Received: October 11, 2019. Revised: March 20, 2020. Accepted: April 16, 2020. Published: April 19, 2020.

A new vision for reconciling the values of the economic evaluations using AHP method

Stefan Adrian OAE
Dep. of Engineering and Technological Systems Management ," Polytechnic" University Bucharest
Bucharest, Romania
oae_stefan@yahoo.com

Gabriel Iulian FÂNTÂNĂ
Department of System Theory
"Polytechnic" Universaty Bucharest
Bucharest, Romania
gabi_fantana@yahoo.com

***Abstract*— the field of economic evaluation that uses as reference International Standards for Evaluation is a current field. It requires special attention especially on the decision making of the assessment which is reflected in the choice of the final value of the asset evaluated. The need to substantiate this important stage in the evaluation process of reconciliation values led us to the idea of bringing a new tool to assist and raise the quality of the decision making of the evaluator. This tool involves highlighting an algorithm based on analytic hierarchy process, AHP, of the assessment approaches. The main consequence of using this tool is to reduce decision errors and is used as a mean of checking the reconciliation of values.**

Keywords*—-assessment; reconciliation of values; value, decisional matrix; AHP

I. INTRODUCTION

Specialists in the field of economic evaluation, uses several approaches which concern asset value to be evaluated. Within each work, approach results more specific guidance on the value of each approach because of the methods and the level of qualitative and quantitative information used within them.

Choosing the most appropriate approaches or methods depends on consideration of the following:

- adopted value type, determined by its purpose;
- availability of input data and information for evaluation;
- approaches or methods excellently relevant market participant.

To get an indication of the value, you can use more than one approach or method of assessment, especially if there is insufficient real or observable input to a single method lead to obtaining a credible conclusion. When using multiple approaches and methods, indications of value obtained must be analyzed and reconciled to arrive at a conclusion on value. [1]

To understand the value resulting in its context, the evaluation report will refer to the approach or approaches adopted, the key input data used and the main reasons for the conclusions drawn. [1] [15]

The differences in results require an analysis and a solution by reconciling values. Where there is value, there is an opinion on value. The evaluator makes a decision by applying a combination of all three approaches to value. [2] [14]

The need for the application of this algorithm is the result of efforts of study, refine and test evaluation methods and applications to be developed to deal with various problems arising from the evaluation in the future. [2]

IFRS 13 includes a "fair value hierarchy" that classifies assessments depending on the nature of the input data available. In short, the three hierarchical levels are:

- Level 1 input data are "price quotations (unadjusted) for identical assets or liabilities in markets that the entity can access at the measurement date";
- Level 2 input data are "inputs other than price quotations included in Level 1 that are observable for the asset or the liability, either directly or indirectly ";
- Level 3 input data are unobservable inputs for the asset or the liability.[1]

Thus a major final decision on the value it has the quality of the input data. In this regard, input data specific to methods of assessment refers the accurate of the term "hypothesis for evaluation". [3]

The three approaches to value are independent of each other, although each approach is based on the same economic principles. All approaches aim to develop an indication of value. The conclusion over the final value depends on the consideration of all the information and processes used, and the reconciliation of the values derived from the results of different approaches in their final estimate.

Using algorithm based on AHP, meets the decision act of the evaluator on the enabling to increase the quality of the final value.

II. METHODOLOGY

A. *Multicriteria Decision Analisys Methods*

The multi-criteria analysis is a ranking of alternatives by reference to a lot explicit objectives that the decision maker has identified and which set measurable criteria for evaluating their completion, providing several ways of aggregating data the criteria for obtaining global indicators (scores) performance alternatives.

The problem of multi-criteria analysis outlined in the matrix performance or consequences. The problem is described by:

- Decision alternatives A = {A_1, A_2, ..., A_m};
- The criteria for decision: C = {C_1, C_2, ..., C_n};
- The consequences are quantitative (numerical) alternatives to satisfy a particular contribution of a particular decision criterion: CD = {d_{ij}, $1 \le i \le m$, $1 \le j \le n$}, where the element d_{ij} is the consequence of the criterion C_j resulting from choosing alternative A_i;
- Weights are associated to decision criteria and determine their significance: P = {p_1, p_2, ..., p_n}. Each decision criterion C_j ($1 \le j \le n$) is associated with weight p_j set by the decision maker subjectively or by a special technique.

