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PRIORITIZING THE INTERNAL AUDIT UNIVERSE IN A PHARMACEUTICAL COMPANY: AN INTEGRATED AHP–TOPSIS APPROACH

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ABSTRACT

Purpose- The purpose of this study is to determine which units should be primarily applied to the internal audit universe in the pharmaceutical company where the application is carried out, with the support of the top management and using analytical decision-making methods.
Methodology- In the study, AHP and TOPSIS, which are MCDM methods, were used together. In the first stage, the criteria affecting the internal audit were weighted with the AHP method; then, the sub-units of the company were evaluated concerning the results of the TOPSIS method.
Findings- As a result of the analyses, the most critical factors affecting the internal audit universe were determined. These findings reveal the basic elements that should be taken into consideration in the internal audit process and contribute to a more systematic structure of corporate audit practices. In addition, it has been shown that a more efficient and target-oriented internal audit process can be carried out with limited human resources with the application of the TOPSIS method. This approach supports the effective use of resources and organizational stability in audit processes.
Conclusion- Based upon the analysis and findings, it may be concluded that objectively weighted criteria with AHP and prioritization with TOPSIS allowed the pharmaceutical company to direct limited audit resources to the highest risk units. The resulting model not only increases stability and efficiency in the existing organizational structure but also provides a transparent, repeatable, and defensible internal audit framework for companies of different sectors and sizes.

Keywords: Audit universe**,** multi attribute decision making, TOPSIS, AHP
JEL Codes: M42, C44, L22

1. INTRODUCTION

As in all industries, the pharmaceutical sector is also expanding rapidly, driven by rapid technological advancements (Ortakarpuz et al., 2018). These rapid developments bring work intensity and risks that may occur in the work environment (Bota-Avram & Popa, 2011). At this point, regulations and internal audit structures come into play. A risk-based internal audit structure needs to be established, and the established structure needs to be applied to all units at certain intervals (Institute of Internal Auditors, 2020). In today's business world, companies want to manage their limited employee resources and finances correctly. Managing the internal audit mechanism is of great importance at this point. The internal audit process may vary depending on factors such as the turnover of the relevant sub-unit of the company, its dependence on legal processes, its personnel, and the company's location. This situation can be explained by the fact that different types of applications are required in each area of the company. When considering multinational companies, it becomes clear that different practices must be implemented following the legal processes of each country. At this point, deciding which unit needs what level of auditing is a complex process and can be open to subjective evaluations.

In the classical internal audit method, the approach is usually based on the auditors' experiences, intuitions, and internal observations, and is mostly dependent on subjective assessments. In this method, the prioritization of the processes to be audited is mostly done according to fixed scoring systems, past audit results, or the opinions of managers. Criteria weights are usually kept constant or calculated by simple multiplication on a certain scale. This situation may cause some limitations, such as not being able to adequately reflect the real risk levels of the processes, not being able to adapt quickly to changing conditions, and a lack of transparency in the decision-making process. However, in today's complex and rapidly changing business environment, it has become necessary to support this method with systematic and data-based alternatives.

Such multi-dimensional decision problems can be systematically analyzed with Multi-Criteria Decision Making (MCDM) techniques. MCDM methods provide objective and consistent results on how to allocate resources most efficiently by considering different criteria simultaneously. Thus, internal audit activities can be planned with both a risk-focused and strategic approach. In the continuation of the study, different internal audit functions were weighted with the Analytic Hierarchy Process (AHP) method, and their importance levels were revealed. Thanks to the Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) methodology, the internal units were ranked with the help of the weights found with the AHP method. The order in which internal audit activities should be carried out in company units has been determined.

The biggest difference between the Internal Audit Universe created using the classical and AHP & TOPSIS methods is the method of determining the criteria weights affecting the study, and therefore the weights of the criteria. The difference in weights is the factor that most affects the audit priority of the processes within the institution. Determining the weights of the criteria with the AHP method, which is an objective decision-making technique, rather than the subjective opinion of the auditor and the company management, has ensured that the audit priorities of the institution are more systematic, transparent, objective, planned, professional, dynamic, and explainable. Another major difference is that, while the weights determined in the old method were found only by multiplying the risk values determined on a 4-point scale for each subsection, the new method is more analytical and data-oriented, thanks to applying all steps of the TOPSIS method. Additionally, the application of multi-criteria decision-making methods like AHP and TOPSIS enhances the clarity and defensibility of decision-making processes for all stakeholders involved in the audit process. This contributes to building greater trust and confidence at the management level (Kahraman et al., 2015).

In the following parts of the study, firstly, methodologies are explained, then in Part 3, application of the proposed model to the selected problem is presented with a step-by step approach. After the final results are provided, future studies are proposed in the conclusion.

