A Computer Model for Auditor Performance Evaluation

Igor Karnet, Eva Jereb, and Tanja Rajkovič

***Abstract*—**A multi-attribute hierarchical evaluation model was developed to evaluate auditors' performance. We have achieved assessment transparency. The model is intended for self-assessment of individual auditors, and especially for managing auditing departments to support frequent assessment of auditors' effectiveness and performance. It offers an explanation of both strengths and weaknesses of individual auditors, which is a good starting point for improving auditors' status and for continuing their development. By using this auditor performance evaluation model, we achieved new quality in terms of a comprehensive implementation of the auditing procedure because, over the long term, appropriate assessment of auditors has a positive impact on the success d effectiveness of the performance of both individuals and auditing departments as a whole.

***Keywords*—**auditor, evaluate, performance, multi-attribute modeling

I. Introduction

Service and product Service and product quality is one of the most important goals of every successful company. Quality can only be achieved with employees' assistance [1], [31], [35], [46], [47]. To determine how well individual employees are performing, it is necessary to assess and evaluate their performance and achievement [34], [56], [66], [67], [78]. Auditors are no exception to this [2], [45], [50], [51].

Professional literature contains many different models that have already been developed to assess and manage human resources. Some are stand-alone models that apply to specific occupations; for example, for assessing the quality of instructors in higher education [27], for assessing the quality of teachers [57], for assessing the performance of faculty members of Palestinian public universities [43], for teacher self-assessment [55], and for evaluating class performance in primary schools [41]. Another group of models addresses an individual area within a particular profession or group; for example, to develop and validate a taxonomy of interpersonal job performance behaviors [13], [20], [54]. Harris [30] described the influence of rater motivation on performance assessment. Pettijohn, Pettijohn, and d'Amico [58] determined the influence of characteristics, processes, and forms of assessment on salespersons' motivation and job satisfaction. Larkin and Schweikart 10[49] identified significant factors associated with successful auditor performance in internal auditing. Many models focus on a specific area and are applicable across jobs or environments; for example, [11] and, specifically, for selecting scholarship students [85], for selecting personnel and assessing applicants' suitability to fill a job [38],[69], for assessing empowerment, performance, and satisfaction [68], for selecting contractors [25],[76], for measuring the influence of assessment on salesperson satisfaction and commitment [58], and for employee performance assessment [33], [70]; there are also models with general applicability (e.g. [16], [17], [81].

Overviews of various models have been conducted by several authors, including [21] [74], [75], [82], [83]. These overviews have determined the general applicability of particular models and what special features they possess.

Despite a comprehensive literature review of studies on interpersonal performance evaluation, no applicable model was found that sufficiently assesses auditor performance. Such a model must take into account the needs of auditors, who are a fairly specific group of people [23] characterized by a broad area of knowledge and experience [31], [45], personal and professional ambitions and goals [32], [72], [79], great potential to become administrative or managerial staff, their methods and conduct of everyday activities [32], [79], their needs for extensive continuing education [28], [42], training [46], certification [18], and similar features [40].

To address the need for frequent (e.g., monthly) auditor performance evaluation, we developed a model that assesses variables (in this case, auditors) with regard to the goals and expectations set [40]. Assessing the variables in multi-attribute decision making takes place using a multi-attribute decision-making model, which is generally based on three components: selected general attributes as well as attributes specific to the profession, their range of values, and the utility functions that combine subordinate attributes into superordinate ones. The theory of multi-attribute decision making offers a formal basis for developing a model in which the basic problem is connecting assessments by individual attributes into an overall assessment, as well as the interconnectedness of heterogeneous attributes, their fuzziness, and their varying influence with

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regard to numerous factors [9], [22]. Transparency of assessment is made possible by applying artificial intelligence methods. The results are primarily seen in explaining the assessments and in the transparency of procedures as a whole [3], [62]. This approach is especially appropriate when dealing with complex systems in which there are many factors that are interconnected in a complicated manner [7], [44], [85].

II. Auditing Departments and Auditors

The auditing department must specify guidelines and procedures that provide it an acceptable guarantee that it has enough adequately trained staff that respect ethical principles, can perform auditing activities in line with professional standards and legal requirements, and enable the department to issue reports appropriate to the circumstances. These procedures should include hiring, employee task performance and ability assessment, employee suitability assessment, and employee professional development, promotion, remuneration, and needs assessment. The auditing department must thus ensure efficient internal control of the quality of its work [31], [32], [67], [79].

