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Evaluating Internal Auditor Selection through Analytical Network Process: A Case Study Approach

Tamer Youssef Abdel Aziz Ali Elgendy[1, 2*]

1. Department of Accounting, College of Business Administration, Majmaah University, Al-Majmaah, 11952, Saudi Arabia.
2. Department of Accounting, Faculty of Commerce and Business Administration, Helwan University, Arab Republic of Egypt.

Abstract

This research investigates the application of the analytical network process (ANP) for aiding organizations in selecting internal auditors. The study develops a comprehensive model based on systematic scientific methods, which is then applied to a company listed on the Egyptian Stock Exchange for a case study. The analysis evaluates three options— insourcing, outsourcing, and co-sourcing—by considering various main and sub-factors related to auditor selection. The results show that insourcing is the top choice with 39.20%, followed by co-sourcing with 37.36% and outsourcing with 23.43%. In addition, a sensitivity analysis was conducted, focusing on the factors of neutrality, independence, and objectivity. The analysis showed that increasing the relative importance of this factor caused a shift in the ranking order, indicating how the weighting of specific factors can affect the selection process.

Keywords: Analytical network process (ANP), Internal auditor selection, Analytical hierarchy process (AHP), Outsourcing, Insourcing, Co-Sourcing

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Corresponding author: Tamer Youssef Abdel Aziz Ali Elgendy
E-mail ✉ t.elgendy@mu.edu.sa; tamerali@rocketmail.com

Introduction

Internal auditing is defined by the Institute of Internal Auditors as an independent and objective assurance and consulting activity aimed at adding value and improving an organization's operations. It helps organizations achieve their goals by applying a disciplined approach to evaluate and enhance risk control, management, and governance processes [1]. However, this definition does not specify whether the internal auditor should be an internal or external source, leading to three main alternatives for appointing an internal auditor: insourcing, outsourcing, or co-sourcing.

The researcher sees a need for a new approach to selecting the internal auditor that minimizes the challenges posed by traditional methods and aligns with the organization's specific needs. The most effective and widely used method for selecting between alternatives is the analytical network process (ANP), which is a more advanced form of the analytical hierarchy process (AHP). The ANP helps in decision-making by organizing attributes into a hierarchy based on pairwise comparisons, making it an ideal tool for complex decisions [2]. This methodology enables decision-makers to use their experience and knowledge to make judgments about various elements [3].

ANP is a widely recognized multi-criteria decision-making method that is especially useful in solving complex real-world problems, considering both quantitative and qualitative factors simultaneously [4, 5]. The ANP process involves four key

steps: (1) constructing the model, (2) conducting pairwise comparison matrices and priority vectors, (3) forming the supermatrix, and (4) selecting the optimal alternative [6].

Several studies have examined the application of network or hierarchical analysis methods, or their combination, in selecting and appointing internal auditors. For example, Seol and Sarkis [7] suggested a model for selecting internal auditors using a multi-criteria decision-making method. This approach aimed to enhance the selection and evaluation process of internal auditors by incorporating various attributes and using the AHP, a methodology commonly applied in administrative decision-making across diverse fields.

In a similar vein, Sarkis and Seol [8] explored the combination of the ANP and AHP in the internal auditor selection process. Their goal was to create a more comprehensive model by integrating both methods, considering the interconnectedness of various selection criteria, factors, and alternatives.

Another study by Dağdeviren and Yüksel [9] and Alghamdi *et al*. [10] applied the ANP in the context of staff selection. Unlike traditional methods that ignore the interdependence of factors in personnel selection, this research took into account these interdependencies. It developed a model where the relationships between factors were explicitly considered. Using ANP, the model provided global weightings for the selection criteria and introduced a scale to assess candidates, demonstrating how to evaluate applicant suitability.

The previous studies mainly focused on appointing internal auditors from within the organization. However, the present study differs by comparing internal auditor selection from internal, external, or mixed sources.

Based on the analysis of existing studies, it became clear that while AHP is useful, it has certain limitations. The introduction of the ANP offers a more nuanced solution to overcome these shortcomings. The key difference between AHP and ANP lies in how ANP determines the importance of criteria. Instead of abstractly assigning importance from top to bottom, ANP uses feedback loops from the available alternatives to establish the priority of criteria. This method allows for a more grounded decision-making process by focusing on alternatives rather than abstract goals.

The central research problem could be approached through the following questions:

Does the current method of selecting the internal auditor align with the specific requirements and responsibilities of the internal auditor role?