2. METHODOLOGY

Within the scope of the study, AHP and TOPSIS methods, which are multi-criteria decision-making techniques, were used together. The criteria were weighted by applying the AHP method, then the TOPSIS application was applied, and the alternatives were ranked. Developed by Saaty (2008), AHP is a decision-making tool used to solve complex problems and divides these problems into hierarchies and sub-problems. Model steps are given in Figure 1. When applied in internal auditing, it will allow weights to be assigned to criteria according to their relative importance (Woods et al., 2018; Sarens et al., 2009).

Figure 1: AHP Steps (Adapted from Saaty, 2008)

Step 1: Determining the problem and creating the hierarchical structure.

Step 2: Collecting information from decision makers for criteria and creating normalized pairwise comparison matrices;

$$M = \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ a_{21} & 1 & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & 1 \end{bmatrix}, \ a'_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}, i, j = 1, 2, \dots, n$$

Step 3: Determination of Eigenvector (Relative Importance Vector): $w_i = \left(\frac{1}{n}\right) \sum_{j=1}^{n} a'_{ij}, i, j: 1,2, \dots, n$

Step 4: Checking the consistency of the comparison matrices. First calculating the CI value, then finding the CR value suggested by Saaty is calculated with the equations $\mathrm{CI} = \frac{\lambda_{\max} - n}{n-1}$ and $\lambda_{\max}$represents the largest eigenvalue and n is the number of criteria and RI is the matrix table value determined by Saaty, CR = CI /RI The consistency value must be less than 0.1. In case of inconsistency in the opinions of the decision makers, the consistency value will be greater than 0.1. In this case, step 2 is repeated until the value is less than 0.1

Step 5: The weights of the decision variables are determined.

TOPSIS was proposed by Hwang and Yoon (Hwang & Yoon, 1981). It is a method based on idealizing the positive and negative solutions created by using the best and worst results of the alternatives and then choosing the solution closest to the positive ideal and farthest from the negative ideal (Hwang & Yoon, 1981) as presented in Figure 2.

Figure 2: TOPSIS Steps (Adapted from Hwang & Yoon, 1981)

Step 1: Collecting decision makers' opinions for alternatives and creating a decision matrix: $A_{ij} = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{bmatrix}$

Step 2: Normalization of the Matrix

$$N_{ij} = \frac{a_{ij}}{\sqrt{\sum_{i=1}^{m} a_{ij}^2}} \ (i = 1, \dots, m \ ve \ j = 1, \dots, n) \quad N_{ij} = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{bmatrix}$$

Step 3: Determining Positive Ideal (A*) and Negative Ideal (A-) Solutions. If maximization is aimed at, the positive ideal solution values, which are the maximum values for each column, are determined. Then, the negative ideal solution values are determined by obtaining the minimumvalues for each column. Euclidean distance is used when calculating distance values to positive and negative ideal points.

$$d_{ij} = \sqrt{\sum_{k=1}^{p} (x_{ik} - x_{jk})^2}$$

Step *4: Calculation of Separation Measures* : $S_i^* = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^*)^2} \qquad S_i^- =$

Step 5: Calculating Relative Closeness to the Ideal Solution: $C_i^+ = \frac{S_i^-}{S_i^- + S_i^+}$

3. THE PROPOSED APPLICATION

In the application part of this study, an AHP-TOPSIS-based evaluation, model, and analysis were applied to the in-company units where the application was made. The units examined were evaluated from many aspects and their effects on the company's audit universe were tried to be determined. In the application, firstly, the problem was determined, and the criteria were established. An AHP study was conducted to weigh these criteria, and then the alternatives were ranked using the TOPSIS application.

3.1. Weight Determination with AHP

The steps of AHP, as described below, are used to determine the importance weights of the criteria.

Step 1: Determining the problem and creating the hierarchical structure: The AHP application aims to plan the internal audit universe correctly. To plan correctly, it is aimed to determine and categorize all audit areas within the organization. The AHP application aims to plan the internal audit universe correctly. To plan correctly, it is essential to identify all audit areas within the organization and categorize them accordingly. At this stage, alternatives need to be determined. As an alternative, the sub-units of the company that need internal auditing have been determined.

Afterwards, the criteria were determined to answer the question of the priority/order in which the internal audit activities would be applied in the company, which was the main purpose of the study. In both the old classical method and the method where AHP & TOPSIS decision-making techniques are used, some criteria are used to determine the audit priority. In this study, the most commonly used criteria and sub-criteria in the preparation of the audit universe in Internal Audit departments were used. The criteria selection was finalized with the assistance of academicians who are experts in the field, through an examination of the literature, and with input from company experts. After the criteria and alternatives were determined, managers completed the comparison matrices. The same managers were asked to score the same criteria on a scale of 1-10 for the TOPSIS application, and the application was carried out with these data. In this study, the following risk criteria (Table 1) were used in determining the audit universe (Kahraman et al., 2003).