Internal auditors' missions include performing auditing services connected with providing assurance and advice on how to perform in risk management in a prudent and organized manner in order to economize and optimize business processes, improve operations, and achieve better business performance and effectiveness, thus also achieving greater added value of the audited entity and organization as a whole. In other words, this is the improvement of leadership and management quality, which leads to achieving better business goals, a higher profile, and greater added value of an organization [2], [45], [61], [63], [67], [84].

III. Methodology

The greatest problem in assessing auditors' performance is comprehensive interpretation of the results of measuring a broad spectrum of diverse, relatively interdependent attributes [85]. These facts practically call for the use of expert IT tools to simulate a synthesis of the results, which otherwise takes place in the professional's head. Decision making is a difficult process [48], [52]. People have a very limited ability to simultaneously process a large amount of diverse information with varying levels of importance [5], [48]. In order to overcome this problem, an expert modeling method was selected; this method presents knowledge in a more people-friendly manner than conventional decision-making methods [3], [62].

The most important feature of this model, which includes several attributes and options (i.e., auditors), is that it includes the application of state-of-the-art IT methods with an emphasis on artificial intelligence methods in demanding procedures of multi-attribute decision making, which provide transparency and explanation.

The general multi-attribute decision making includes the following [7], [48]:

Option set $A = \{a_1, a_2, a_3, ..., a_n\}$.

Preferential relation P

Relation P organizes set A by desirability, suitability, and utility

Attribute set X: $\{x_1, x_2, x_3, ..., x_n\}$

$x_i : A \rightarrow D_i$ where D_i is the range of values of individual attributes.

Each option a from set A is described with an attribute value vector:

$a \triangleq x1(a), x2(a), x3(a), ... xn(a)$.

Preferential relation P, which organizes set A by desirability or utility, is replaced by a utility function. The utility function in: $A \rightarrow D$ is replaced by function $vx : D_1 \times D_2 \times D_3 \times ... \times D_n \rightarrow D$.

The suitable transparency and explanation of the decision-making procedure and the explanation of the final assessment were carried out using DEXi[1] software, an application for multi-attribute decision making [36]. DEXi was developed in Slovenia by the Jožef Stefan Institute and the University of Maribor's Faculty of Organizational Sciences. It is based on the DECMAC (DECision MAKing) methodology developed by Janet Efstathiou and Vladislav Rajkovič. DEXi consistently follows the model of multi-attribute assessment, which is designed such that the basic problem is broken down into smaller, less complex problems that are usually resolved more easily than complex problems [7], [22], [48]. Some authors that have developed other models chose other tools and methods; for example, [33] developed a case study on employee performance assessment using AHP, and [11] developed the Computerized Adaptive Rating Scale (CARS) Prototype with adaptable criteria. DEXi already has embedded tools that assist the decision maker in defining attributes, developing utility functions, capturing data on options, and assessing options, which is also the most important operation [9], [36], [29]. DEXi differs from the majority of other multi-attribute decision-making support tools because it uses qualitative (i.e., symbolic) rather than quantitative (i.e., numeric) attributes. Qualitative modeling of preferential knowledge facilitates the understanding and interpretation of assessments and options [4]. In DEXi, the merge function is defined through if-then definition rules and not numerically through weights or other formulas; DEXi thus supports weights indirectly [6], [8], [10]. DEX integrates the interdependence of attributes in a more conceptual manner (i.e., there are adjustments and weights). DEX is the only methodology that enables this; this is also the reason why the DEX methodology and the DEXi software were chosen from among all available multi-attribute decision-making methodologies.

IV. Performance Assessment Model

Monthly assessment of auditors' performance was used to establish a basis for the most objective and just rewarding of

[1] More information about the DEXi program is available at: http://kt.ijs.si/MarkoBohanec/dexi.html

work performed or payment of an appropriate monthly income. In addition, the goal was also to increase the quality of auditors' work as well as their productivity or efficiency, and their motivation and work satisfaction. This also increases the added value of the auditing department as well as the entire organization.

The model presented below can be used for both internal auditors and external auditors employed in auditing companies, which is why no distinction is made between internal and external auditors and the generic term "auditor" is used instead. In addition, it is unnecessary to distinguish between internal auditing departments and external auditing companies, and so the term "auditing department" is used.

