cope with daily activities	**39.1%**	**1**
CR=10,0%			

Next, it is necessary to calculate so called global priorities. The term *local/global priorities* is used to describe their "place" in the hierarchical structure and relations to the decision goal. Local priorities are those derived from the PC matrix. They show importance of any element with respect to its "parent" element, located one level above in the hierarchy. Global priorities represent "share" of each element in realization of the main goal (top of the model), regardless their place in the hierarchy. For subcriteria, they are calculated by multiplying their local priorities by the weight of their parent criterion [13]. **Table 3** presents global priorities for health-related indicators.

The same calculations should be performed for all the criteria's indicators, and their grobal priorities should be calculated.

The results show that the indicator showing the percentage of the population with limited ability to cope with daily activities takes almost 13% share in realization of the main goal.

Table 3. Global priority values for health indicators

	Category	Global	Rank
1	% who assess health positively	1,32%	7
2	% who assess their health negatively	1,74%	6
3	% of >15 years old overweight/obese	3,42%	3
4	% of people who smoke every day	2,47%	5
5	% of people not visiting a doctor due to long waiting list	3,29%	4
6	% of people not visiting a doctor due to lack of money	7,80%	2
7	% of people with limited ability to cope with daily activities	**12,86%**	**1**

5. CONCLUSIONS

Tha aim of this paper was to demonstrate how to use the AHP method in measuring the quality of life. The criteria which were used in this example came from the Polish Main Statistical Office and consisted of the 9 main aspects. In this paper, health-related aspect was additionally analysed in terms of specific indicators. The most significant indicator (with the highest priority value) was the percentage of people with limited ability to cope with daily activities.

The AHP method is useful for practitioners to assess how significant are the specific factors in assessment of the quality of life. It is a multifaceted concept and usually involves numerous questions. It would be convenient to determine first the most significant features in the quality of life evaluation, and then focus on several characteristics instead of considering several dozen of questions (e.g. WHOQOL).

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