Table 1: List of Main and Sub-Criteria for the Selected Problem

Criteria		Sub Criteria
Financial Impact(A)	A	-
Legal and Process Risk (B)	B1	Interaction and influence risk with other processes
	B2	Complexity risk of activities and transactions
	B3	Legal compliance and regulatory risk
Employee(C)	C1	Staff inadequacy and turnover risk
	C2	Organizational change risk in the last 3 years
Audit (D)	D1	Number of frauds and irregularities risk
	D2	Risk of not being audited for a long time
	D3	Risk of inadequacy of internal control systems
	D4	Audit Maturity Risk
Distance risk from the head office(E)	E	-
Corporate Risk Inventory Current Risks(F)	F	-

Step 2: Creating pairwise comparison matrices: Comparison matrices were used to determine superiority. After scoring the sub-criteria, the final comparison matrix, a 6x6 matrix with 6 main criteria, was obtained. The intensity of importance values in Table 2 was used when making comparisons.(Vaidya and Kumar, 2006) The 1-9 comparison scale prepared by Satty was used (Saaty and Sodenkamp, 2008).

Table 2: An Example for a Pairwise Comparison Matrix

Pairwise Comparison Matrix						
Decision Variables	**A**	**B**	**C**	**D**	**E**	**F**
A	1	3	5	1/5	7	3
B	1/3	1	3	1/5	5	1/5
C	1/5	1/3	1	1/9	3	1/5
D	5	5	9	1	9	3
E	1/7	1/5	1/3	1/9	1	1/9
F	1/3	5	5	1/3	9	1

Normalized Comparison Matrix						
Decision Variables	**A**	**B**	**C**	**D**	**E**	**F**
A	0.143	0.206	0.214	0.102	0.206	0.399
B	0.048	0.069	0.129	0.102	0.147	0.027
C	0.029	0.023	0.043	0.057	0.088	0.027
D	0.713	0.344	0.386	0.511	0.265	0.399
E	0.020	0.014	0.014	0.057	0.029	0.015
F	0.048	0.344	0.214	0.170	0.265	0.133

Step 3: Determination of Eigenvector (Relative Importance Vector): As a result of the steps, the criterion weights were determined as 0.21 for A, 0.09 for B, 0.04 for C, 0.44 for D, 0.02 for E, and 0.20 for F, respectively. These results show that criterion D has the highest importance, whereas criterion E has the lowest weight value.

Step 4: Calculating the Consistency of Eigenvector: The consistency of pairwise comparisons made by the raters was assessed using the Random Index table (Mumpower et al., 2012). According to this consistency analysis, the comparisons made between the criteria are within the accepted threshold range. In the AHP analysis, the number of criteria was determined as 6. The highest eigenvalue obtained was 6.65. The Consistency Index (CI) calculated according to this value was found to be 0.13. The Random Consistency Index (RI) value used for the six criteria was 1.24. The Consistency Ratio (CR) was 0.1051. Since the CR value was slightly above 10%, the decision matrix was at an acceptable level.

3.2. Listing the Alternatives with TOPSIS

In this study for the selected problem in the pharmaceutical industry, TOPSIS is used to list the units to be audited internally. The method is implemented by following the steps below.

Step 1: Decision Matrix: The opinions of the decision makers' regarding the alternatives initial decision matrix is constructed as presented in Table 3. The rows of the decision matrix contain i,i=1,2,…..m alternatives, and the columns contain j,j=1,2,….n criteria.

Table 3: Initial Decision Matrix

Dep.	A	B1	B2	B3	C1	C2	D1	D2	D3	D4	E	F
DLDF	3.00	1.50	1.50	3.00	2.00	1.58	4.00	4.00	2.00	1.00	4.00	2.00
DLGAB	2.00	3.00	1.75	2.00	2.88	2.38	4.00	4.00	1.63	2.63	4.00	4.00
DLUKÇ	3.00	2.67	2.00	3.00	2.00	1.00	1.00	2.00	2.00	1.00	4.00	2.00
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.
GMUÜ	4.00	2.00	1.00	3.00	3.00	2.00	4.00	4.00	2.00	1.00	2.33	2.00
GMY	1.00	3.25	3.25	2.00	1.75	1.00	1.00	4.00	2.50	1.00	1.00	2.00
GMKS*	2.00	1.67	1.17	3.00	1.00	1.00	3.00	2.00	1.00	1.50	1.00	2.00
GMH	2.00	2.00	2.00	3.00	2.00	1.00	1.00	1.00	1.00	3.00	1.00	2.00

Step 2: Normalized Decision Matrix: In the second step, the initial decision matrix is normalized based on Step 2 as presented in Table 4.