The difference between internal and external auditors primarily lies in their employers, audited persons and entities, and the manner of acquiring auditing business; however, the method of performing auditing activities, and the purpose and goal of the audits, are similar.

The model presented below refers to all auditors, both internal and external.

The decision-making process was divided into four phases: (1) criteria identification and criteria structuring, (2) utility function definition (decision rules), (3) description of variants, and 4) evaluation and analysis [60].

A. Attribute identification and selection

In selecting and identifying attributes, the importance of good auditing performance was taken into account. The attributes selected are therefore logical, clear, and understandable to all auditors. Attribute identification was conceptually an extremely sensitive and demanding operation [54]. It demanded thorough reflection, a great deal of negotiation, testing, and modification, and especially good knowledge of the auditing goals and the performance of auditing activities.

As already mentioned above, it is very important that the attributes meet requirements such as attribute measurability and the principle of completeness or, in other words, that the attributes that significantly influence the decision not be ignored. The attributes are not duplicated.

The unstructured attributes were obtained based on practical findings on the performance of auditors and the auditing department, theoretical findings on the operation and quality assurance of auditors' work, and the brainstorming of auditors and other auditing professionals. The participants included both the persons that would be assessed and the persons that would carry out the assessments, which increases the model's reliability and the probability that it will later be accepted and more trusted [26], [33], [65]. Similar behaviors were then grouped together in order to provide clarity and maximize the power of predictions of the model developed [19], which includes 51 attributes; of these, 34 are basic and 17 are aggregate [40].

The joint criterion "auditor's assessment" is composed of four sets of attributes: (i) "personality characteristics," (ii) "skills," (iii) "professionalism," and (iv) "work implementation." In this, the use of a multi-stage assessment concept was planned in order to achieve constructive assessment and a maximum level of assessment objectivity. This made it possible to predict the assessment of the head of the auditing department, the head/members of the auditing team, and the auditees' assessment, in which the audited entity assesses the auditor.

The set "personality characteristics" is composed of two subsets. The first refers to personal tidiness and includes the auditor's cleanliness, body odor, and clothes. The second subset refers to auditors' general features and includes auditors' reliability and accuracy in performing their tasks, and auditors' adaptability to changes. A generally capable individual is not necessarily suitable for work in an auditing department or vice versa. An individual may be very capable but not suitable for working with people or working in an auditing team, may be inflexible, and so on. The characteristics that auditing companies seek in individuals are thus connected not only with their capability, but also their suitability for work in an auditing department. It is appropriate that auditors behave in a suitable manner, and their external appearance is also important. Through their appearance, auditors display their attitude towards the auditee and the auditing discipline, as well as their attitude towards themselves. Compared to the other three sets, this set nonetheless influences the final assessment of an individual auditor's performance the least.

The "skills" set is composed of three subsets: "work approach," "management skills," and "general." The "work approach" subset refers to work within an auditing team, the auditor's communication skills, and the transfer of know-how to coworkers and auditees. The "management skills" subset is composed of "leadership" and "interest coordination" attributes. These attributes are used to assess the ability to lead the auditing or project team and the ability to coordinate various interests and opinions. The last subset refers to the auditor's general skills. It is composed of (i) "computer work," in which handling the computer and computer applications (e.g., Microsoft Office, ACL) is assessed, (ii) "general knowledge," and (iii) "promotion" of the discipline, employer, and oneself.

The auditor's skill is vital, but not the only condition for performing the audit. The importance of this set is thus approximately the same as the other two sets (i.e., "professionalism," and "work implementation").

"Professionalism" is the third set, which is also divided into three subsets: "work," "quality," and "know-how." The "work" subset focuses on how auditors monitor developments in their field of activity. The "quality" subset assesses the quality of performing auditing activities, and the "know-how" subset focuses on the know-how that auditors require to perform their daily activities and tasks.

The assessment in the "work" subset is affected by familiarization with and adherence to the auditor's code of

ethics as well as laws, standards, and other internal and external organizational regulations. This assessment concludes with the assessment of familiarization with the latest developments in the auditors' work and professional area. This subset thus assesses the knowledge of the legislative framework of auditing and the area covered by the auditor. Auditors' behavior and performance should set an example to others.