Can the integration of the ANP and the AHP enhance the decision-making process in selecting and appointing the internal auditor?

What are the primary and secondary factors necessary for selecting the internal auditor through the integration of ANP and AHP?

How can the integration of the Network Process and AHP be applied to develop a model for optimizing the decision to select and appoint the internal auditor?

Is it possible to apply the proposed model to corporations listed on the Egyptian Stock Exchange?

Research objective

The primary aim of this research is to develop a proposed model for selecting the internal auditor using the ANP. This main objective can be broken down into several sub-goals, which are:

Identify the factors influencing the selection of the internal auditor.

Use the integration of ANP and AHP to compare the main and secondary factors for each alternative.

Construct the proposed model to optimize the decision-making process for selecting the internal auditor.

Implement the proposed model by evaluating alternatives for selecting the internal auditor through a case study.

Research hypothesis

To achieve the research objectives, the following hypothesis will be tested:

The use of the ANP contributes to optimizing the decision-making process for selecting the internal auditor.

Materials and Methods

This research employs a deductive and inductive approach. The researcher analyzes various sources, such as books, journals (both Arab and foreign), legislation, professional publications, and other relevant materials. By reviewing these, key points and criteria related to the research topic are identified. The proposed model will then be applied to a case study of a publicly traded joint-stock company listed on the Egyptian Stock Exchange, aiming to enhance the process of selecting and appointing the internal auditor.

Steps to develop the proposed internal auditor selection model

To create an effective model for selecting the internal auditor, four key steps must be followed, as described below:

Step 1: Construction of hierarchical and network structures

This step involves identifying key factors that differentiate the alternatives (criteria for selection) and outlining the available alternatives (options for selection).

Identifying Differentiation Factors (Selection Criteria)

The researcher categorizes the selection criteria into main and sub-factors as follows:

First major factor: essential qualities and characteristics of internal auditors

The required qualities and characteristics of internal auditors can be grouped into two categories of skills:

Cognitive Skills include: creative skills, analytical skills, and behavioral skills, which include: personal skills, social/interpersonal skills, and organizational skills.

Second major factor: impartiality, independence, and objectivity

This factor highlights the importance of internal auditors maintaining impartiality, independence, and objectivity throughout their work.

Third major factor: cost of services (Fees)

This factor considers the financial costs associated with selecting the internal auditor, which should be factored into the decision-making process.

Fourth major factor: offering contemporary auditing services

This factor aligns with the modern approach to internal auditing, which includes the following services: assessing and improving risk management effectiveness, evaluating and enhancing governance and control processes, and providing assurance and consulting services.

The researchers suggest that the selection factors for choosing an internal auditor can be categorized into main factors and sub-factors. The following outlines these factors [11].

Second step: determining available alternatives (selection alternatives)

The definition of internal auditing allows for three primary alternatives for selecting an internal auditor:

First alternative: insourcing

In this case, the internal audit is performed by auditors who are employees of the organization. These employees are assigned by the management to handle the internal audit function within the facility itself.

Second alternative: outsourcing

This option involves hiring an external auditing firm to carry out the entire internal audit function. The external firm assumes full responsibility for the internal audit process.

Third alternative: co-sourcing

This approach involves a combination of outsourcing and insourcing. An external audit firm performs part of the internal audit work, while the organization's internal audit department handles the rest of the tasks. This represents a collaborative approach between the internal and external auditors.

Step 2: pairwise comparison of main and sub-factors

The second step involves conducting pairwise comparisons of the main factors and their respective sub-factors, followed by weighting them according to their relevance to the goal. The degree of importance between any two factors is measured using both verbal and numerical methods. When a group of experts is involved, the geometric mean is used to aggregate the results of each comparison.

However, before performing these pairwise comparisons, it is important to note that the AHP has limitations, particularly in how it fails to measure internal relationships between the factors. To overcome this limitation, the ANP is integrated with AHP. This integration ensures that all interdependencies and relationships among the factors (both main and sub-factors) are taken into account, providing a more comprehensive decision-making model.

Table 1 displays the relative importance scale based on Saaty's classification [12].