Table 4: Normalized Decision Matrix

Dep.	A	B1	B2	B3	C1	C2	D1	D2	D3	D4	E	F
DLDF	0.274	0.156	0.178	0.256	0.226	0.199	0.312	0.261	0.237	0.118	0.456	0.188
DLGAB	0.183	0.312	0.208	0.171	0.325	0.299	0.312	0.261	0.193	0.311	0.456	0.376
DLUKÇ	0.274	0.277	0.238	0.256	0.226	0.126	0.078	0.130	0.237	0.118	0.456	0.188
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.
GMUÜ	0.091	0.338	0.386	0.171	0.198	0.126	0.078	0.261	0.296	0.118	0.114	0.188
GMY	0.183	0.173	0.139	0.256	0.113	0.126	0.234	0.130	0.119	0.178	0.114	0.188
GMKSSPO	0.183	0.208	0.238	0.256	0.226	0.126	0.078	0.065	0.119	0.355	0.114	0.188
GMH	0.091	0.104	0.119	0.142	0.169	0.252	0.078	0.261	0.119	0.237	0.114	0.188

Step 3: Determining Positive and Negative Ideal (A-) Solutions: Based on Figure 2, Step 3, A* and A- are calculated as presented in Table 5.

Table 5: Positive and Negative Ideal Solutions

	A	B			C		D				E	F
	A	B1	B2	B3	C1	C2	D1	D2	D3	D4	E	F
Positive Ideal	0.077	0.004	0.003	0.021	0.013	0.002	0.076	0.030	0.019	0.009	0.011	0.074
Negative Ideal	0.019	0.001	0.001	0.006	0.004	0.001	0.019	0.007	0.006	0.003	0.003	0.018

Step 4: Calculation of Separation Measures: Separation measures are calculated for each alternative using positive and negative ideal solutions (See Table 6).

Table 6: Separation Measures

	DLDF	DLGAB	DLUKÇ	GMBT	GMDT	GMF	GMH	GMIK	GMİ	GMK
S+	0.038	0.040	0.041	0.055	0.055	0.043	0.060	0.057	0.058	0.059
S-	0.114	0.121	0.119	0.100	0.120	0.077	0.105	0.074	0.096	0.087

	GMKİ	GMM	GMTLZ	GMTÜ	GMTS	GMUÜ	GMY	GMKSSPO	GMH
S+	0.062	0.071	0.072	0.073	0.080	0.081	0.082	0.083	0.091
S-	0.082	0.092	0.089	0.077	0.080	0.066	0.063	0.061	0.059

Step 5: Calculating Relative Closeness to the Ideal Solution: The highest proximity values were observed for DLDF, DLGAB, DLUKÇ, and GMKİ, which showed that these alternatives should be prioritized. Options such as GMUÜ, GMY, GMKSSPO, and GMH have relatively less importance with lower CI+ values.

4. CONCLUSION

In the classical method, preparing the Internal Audit Universe relied on subjective judgment, historical data, and limited stakeholder input, often lacking structured decision-making. In contrast, the modern approach incorporates multi-criteria decision techniques like AHP to systematically prioritize risk factors based on expert input and relative importance, and TOPSIS to rank audit areas by how closely they align with an ideal risk profile. Also, the results could be given about which one is more reliable for the institution if the results are compared with both methods.

The use of AHP and TOSIS provided the Board of Directors for the Internal Audit Plan, with an objective and data-driven decision-making process, providing more confidence and risk-focused gain compared to the traditional approach. The work also increased transparency, reduced bias, and ensured that audit priorities were aligned with the organization's strategies and current risks. It also led to more agile decisions, stronger stakeholder trust, and better resource allocation. As a result, it supported long-term sustainability by encouraging continuous improvement, adaptability, and alignment with the organization's evolving goals and risk environment. The order of importance and weights of the criteria determined to evaluate risks and reach audit priority were evaluated during the time of this study by company managers based on the Internal Audit Universe results prepared with the AHP and TOPSIS method.

The Internal Audit Plan was prepared based on the Internal Audit Universe results in the form of processes and sub-processes. The prepared Internal Audit Plan was accepted with much less intervention compared to the Internal Audit Plan prepared with the classical method, Internal Audit Universe. The interventions made by the Board of Directors were mostly in the form of adding to the plan the possible risky operational areas that could not be audited in the recent past, and the special subject-based audits that were outside the processes used in the Internal Audit Universe. In addition to the integrated use of AHP and TOPSIS methods in this study, other MCDM techniques can also be applied to address the problems within the internal audit domain.

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