The "quality" of performing auditing activities represents the second subset of the "professionalism" set. It is composed of coworker satisfaction, auditees' satisfaction with the manner of audit implementation in their audited entity, and with the introduction of improvements to their field of activity or the auditing department in general. Sometimes it is difficult to ensure suitable quality, at least in audited areas that demand a high level of specialization. This is especially the case in IT and computer science. A concrete example is a firewall and the appertaining defense mechanisms that prevent unauthorized access to the organization's IT system. In such cases it is clear that the auditor does not have the same level of knowledge and experience as an IT specialist, who is an expert in this area. This specialist may assess the auditor's professionalism as deficient or even unsatisfactory, although this may not be the case because the auditor does not need such thorough knowledge and experience to satisfactorily audit this area.

The "know-how" subset is composed of the following attributes: "professional expertise," "specialization," part-time study," and "foreign languages." It is very important that auditors undergo continuous education and increase their knowledge. Appropriate professional expertise in the area the auditor is covering is a precondition for performing an audit in this area. Foreign language (especially English) skills are vital for auditors because they must often use foreign literature. Specialization is welcome, especially if the auditing department is large and can afford for their auditors to specialize in individual areas. To certain extent, part-time study proves that auditors are prepared to sacrifice part of their free time to enhance their expertise and profile, and indirectly raise the profile of the auditing department.

The last set, called "work implementation," is also composed of three subsets: "work scope," "audit implementation," and "results." This set measures the quantity of the work performed during the assessment period, the adequacy and performance of implementation of individual audits, and the quality of implementing individual auditing stages.

The "work scope" subset includes the scope or level of plan realization, the timeliness of audits and other auditing activities implemented, and the number of audits, in which it is important in how many audits the auditor was only a team member and in how many audits he or she was the head of the auditing team.

The "audit implementation" subset is formed based on the scope and importance of incorrect information in the auditor's report, and the limitation of the audit scope, which can also be the result of a lack of time, know-how, and experience. IT-system auditors in particular can have problems defining the limits of individual audits because otherwise it may quickly happen that, due to expanding the scope and area of audit, the audit is prolonged and exceeds the planned timeframe and budget. The "implementation" subset also assesses the scope of consulting in both formal and informal forms.

The last subset, called "results," is divided into "planning" the audit, "work material," "reporting" on the audit findings, and "monitoring recommendations." Individual audits are composed of several stages, from planning and preparing the audit, to implementation, to reporting the findings. The basic work material is the records containing information on the audited entity and data and information obtained from this entity, records on checks and tests, interview records, reports, and so on; in addition, the basic material is also all the records on the preparations for the audit, and reporting on and monitoring the implementation of recommendations. It is very important that the work material be complete and comprehensive, and that it contain appropriate proofs based on which the auditors have created their findings and the resulting measures and recommendations.

A tree of attributes for assessing auditors' performance with brief descriptions of individual attributes is presented in Fig.1:

Attribute	Description
Auditor's assessment	Final auditor performance assessment.
Skills	Auditor's skills.
Interpersonal skills	Ability to work with colleagues and others (e.g. audited entity, etc.).
Work in auditing team	Ability to work in auditing or project team.
Communication skills	Auditors communications skills.
Knowledge transfer	Ability to transfer knowledge to coworkers and others.
Management skills	Presence of auditor's management skills.
Leadership	Ability to lead an auditing or project team.
Interest coordination	Ability to coordinate diferent interests and opinions.
General	Presence auditor's general abilities.
Computer work	Handling computers and computer applications.
knowledge	Auditor's general knowledge.
Promotion	Interest in holding tasks, writing articles.
Professionalism	Auditor's professionalism as a condition of work quality.
Work	Following developments in the auditor's field of activity.
Code of conduct	Following the ethical code of conduct and performance.
Laws and standards	Following legislation, standards, and internal and external regulations.
Latest developments	Ability to follow the latest developments in the field of activity.
Quality	Quality performance of auditing activities.
Coworker satisfaction	Monitoring the satisfaction of coworkers/auditing team members.
Auditee satisfaction	Monitoring the satisfaction of the audited entity and organization management.
Introduction of improvements	improving work quality and streamlining workflow.
Know-how	Know-how required to perform daily tasks.
Expertise	Familiarization with the audited area/operations in the auditing entity.
Specialization	Completed specialization or acquired certificate.
Part-time study	Part-time study as a supplement to education complete.
Foreign languages	Foreign language skills.
Work implementation	Audit implementation.
Scope of work	Quantity of work performed.
Number of audits	Number of audits on a yearly basis.
Team head	Number of audits in which the auditor participated as a auditing team head.
Team member	Number of audits in which the auditor participated as the auditing team member.
Plan realization	Scope of realization of planned audits.
Timeliness	Timeliness of individual audit.
Audit delivery	Delivery of individual audits.
Incorrect information	Significantly incorrect statements of facts.
Audit limitation	Limitation of auditing area/reduction of auditing scope.
Consulting	Scope of consulting (including informal consulting).
Results	Quality of individual auditing stages performed.
Planning	Quality of auditing plan.
Work material	Quality and comprehensiveness of work material.
Reporting	Suitability of reporting findings.
Recommendation implementation	Ongoing monitoring of how recommendations are implemented.
Personal characteristics	Auditor's personal characteristics.
Physical appearance	Auditory physical appearance.
Body	Personal hygiene.
Clothes	Appearance of dress.
Characteristics	Auditor's personality characteristics.
Reliability	Work reliability.
Accuracy	Accuracy at work.
Adaptability to changes	Ability to adapt to changes and new situations.