Table 1. The scale of relative importance

Verbal Analogy	Definition	Numerical weight
The two factors have equal importance	Equal importance	1

One factor is slightly more important than the other	Moderate importance	3
One factor is more important than the other	High importance	5
One factor is significantly more important than the other	Very important	7
One factor is the most important	Utmost importance	9
Average values between the previous weights used for numerical comparison	Intermediate importance between the above values	2, 4, 6, 8
Comparison requires selecting the smaller element as a reference unit, with the larger element being double that unit	Reciprocal values in comparison	Reciprocal of the above values
When consistency and stability are assumed, numerical values from matrix expansion provide this ratio	Logical functions	-
When the elements are nearly identical and hard to differentiate, the moderate value is between 1.3, and the extreme value is 1.9	For very similar activities	(1.1 – 1.9)

This matrix is formulated for each main factor, including their respective sub-factors, like comparisons between the sub-factors themselves.

To ensure the accuracy and reliability of the results, it is crucial to maintain a certain level of consistency when prioritizing activities or elements based on specific criteria. The AHP measures this consistency by measuring the consistency ratio. Ideally, the consistency ratio should not exceed 10%. For smaller matrices, the ratio should be below 5% for a 3 × 3 matrix, 9% for a 4 × 4 matrix, and 10% for larger matrices. If the ratio is greater than 10%, this suggests that the judgments may be inconsistent and need to be noted [13].

The formula for determining the consistency ratio is as follows [14]:

$$CR = \frac{CI}{RCI} \quad (1)$$

Where: CR = consistency ratio.
CI = consistency index.
RCI = random consistency index.
The consistency index is determined as follows [15]:

$$CI = \frac{\lambda_{Max} - N}{N - 1} \quad (2)$$

Where: CI = consistency index.
λ Max = eigenvalue for the matrix of binary comparisons.
N = the number of factors being compared.

Table 2 shows the values of the random consistency index, as follows [16, 17]:

Table 2. The values of the random consistency index

N	1	2	3	4	5	6	7	8	9	10
Random consistency index (RI)	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Third Step: This phase involves conducting pairwise comparisons between the decision alternatives and evaluating their relative importance concerning the main and sub-factors. This is followed by determining their stability and creating a preference matrix for each alternative in terms of each factor. A preference vector is then calculated to establish the relative weight of each alternative for every factor.

Fourth Step: At this stage, each alternative is assessed according to each selection criterion, and a sensitivity analysis of the model is conducted. The best alternative is identified by summing the products of each alternative's relative weight and the overall weight. To test sensitivity, the preference vector for the main selection factors is adjusted to examine how the change in one factor's importance influences the alternatives.

Case study: applying the model to select the internal auditor

This section explores how the proposed model is applied to improve the internal auditor selection process. Three alternatives are evaluated: hiring an internal auditor, hiring an external auditor, or a combination of both.

About the company

El Sewedy Electric Company, established in 1938, initially focused on distributing electrical supplies. Over time, the company became a prominent player in Egypt's energy sector and expanded internationally. El Sewedy Electric operates across five main divisions: cables and wires, meters, electrical activities, transformers, and projects and development, serving a diverse range of customers from large corporations to individual clients.

Study sample

The study's sample consists of the members of El Sewedy Electric's Board of Directors and the Audit Committee.

Data collection and analysis using super decisions software

The data was input into Super Decisions software, which aids in calculating the relative importance of both the main and sub-factors. It also helps in determining the best selection alternative. The software assesses the consistency of the data entered, ensuring the ratio remains within an acceptable range (below 10%). If this threshold is exceeded, the data is revised in collaboration with the company's Board and Audit Committee.

Methods of data entry in super decisions

Super Decisions offers various data entry methods to accommodate different user preferences and decision-making situations. These methods include direct entry, questionnaire mode, matrix mode, verbal mode, and graphic mode, making the software adaptable for users dealing with complex decisions and multiple alternatives.

Results and Discussion

Application of the model to El Sewedy Electric

The researcher walks through the application of the proposed model for selecting the internal auditor at El Sewedy Electric. **Figure 1** shows the hierarchical and network structure created in the super decisions software, including the goal, key factors, and alternatives considered.

Figure 1. The goal, the main and sub-factors, and the available alternatives

As depicted in **Figure 1**, the symbols used in the program are designed to represent the overall goal, as well as the primary and secondary factors and alternatives. However, it's important to recognize that the AHP has a limitation in that it does not account for the internal relationships among factors. To overcome this, the integration of the ANP with AHP was implemented, which allows for the consideration of the interdependencies among factors. When this integration is applied within the super decisions program, the results are displayed in **Figure 2**.