B. Analythic Hierarchy Process (AHP)

AHP is a compensatory method with linear additive model. The calculation of the weights and performance is based on comparison of the pairwise of alternatives and criteria. AHP considers that all decision criteria are arranged in a hierarchical structure, which has the root in the overall objective. This decomposes successively in criterion and sub-criterion levels. Comparison of decision criteria and of alternatives in AHP is done using comparison matrices that serve the performance matrix formation.

The basic principle of AHP includes the following steps:

- Define the requirements and purpose of the problem;
- Identify the factors that influence the overall objective;
- The overall objective evaluation decomposition hierarchy of detailed decision criteria and alternatives that are easy to manage;
- Selecting an intensity scale of importance, to generate comparisons pair between decisional criteria in the form of comparison matrix;
- The estimation of the relative priorities of decision criteria and of eigenvalue method or geometric method;
- The decision matrix property verification to ensure proper choice aggregating relative priorities of decision criteria;
- Rank the aggregation of decision criteria weights with performance report every variant decision criterion.

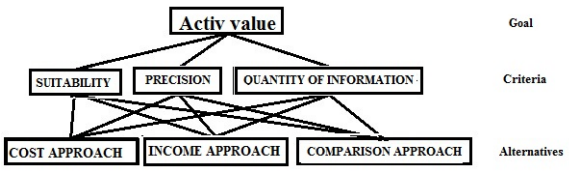

Fig. 1. Structure of AHP model [4]

Centralization of data problem can be in the form of a comparison matrix of alternatives with respect to each criterion, according to relation (1) [7].

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix} \quad (1)$$

Each term a_{ij} $1 \le i \le m$ and $1 \le j \le n$, reflects the scale of the ratio between the basic priority assigned to each criterion. To make these determinations Saaty developed a scale for the transfer quality in quantity of nine points (Table 1). It is argued that the scale is based on psychological experiments and is designed to accurately reflect the priorities of the comparisons between the two elements, minimizing at the same time, the difficulties involved:

TABLE I. THE INTENSITY SCALE OF IMPORTANCE IN AHP [10]

Importance	Description
1	Equal importance of both elements
3	A smaller value of an element to another one
5	Significant or critical importance of an item to another
7	Demonstrated the importance of an item to another
9	The absolute weight of an item to another

Other scale values of 2, 4, 6 and 8 are intermediate values can be used to represent shades of costs in addition to the five basic evaluations.

Each element a_{ij} is determined and referred to as d_{ij}, the principal diagonal will have the value 1 (when an object to them, have the same weight), and may be an example of a matrix compared according to relation (2):

$$D = \begin{bmatrix} 1 & d_{12} & \cdots & d_{1n} \\ d_{21} & 1 & \cdots & d_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ d_{m1} & d_{m2} & \cdots & 1 \end{bmatrix} \quad (2)$$

Comparison matrix D is written in this form:

$$D^{(k)} = \left\{ d_{ij}^{(k)}, 1 \le i \le m, 1 \le j \le n \right\} \quad (3)$$

The element of line i and column j of $d_{ij}^{(k)}$ matrix is a number that compares the contribution of alternative A_i decision with the contribution of alternative decision A_j to the meeting the decision maker C_k ($1 \le k \le n$).

The Convention establishes that:

- $d_{ij}^{(k)} > 1$ whether alternative contribution A_i to meeting the criteria for deciding C_k is greater than the contribution of alternative A_j;
- $d_{ij}^{(k)} < 1$ whether alternative contribution A_i to meeting the criteria for deciding C_k is less than the contribution of alternative A_j;

- $d_{ij}^{(k)}$ = 1 whether alternatives A_i and A_j satisfy equally decision criterion C_k.