Fig. 1: Tree of attributes for assessing auditors' performance.

A. Ranges

In the next step, the attributes were assigned measurement scales or ranges of value that they may have in the assessment.

The value ranges are discrete. It is recommended that the number of values grow slowly from the leaves towards the root node of the attribute tree. Most of the attributes were assigned a range of three values indicating whether the skill is inappropriate (deficient), partially appropriate (satisfactory), or appropriate (very good). In cases where it was estimated that the range of three values was insufficient, this was expanded to four or five values. It is recommended that binary ranges of value be avoided because insufficient differentiation of the options assessed is achieved. An example of three different ranges of value is the attribute "adaptability to changes." This attribute can have one of the following three values: "inappropriate," "partially appropriate," and "appropriate," in which the "inappropriate" value denotes unsatisfactory value, the "partially appropriate value" denotes below-average attribute value, and the "appropriate" value denotes the anticipated or above-average attribute value. Attribute values increase from below-average to above-average, which mitigates and accelerates the process of capturing the utility functions in DEXi. The three-point measuring scale is used by the majority of attributes, especially the basic ones. A range of four values was assigned to four basic sets and a range of five values was assigned to the

common attribute "auditor's assessment."

B. *Utility functions*

This stage determined the utility functions, which define the influence of lower-level attributes on those higher up in the tree (all the way up the top of the root node, which represents the final assessment of options). The utility function thus defines the interconnections between the attributes and their influence on the assessment at a higher level. In this way, the value is defined for individual leaves or the basic attributes with each option description. The form of the utility functions and the method of their capture depend on the auditor assessment experts that helped design the model.

Due to the large amount of decision-making rules, only one utility function is presented below.

In defining the auditors' "Characteristics," their reliability, accuracy, and adaptability to changes are assessed (Fig. 2), in which reliability was ascribed a somewhat greater importance. There are several exclusion rules, but here only one is discussed: if the auditor's reliability and accuracy are inadequate, the auditor's characteristics are assessed as inappropriate, regardless of the auditor's good adaptability to changes.

	Reliability	**Accuracy**	**Adaptability to changes**	**Characteristics**
	42%	37%	21%	
1	inappropriate	inappropriate	*	inappropriate
2	inappropriate	<=partially appropriate	<=partially appropriate	inappropriate
3	inappropriate	*	inappropriate	inappropriate
4	*	inappropriate	inappropriate	inappropriate
5	<=partially appropriate	>=partially appropriate	***appropriate***	partially appropriate
6	*	partially appropriate	***appropriate***	partially appropriate
7	<=partially appropriate	***appropriate***	>=partially appropriate	partially appropriate
8	partially appropriate	*	>=partially appropriate	partially appropriate
9	>=partially appropriate	<=partially appropriate	>=partially appropriate	partially appropriate
10	partially appropriate	>=partially appropriate	*	partially appropriate
11	>=partially appropriate	partially appropriate	*	partially appropriate
12	***appropriate***	***appropriate***	*	***appropriate***

Fig. 2: Decision-making rules in the "Characteristics" set

Utility functions and decision-making rules are also defined for other attributes [40], but they are not presented due to limited space. Creating decision-making rules represents an articulation of expert knowledge, which explains how the attributes that make up a superordinate attribute connect with one another, or how their joint aggregate value depends on the value of an individual attribute.