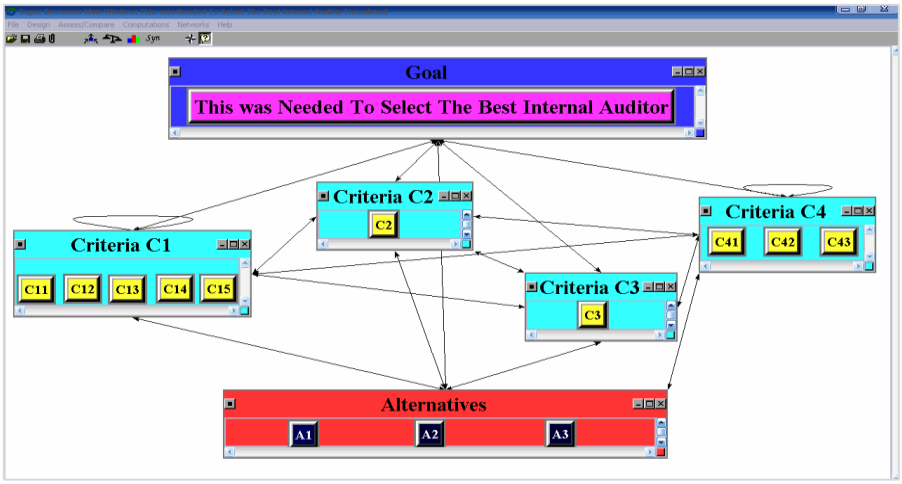

Figure 2. The integration between the analytical network process and the analytical hierarchy process

Evaluating the priority of each alternative based on selection criteria

The researcher completed the binary comparison matrix for the alternatives concerning the selection criteria by utilizing the gathered data and inputting it into the super decisions program. The outcomes of these comparisons and the evaluation of alternatives are summarized in **Table 3**:

Table 3. Summary of binary comparison results and alternative evaluation

Alternatives	Sub-factors	Main factors
A3	0.24021	C11 = 0.38771
A2	0.44343	C1 = 0.35365
A1	0.24931	C12 = 0.11347
A3	0.20984	C13 = 0.30014
A2	0.16920	C14 = 0.12659
A1	0.15706	C15 = 0.07209
A3	0.34874	C2 = 0.44375
A2	0.49339	C3 = 0.12484
A1	0.19580	C41 = 0.62501
A3	0.08096	C42 = 0.23849
A2	0.57143	C43 = 0.13650
A1	0.18839	Total
A3	0.3955	0.2137
A2	0.3908	Total

1. Degree of importance of main factors in selecting the internal auditor

From the data presented in **Table 3**, the internal auditor's qualities and characteristics emerged as the second most important factor, accounting for 365.35%. The factors of impartiality, independence, and objectivity received the highest ranking at 375.44%. Fees ranked third with a score of 484.12%, while the provision of new services, aligned with the contemporary understanding of internal auditing, placed last at 776.7%.

2. Importance of sub-factors related to the qualities and characteristics of internal auditors

According to **Table 3**, the sub-factor of technical skills ranked highest at 771.38%, while analytical skills secured fourth place with 347.11%. Personal skills ranked second with 314.30%, interpersonal skills came third with 659.12%, and organizational skills were the least important at 209.7%.

3. Prioritization of alternatives based on technical skills

The analysis reveals that insourcing ranked highest for technical skills, with a value of 961.53%, followed by co-sourcing with 696.29%. Outsourcing was rated the lowest in this category, with a score of 342.16%.

4. Prioritization of alternatives based on analytical skills

Insourcing was also ranked first for analytical skills with 360.48% while co-sourcing ranked second with 874.34%. Outsourcing ranked third with a value of 766.16%.

5. Prioritization of alternatives based on personal skills

For personal skills, co-sourcing received the highest rating at 343.44%, insourcing followed in second place with 737.38%, and outsourcing was ranked third with 920.16%.

6. Prioritization of alternatives based on interpersonal skills

Insourcing was the top choice for interpersonal skills, with a rating of 995.54%, while co-sourcing ranked second with 021.24%, and outsourcing was rated the lowest at 984.20%.

7. Prioritization of alternatives based on organizational skills

Insourcing was ranked first for organizational skills, achieving 363.59%, followed by co-sourcing at 931.24%, and outsourcing ranked third with 706.15%.