Next, add up the columns of the matrix of comparison, $S_j^{(k)}$ $1 \le j \le m$, according to (4) and builds normalized matrix D* in (5).

$$S_j^{(k)} = \sum_{j=1}^{m} d_{ij}^{(k)} \quad ,1 \le i,j \le m \tag{4}$$

This step is performed for each criterion and alternative.

$$D^* = \begin{bmatrix} \frac{d_{11}}{s_1} & \frac{d_{12}}{s_2} & \cdots & \frac{d_{1n}}{s_m} \\ \frac{d_{21}}{s_1} & \frac{d_{22}}{s_2} & \cdots & \frac{d_{2n}}{s_m} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{d_{m1}}{s_1} & \frac{d_{m2}}{s_2} & \cdots & \frac{d_{mn}}{s_m} \end{bmatrix} \tag{5}$$

The sum of each column must be 1 if the calculation is done properly. Further consequences are calculated column that is attached to the end of the matrix D *. Their amount should be also one in order to ensure a correct determination.

Calculate the consequences, as the average per line items are written in one column:

$$p_i^{(k)} = \frac{1}{m} \sum_{j=1}^{m} \frac{d_{ij}^{(k)}}{S_j^{(k)}} \quad ,1 \le i,j \le m \tag{6}$$

The last step is to generate performance matrix (7) will look to choose the best alternative.

$$P = \begin{bmatrix} p_1 & p_2 & \cdots & p_n \\ s_{11} & s_{21} & \cdots & s_{n1} \\ \vdots & \vdots & \ddots & \vdots \\ s_{1m} & s_{2m} & \cdots & s_{nm} \end{bmatrix} \tag{7}$$

Also the columns in the matrix amount should be from 1 to warrant that all the calculation is correctly performed.

Optimal alternative is the one that will have the highest score. To check the consistency of results must be made a check. The reason it is important to do this test is to avoid any error on the final choice of the alternative. If a person indicates that a more important than B, C is more important than in the latter, C is less important than it would mean that C is more important than C, which may not be true. So the person who made an error in judgment, therefore, it is important to know whether it is consistent proceedings. Consistency index (CI) [8] is calculated by the formula (8):

$$CI = \frac{\lambda_{max} - n}{n-1} \tag{8}$$

Checking the correctness of the results is done through the relationship (9). Chooses the scale factor RI is random index [12] in Table 2.

TABLE II. RANDOM INDEX RI USED AHP

1	2	3	4	5	6	7	8	9
0.0	0.0	0.58	0.9	1.12	1.24	1.32	1.41	1.45

The random index RI is chosen by the rank of the coefficient matrix and decision accordingly. For rank three, the value is RI = 0.58.

$$CR = \frac{CI}{RI} \tag{9}$$

Using scale to medium consistency index RI [7] given by Professor Saaty, can be calculated a rate consistent CR [8]. If the value is below 10%, the result is correct and acceptable. If it is above this value, the algorithm needs to be reviewed.

III. SIMULATION OF THE AHP PROCEDURE IN EVALUATION

A. Applicability

The scope of AHP can be seen in Abbas-Eshlaghy Tolo and Mahdi Homayonfar [6]:

- Environmental Management;
- Water management;
- Business and Financial Management;
- Transport and logistics;
- Production;
- Energy Management;
- Managerial and strategic planning;
- Social services;
- Military service.

In the evaluation process, an appraiser uses several approaches work as alternatives in the AHP, and they are cost approach ACOS, ACOM comparison approach and the income approach AVEN. Each approach gives a different indication of value. When using two or all three approaches [13], the evaluator must reconcile indications of value. Resolving differences among the different indications of value is called reconciliation.

In the final reconciliation, the assessor reviews the whole process, ensuring that the available information and analysis techniques and applied logic led to consistent judgments.

B. Criteria for reconciliation

Reconciliation requires a careful analysis of the resulting logic procedures every indication of value. AD adequacy, accuracy PR and amount of information or evidence are criteria that a CD evaluator forms a final opinion of value.

These criteria are used to analyze each approach in part by the evaluator. The literature each criterion is described as follows:

- Adequacy AD approach using designated assessment is directly correlated with the type of property;

- Accuracy of PR is evaluated by evaluator confidence in the accuracy of the information and corrections for each property analyzed within each approach work:
- Quantity of CD evidence is a quantitative criterion and studied in correlation with the other two criteria described above. Although the first two criteria of a qualitative nature, they are not relevant unless they bring the matter quantitatively.