Fig. 3 presents how the "professionalism" and "work implementation" attribute sets, which have the greatest influence on the final assessment of options (i.e., 30% each), influence the final auditors' assessment if the "personal characteristics" and "skills" attributes are given the highest possible score.

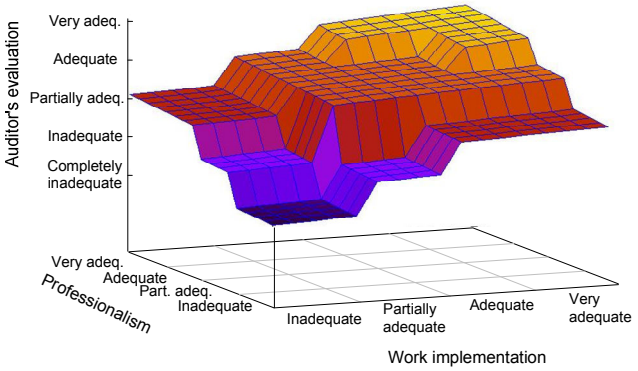

Fig. 3: The influence of the "professionalism" and "work implementation" attribute sets on the final assessment of options; this figure represents the assessment [4,4,x,y]

A. *Model validation and verification*

Validation represents a very important part of developing a model. Its primary purpose is to establish whether the model developed works as it was intended to. In order to be sure that the model functioned satisfactorily, it was tested in a real environment. Based on the results obtained, the model was further improved. At every development stage, the model was appropriately modified and thus improved. This process was repeated until the desired model behaviour was achieved. Each modification was followed by a validation of the model.

The preliminary validation, which shows whether the model functions correctly, was carried out by testing the model on several sample cases and by testing the accuracy of solutions according to documented results and expert/rater assessment.

This was followed by several months of trial use of the model in a real environment.

The model testing results confirm that the multi-attribute hierarchic model functions appropriately; the great advantage of this model is its transparent analysis. This can be claimed

on the basis of suitably selected, assessed, and structured attributes [40], on the basis of including various raters that are familiar with the ratees' work and know their performance at work well [14], [24] and trust the assessment model or system [77], such as auditing department heads, auditing team members, and auditees, and on the basis of the frequency of assessment. If used properly, the model as a whole enables transparent analysis of auditors' performance.

B. Results

Each auditor (option) is described with the values of the basic attributes (i.e., the ones lying on the leaves of the tree). This description is the result of a relatively demanding study of auditors' performance and the collection of auditor data. One must pay attention to the reliability of the sources of information on an individual auditor (option) and the completeness of data. In this, insufficient, unreliable, or less accurate data are often encountered.

1) Evaluating auditors

Assessing auditors (options) entails a process of determining the final auditors' assessment based on their description according to the basic attributes – that is, based on their descriptions by attributes on the leaves of the decision-making process. The auditor that receives the highest assessment is usually the best.

In the case presented, real options were assessed: seven internal auditors working in the internal auditing department of a large Slovenian financial organization. This internal auditing department has a relatively large number of internal auditors with various expertise, experience, and professional areas covered. Both financial statements auditors and IT-systems auditors were included. This ensures the diversity of the auditors included, based on which appropriate validation can be performed.

Assessments are obtained from various sources (i.e., auditing department head, auditing team head and members, and representatives of the audited entity), which decreases the subjectivity of the assessment and increases its accuracy.

Based on 34 basic and 17 aggregate attributes, the decision-making rules, and the weights of individual attributes, auditors 1, 4, 5, and 6 are assessed as "adequate," auditors 3, and 7 are assessed as "partially adequate," and auditor 2 is assessed as "inadequate;" this means that none of them obtained the highest assessment of "very adequate" and no auditor was assessed as completely inadequate. Fig. 4 presents the final assessments of individual internal auditors.