8. Prioritization of alternatives based on neutrality, independence, and objectivity

Outsourcing was rated highest for neutrality, independence, and objectivity, with a score of 360.48%. Co-sourcing came second with 874.34%, and insourcing ranked third at 766.16%.

9. Prioritization of alternatives based on fees

Insourcing emerged as the preferred choice for fees, with a rating of 064.73%, while outsourcing ranked second at 839.18%, and co-sourcing was ranked last with 096.8%.

10. Importance of sub-factors related to providing new services in internal auditing

The sub-factor of evaluating the effectiveness and improvement of risk management processes ranked highest, with 501.62%, followed by evaluating and enhancing control and governance processes at 849.23%. Consulting and assurance services were rated third with 650.13%.

11. Prioritization of alternatives for evaluating the effectiveness of risk management processes

For the evaluation of risk management processes, co-sourcing ranked first with 339.49%, followed by insourcing in second place with 081.31%, and outsourcing ranked third at 580.19%.

12. Prioritization of alternatives for evaluating control and governance processes

Co-sourcing led control and governance evaluations with a score of 961.53%, followed by outsourcing with 696.29%. Insourcing ranked third with 342.16%.

13. Prioritization of alternatives for providing consulting and assurance services

In the area of consulting and assurance services, co-sourcing was the top alternative with 143.57%, while outsourcing ranked second with 571.28%, and insourcing came third with 286.14%.

Evaluation of the three alternatives and determination of the best internal auditor

In this section, the three alternatives are assessed based on the overall goal of choosing the best internal auditor. This evaluation considers the relative importance of the alternatives concerning both the sub and main factors used for selecting the internal auditor. According to **Table 3**, the first alternative, insourcing, was ranked highest with a score of 20.39%. The 2nd alternative, outsourcing, came last with 43.23% while co-sourcing placed second with 36.37%.

Sensitivity analysis of the proposed model's results

It is important to evaluate how changes in the priorities of the main factors affect the decision. This can be done by altering the priority of one factor while keeping the others constant, ensuring that the total sum (including the altered factor) equals one. To facilitate this, the super decisions program offers four different methods to display the findings of sensitivity changes: plot, Barchart, Reichart, and horizontal Barchart.

For this analysis, the researcher utilized the plot method to test the sensitivity by adjusting the priority of the 2nd main factor, which concerns neutrality, independence, and objectivity. **Figure 3** illustrates the data input for this factor, showing the ranking of the alternatives based on the general model, before conducting the sensitivity analysis.

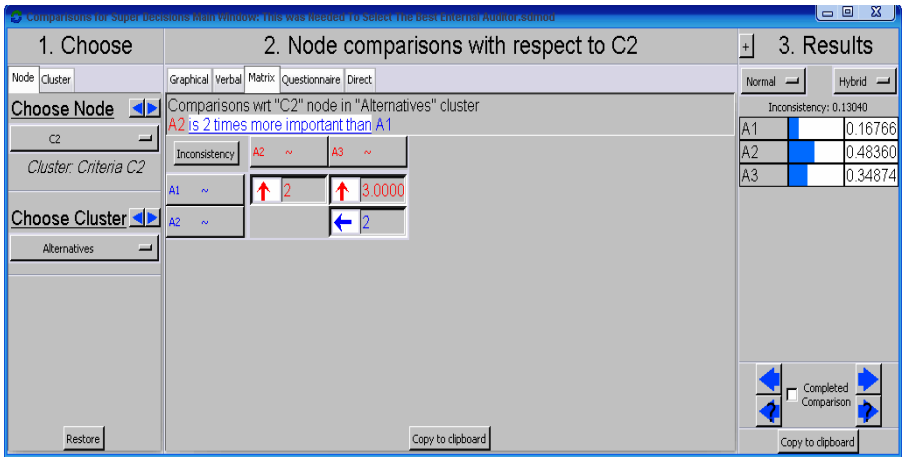

Figure 3. The arrangement of the available alternatives according to the general model, before conducting a sensitivity analysis

As shown in **Figure 3**, based on the proposed selection model, insourcing ranks first, followed by co-sourcing, and outsourcing comes last.

When applying the test through the super decisions program to the 2nd main factor (independence, impartiality, and objectivity), the relative importance of this factor in the model was increased for the 3rd alternative, shifting its ranking over the 2nd alternative from a ratio of 1/2 to 4.

Figure 4 illustrates the updated data for the 2nd main factor (independence, impartiality, and objectivity), and accordingly, presents the revised order of the alternatives after conducting the sensitivity analysis.