The evaluator may find that these criteria, adequacy, accuracy and amount of information that can be applied in all three cases, the approaches work. It is possible to find that these criteria are not applicable in any approach, this evaluator's ability to keeping fit these situations. In practice this situation can be represented in tabular form as follows:

TABLE III. CRITERIA AND APPROACES OF WORK

	ACOS	ACOM	AVEN
AD	X		X
PR	X	X	
CD		X	X

This is a representation of a table so they are checked as examples those cells with the elements that give information about of work through the criteria approaches. The evaluator then takes a decision in correlation with the approach that provides the most information to help him to issue an opinion on the final value.

Interestingly, the panel examined the case when cells are filled so that she does Equality of information criteria each approach, whether by one, two or all three, with the illustrative representation of Table 3. This case involves a detailed analysis of the use of AHP process help solve these situations equality. Besides AHP process can be extended to any combination of response criteria within each approach of work.

The purpose of this analysis is to establish the market value of an apartment that result from the application of the three approaches work cost approach ACOS, ACOM comparison approach, income approach AVEN and whose optimal value is selected in relation to the three criteria : AD adequacy, accuracy PR and quantity of information or evidence CD using AHP method.

We consider that we have evaluated a t wo bedroom apartment located in the northern part of the city. The purpose of evaluation is to establish the market value of the apartment to sell it. Market Study shows that in that area there is demand for two-bedroom apartments and real estate developers to build and seeks solutions to compensate for this deficit is reflected through an increased relative degree of this type of apartment rents. There are signs that the market there selling old apartments there, the interest of potential customers being targeted equally and the old apartments but according to new financial available possibilities. Considering these inputs will go step by step through the process AHP matrix to realize optimum performance and selection on the alternative that has the best score.

The first step is to determine the matrix D is to be compared to each criterion.

TABLE IV. THE APPROACES COMPARED WITH CRITERION AD

	ACOS	ACOM	AVEN
ACOS	1.0000	7.0000	3.0000
ACOM	0.1429	1.0000	0.2000
AVEN	0.3333	5.0000	1.0000

TABLE V. THE APPROACES COMPARED WITH CRITERION PR

	ACOS	ACOM	AVEN
ACOS	1.0000	3.0000	5.0000
ACOM	0.3333	1.0000	3.0000
AVEN	0.2000	0.3333	1.0000

TABLE VI. THE APPROACES COMPARED WITH CRITERION CD

	ACOS	ACOM	AVEN
ACOS	1.0000	3.0000	0.5000
ACOM	0.3333	1.0000	0.2000
AVEN	2.0000	5.0000	1.0000

TABLE VII. CRITERIA COMPARISON

	AD	PR	CD
AD	1.00	1.00	1.00
PR	1.00	1.00	1.00
CD	1.00	1.00	1.00

The second step is to determine the normalized matrix D*

TABLE VIII. NORMALIZED MATRIX FOR AD CRITERION

	ACOS	ACOM	AVEN
ACOS	0.6774	0.5385	0.7143
ACOM	0.0968	0.0769	0.0476
AVEN	0.2258	0.3846	0.2381

TABLE IX. NORMALIZED MATRIX FOR CD CRITERION

	ACOS	ACOM	AVEN
ACOS	0.3000	0.3333	0.2941
ACOM	0.1000	0.1111	0.1176
AVEN	0.6000	0.5556	0.5882

TABLE X. NORMALIZED MATRIX FOR PR CRITERION

	ACOS	ACOM	AVEN
ACOS	0.6522	0.6923	0.5556
ACOM	0.2174	0.2308	0.3333
AVEN	0.1304	0.0769	0.1111

TABLE XI. NORMALIZED MATRIX FOR CRITERIA

	AD	PR	CD
AD	0.33	0.33	0.33
PR	0.33	0.33	0.33
CD	0.33	0.33	0.33

The third step consists in adding a new column at each normalized matrix, which will be called column consequences, calculated as the sum of each line divided by the number of criteria.