Attribute	**Auditor 1**	**Auditor 2**	**Auditor 3**	**Auditor 4**
Auditor's assessment	adequate	inadequate	partially adequate	adequate
Professionalism	adequate	partially adeq.	inadequate	***very adeq.***
Work	part. appropr.	part. appropr.	part. appropr.	***appropriate***
Code of conduct	***appropriate***	part. appropr.	***appropriate***	***appropriate***
Laws and standards	part. appropr.	part. appropr.	part. appropr.	***appropriate***
Latest developments	***appropriate***	part. appropr.	part. appropr.	***appropriate***
Quality	***appropriate***	part. appropr.	inappropriate	***appropriate***
Coworker satisfaction	***appropriate***	part. appropr.	***appropriate***	part. appropr.
Auditee satisfaction	***appropriate***	***appropriate***	part. appropr.	***appropriate***
Introduction of improvements	***appropriate***	part. appropr.	inappropriate	***appropriate***
Know-how	adequate	adequate	partially adeq.	adequate
Expertise	***appropriate***	***appropriate***	***appropriate***	***appropriate***
Specialization	none	none	in prograss	in prograss
Part-time study	no	no	no	no
Foreign languages	one actively	one actively	none actively	one actively

Fig. 4 Partial representation of auditors' performance assessment by individual attributes ("professionalism" set)

How this assessment of auditors will affect decisions such as awarding bonuses, promotion, reassignments, dismissals, profile enhancement, and so on depends on the concrete case (i.e., the internal organizational regulations or agreement at the auditing department).

1) Analysis of assessment and explanation of evaluation

The assessment of each option in line with the knowledge database (i.e., the attribute tree and decision-making rules) can be followed by an analysis of results composed of one or more activities presented below [37]:

What-if analysis is performed interactively by changing the description of an option, reassessing it, and comparing the results obtained with the original ones;

Sensitivity analysis, like what-if analysis, assesses the effects of changing the utility functions;

Selective explanation identifies the most important advantages and disadvantages (pros and cons) of options, which is important for justifying the decision.

Assessment analysis determines why the results are as they are. It seeks to explain where they originate and to confirm that the assessments are in line with expectations [9], [36], [48]. A comprehensive picture of auditors' performance is thus obtained as well as a higher-quality, better justified, and verified decision. In doing this, the computer-support tools are

practically indispensable because they contain embedded tools that considerably mitigate these kinds of analyses.

Despite their poor assessments, auditors 2, 3, and 7 are nonetheless worth some attention. It can be established why they achieved a poorer assessment and what could improve their final assessment. Perhaps this is a characteristic that an individual auditor can improve relatively quickly; for example, by taking a specific training course, or simply through conversation and increased self-control. The what-if analysis presented in section 4.5.5 established whether this is indeed the case.

2) Vredana

In qualitative assessment, problems often occur with classifying a large number of options into a typically small number of individual classes. In this case, the classes represent the individual assessments or values that an attribute can have. This involves problems arising from a lack of sensitivity in ranking options within the same class.

This problem was solved by introducing a combined qualitative and quantitative assessment of options, which was made possible through the use of the Vredana application, which adds to the functionality of DEX-i. A numerical value from a continuous interval is adjusted to the option assessment results. The options remain ranked in the same assessments as in the basic qualitative assessment, but they are also additionally organized within the class in line with the numeric assessment obtained [7], [73].

Based on the data collected in DEXi, Vredana also ranks or assesses auditors within an individual discrete assessment or class. In this case, four auditors are assessed as "adequate," but Vredana identifies the best one. Vredana thus provides fuller information than DEXi, clearly identifying the distance between the final assessments.

3) Selective explanation of options

The selective explanations of options seeks and analyzes only those (sub)attributes that reflect the strongest or the weakest characteristics of individual auditors. Its main goal is to explain options using only the most relevant information.

The selectiveness in this case refers to the attributes that significantly influenced the differences in the auditors' final assessments. Comparing the four best auditors (i.e., auditors 1, 4, 5, and 6), it can be seen from Fig. 5 that three of the four best auditors can improve their professionalism because only auditor 6 was assessed as very adequate in this regard. Let us thus take a look at what the main reason is for insufficient professionalism.

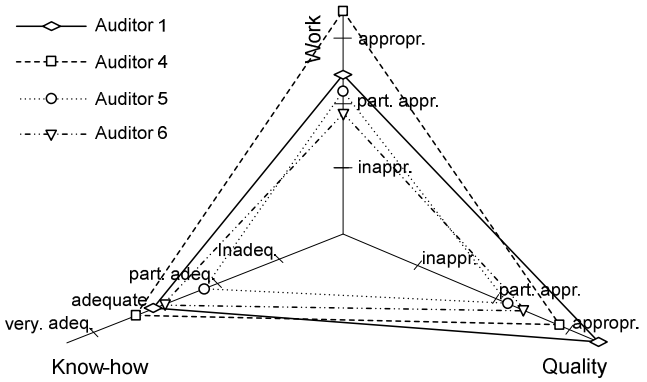

Fig. *5:* Comparison of the four best auditors by individual subsets of the professionalism set.