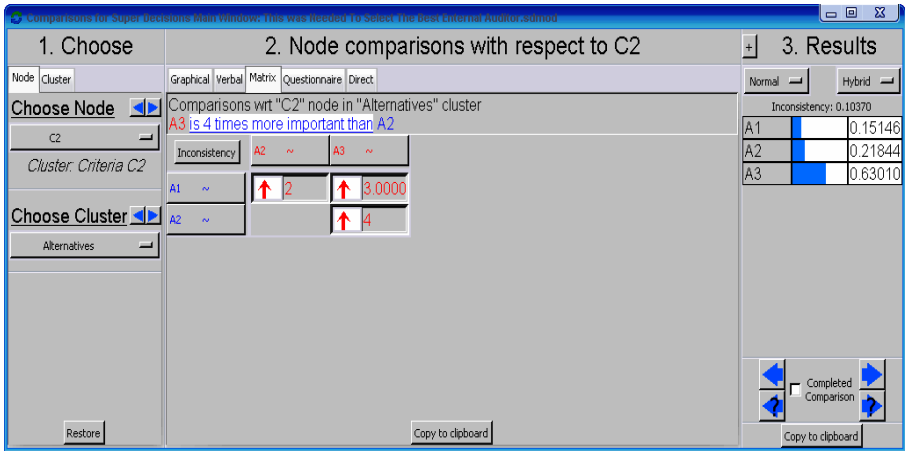

Figure 4. The arrangement of the available alternatives according to the general model, after conducting a sensitivity analysis

As shown in **Figure 4**, the alternatives are affected by changes in the importance of the 2nd main factor (neutrality, independence, and objectivity). When the importance of this factor for the 3rd alternative was increased relative to the 2nd alternative, from a value of 1/2 to 4, the order of the alternatives shifted.

According to **Table 3**, after this adjustment, insourcing moved to second place with a score of 39.08%. Outsourcing dropped to third place with 21.37%, while co-sourcing took the top spot with 39.55%.

Conclusion

The study utilized binary comparisons of alternatives for selection factors, with data entered into the super decisions program to analyze the decision-making process for selecting an internal auditor. The key findings are as follows:

- Importance of main factors in internal auditor selection:
  - The qualities and characteristics of internal auditors ranked second (35.365%).
  - Impartiality, independence, and objectivity emerged as the most significant selection criterion (44.375%).
  - Fees ranked third (12.484%).
  - Provision of new services in alignment with contemporary internal audit practices ranked fourth (7.776%).

- Evaluation of alternatives and selection of the best internal auditor:
  - Insourcing was identified as the top choice, with a preference rate of 39.20%.
  - Outsourcing ranked third at 23.43%.
  - Co-sourcing secured the second position at 37.36%.
- Sensitivity analysis of the model:

A sensitivity test was conducted using the super decisions program to assess the impact of changes in the relative importance of the impartiality, independence, and objectivity factors. Increasing its significance for the third alternative (co-sourcing) relative to the second alternative (outsourcing) from 1/2 to 4 resulted in:

- Insourcing moved to second place (39.08%).
- Outsourcing dropped to third place (21.37%).
- Co-sourcing taking the lead at 39.55%.

These results highlight that the ranking of alternatives is sensitive to shifts in the weighting of key decision factors, particularly impartiality, independence, and objectivity. The changes in priority directly influenced the final rankings, demonstrating the model's adaptability to different decision-making criteria.

Recommendations

- Audit committees and board members should incorporate the ANP and AHP when selecting an internal auditor. The model presented in this study can serve as a structured decision-making tool.
- Board and audit committee members should be educated on the use of the extraordinary decision program to assist in internal auditor selection.
- Academic institutions should integrate ANP and AHP methodologies into their curricula, as these decision-making models have broad applications beyond auditor selection, including business strategy and organizational management.

Future research directions

- Future studies may explore alternative quantitative decision-making models, such as multiple trait analysis, point distribution methods, total points methods, or weighted scoring techniques, to develop comparative models for internal auditor selection.
- Researchers may apply ANP-AHP integration to enhance decision-making when determining whether an internal auditor should be sourced internally or externally, particularly considering cognitive and behavioral competencies.
- The ANP-AHP integration model could also be applied in selecting external auditors to oversee internal audit functions, ensuring alignment with corporate governance requirements and company-specific conditions.

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