TABLE XII. NORMALIZED MATRIX WITH CONSEQUENCES COLUMN

Working approaches			The weight of the criterion
0.6434	0.6333	0.3092	0.33
0.0738	0.2605	0.1096	0.33
0.2828	0.1062	0.5813	0.33

The last step to be done is to build performance matrix that will provide the best alternative. Using column scores, ranking of alternatives is obtained and the decision means selection decision alternative with the highest score as shown in table 13

The result shows that ACOS cost method is the one that indicates the market value of wheelbase, with the best score of 0.5286.

Finally, RC in each case is given by:

Adequacy criterion AD: 5.65% <10%

Accuracy criterion PR: 3.64% <10%

Criterion amount of evidence CD: 0.32% <10%

Alternatives: 0% <10%.

Following this examination we conclude that the decision is correct.

TABLE XIII. MATRIX OF PERFORMANCE

Working approaches	Decisional Criteria			Results
	0.33	0.33	0.33	
	AD	*PR*	*CD*	
ACOS	0.6434	0.6333	0.3092	**0.5286**
ACOM	0.0738	0.2605	0.1096	0.1480
AVEN	0.2828	0.1062	0.5813	0.3234
The sum of columns	1,000	1,000	1,000	1,000

IV. CONCLUSIONS

The problem of decision making in economics is one of the most popular lines of research. AHP approach work effectively and can handle these problems. If the final values are very close together it is important to introduce additional criteria in order to provide a better decision. [4] We can see that this algorithm work indicates predominance of optimal alternative assessment and helps the assessor to make the right decision.

V. THANKS

The work was co-funded by the Sectorial Operational Program for Human Resources Development, financed from the European Social Fund and by the Romanian Government under the contract number POSDRU/1071.5/S/76909.

REFERENCES

[1] UNEAR, 2011, International Valuation Standards (IVS) 2011, Standardele Internationale de Evaluare (IVS) 2011, editia a IXa

[2] Joseph Vella, Ion Anghel , “International Valuation Standards, Valuers and Dinosaurs“ The Valuation Journal , No 1 , pp. 4-17, 2006 .

[3] Sorin V. STAN, PhD, “Considerations regarding the concept « Basis of evaluation or Standards of Value » , « valuation premises » , and « assumptions » “ , No 1(4) , pp. 4-13, 2008 .

[4] G. I. Fântână, S. A. Oae, A. M. Gurau, “Decision Making using the Analytic Hierarchy Process,” International Conferice on MEQAPS '13, pp. 119-124, Brasov, Romania, 2013.

[5] Xu Ling, Yang Jian-Bo, “Introduction to Multi-Criteria Decision Making and the Evidential Reasoning Approach”, *Working paper no.0106*, Manchester School of Management, 2001.

[6] Toloie-Eshlaghy Abbas and Homayonfar Mahdi, MCDM Methodologies and Applications a literature review from 1999 to 2009, *Research,* Journal of International Studies, Issue 21, 2011

[7] Zhang Liyuan, Comparison of classical analytic hierarchy process (AHP) approach and fuzzy AHP approach in multiple criteria decision making for commercial vehicle information systems and networks (CVISN) project, Industrial and Management Systems Engineering – Dissertations and Student Research, 2010

[8] Ishizaka Alessio, Labib Ashraf, Analytic Process and Expert Choice: Benefits and Limitations, ORInsight, p. 201-220, 2009

[9] Evangelos Triantaphyllou, Stuart H. Mann, Using of Industrial and Manufacturing Systems Engineering, *International Journal of Industrial Science*, Vol.2, No.1, 1994, pp. 35-44.

[10] Saaty, T. 1982, Decision-making for Leaders, Wadsworth, California.

[11] Saaty T. L., The Analytic Hierarchy Process. University of Pittsburgh, 1988.

[12] Saaty T., ”The Analytic Hierarchy Process: Planning, Priority Setting, Resource, Allocation”, McGraw-Hill, New York, 1980

[13] Appraisal Institute of Canada , 2011, Canadian Uniform Standards of Professional Appraisal Practice (CUSPAP)

[14] *** Ghiduri de Evaluare (GE) , Ghiduri Metodologice de Evaluare (GME), Glosar IVS 2011, ANEVAR 2012
expert-evaluator.ro/download/Ghiduri_ANEVAR_2012_reactualizat.pdf

[15] *** International Valuation Standards 2011.
www.rics.org/Global/International%20Valuation%20Standards.pdf