Fig. 5 shows that auditors 5 and 6 can improve their quality score, which is composed of auditee and coworker satisfaction, as well as their improvement introduction score. For three auditors, improvement is possible in work, where they were assessed for familiarization with the code of conduct, laws, and standards, as well as keeping abreast of the latest developments in auditing and the conceptual field of the individual auditor's activity. Poorer assessments in the know-how subset resulted from the fact that only auditor 5 is engaged in part-time study, and only auditor 6 has a specialization certificate.

4) What-if analysis

The what-if analysis is performed in DEXi interactively by changing the description of options, reassessing them, and comparing the results obtained to the original ones.

In the case presented, the what-if analysis can be used to establish why an individual auditor was not rated better or to establish what the auditor must and must not do in order to obtain a higher score. The findings obtained this way form a good basis for the interview between the rater (i.e., the head of the auditing department) and the auditor. The if-what analysis is also useful in self-assessment because auditors can establish by themselves where they can improve their results and what their strong areas are, and can thus assess themselves [33], [43]. Feedback is very important [15], [43], [65].

In the testing stage, it is important to detect the auditors' problems, their primary errors, mental models, and beliefs – however, this is not to punish them, but to provide them suitable support for improvement. At the same time, it is important that auditors be given the opportunity to find ways to excel and show their knowledge in various and the most optimal ways.

Referring back to the case at hand: in order for any of the seven auditors to be better rated (auditors 1, 4, 5, and 6 as "very adequate," auditors 3 and 7 as "adequate," and auditor 2 as "partially adequate"), their work, attitude, and other elements should be improved in several areas. In their case, improvement of merely one attribute does not contribute to a higher final assessment.

V. Conclusion

The multi-attribute hierarchic computer model for auditor performance evaluation presented was developed through the implementation of individual stages of the organized decision-making process. First, attributes that are of key importance to the assessment were selected. They were grouped according to their similarity. This was then followed by identification of the range of value of individual attributes and their utility functions. Options were also described (i.e., the auditors that were assessed).

Expert modeling methods provided transparency, analysis of results, selective analysis of results, and analysis or evaluation of hypothetical scenarios in the process of auditor performance evaluation.

The usefulness of using the model presented lies not merely in a more objective and realistic assessment of auditor performance, but also in decreased dissatisfaction that can be caused by unfair and biased evaluation of auditors' work quality [58], [71]. The basic purpose of evaluation is to influence decisions on how to improve productivity and the general state of affairs [39], [53], [80].

The multi-attribute hierarchical computer model for auditor performance evaluation presented here shows that it is possible to achieve new quality in terms of the overall performance of auditors' work assessment because the use of a multi-attribute model enables raters to make better decisions [5][77][85]; in the long run, suitable auditor assessment results in more successful and effective performance of individual auditors and the auditing department as a whole.

The main problem in developing a model is that some attributes interact with one another. Similar to other multi-attribute methods, DEXi does not make it possible to take into account all the hierarchies or a model design that would fully take into account these interactions. In DEXi, only direct interactions between the sub-attributes of a specific attribute can be taken into account; for example, it is impossible to also take into account direct interactions between two basic attributes that structurally belong to two completely different composed attributes and only group at one of the higher levels of the tree.

Limitations include the fact that the model was tested in reality only in one internal auditing department, although it was relatively large. Because previously tested knowledge of auditors and other participating experts was embedded in the model, the evaluation of a relatively small sample is nonetheless considered sufficient; however, this cannot be qualitatively proven. Therefore it is recommended that, prior to any serious use of this decision-making model, the model be additionally validated in practice in various organizations that differ in size, organization, and field of activity.

Given the fact that this multi-attribute hierarchical decision-making model for auditor performance evaluation has been in trial use for several months already, that many professionals and auditors have helped identify the attributes and utility functions, and that positive changes are already visible in the selected organization, we believe this model enables a comprehensive auditor performance evaluation and that it can also be used in other organizations. This decision-making model is primarily intended for organizations' internal auditing departments and for organizations that provide auditing services. With suitable changes to the evaluation attributes and the weights of individual basic and aggregate attributes, it is possible to use this decision-making model in practically any organization and any of its organizational units.

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