

DOKUZ EYLÜL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

**CONSULTANT FIRM SELECTION WITH
MULTI-CRITERIA DECISION MAKING IN THE
IMPLEMENTATION PROCESS OF ENTERPRISE
RESOURCE PLANNING: A REAL WORLD
APPLICATION**

by
Özge DEMİR SOY

September, 2024

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APPLICATION**

**A Thesis Submitted to the
Graduate School of Natural and Applied Sciences of Dokuz Eylül University
In Partial Fulfillment of the Requirements for the Degree Master of Science in
Industrial Engineering, Industrial Engineering Program**

**by
Özge DEMİR SOY**

**September, 2024
İZMİR**

M.Sc THESIS EXAMINATION RESULT FORM

We have read the thesis entitled “**CONSULTANT FIRM SELECTION WITH MULTI-CRITERIA DECISION MAKING IN THE IMPLEMENTATION PROCESS OF ENTERPRISE RESOURCE PLANNING: A REAL WORLD APPLICATION**” completed by **ÖZGE DEMİRSOY** under supervision of **PROF.DR. HASAN SELİM** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

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Özge DEMİRİSOY

**CONSULTANT FIRM SELECTION WITH MULTI-CRITERIA DECISION
MAKING IN THE IMPLEMENTATION PROCESS OF ENTERPRISE
RESOURCE PLANNING: A REAL WORLD APPLICATION**

ABSTRACT

Enterprise Resource Planning (ERP) projects aim to increase efficiency by integrating all business processes and company information under a single integrated system. There are many departments within companies such as accounting, purchasing, procurement, customer relations, human resources and production. Since the failure of ERP projects can lead to serious consequences, the process must be managed very well. One of the success factors is to work with experienced consulting firms. However, choosing the appropriate ERP consultant is a challenging process and is treated as a multi-criteria decision-making problem. In this thesis, the problem of ERP consultancy company selection in a manufacturing firm operating in Türkiye is handled. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is employed in selection of the consultancy firm, and Analytical Hierarchy Process (AHP) is utilized in determining the weights of the criteria. The data is collected by surveying project managers and key users in the company. The criterion with the highest weight in choosing an ERP consultant is cost. Through the proposed solution approach, the selection of an ERP consultancy firm in the manufacturing company considered has been effectively carried out.

Keywords: ERP consultant selection, AHP, TOPSIS, Multi criteria decision making

KURUMSAL KAYNAK PLANLAMASI UYGULAMA SÜRECİNDE ÇOK KRİTERLİ KARAR VERME İLE DANIŞMAN FIRMA SEÇİMİ: BİR GERÇEK YAŞAM UYGULAMASI

ÖZ

Kurumsal Kaynak Planlama (ERP) projeleri, tüm iş süreçlerini ve firma bilgilerini tek bir sistem altında entegre ederek verimliliği artırmayı amaçlamaktadır. Firmaların bünyesinde muhasebe, satın alma, müşteri ilişkileri, insan kaynakları ve üretim gibi birçok birim bulunmaktadır. ERP projelerinin başarısızlığı ciddi sonuçlara yol açabileceğinden bu sürecin çok iyi yönetilmesi gerekmektedir. Bu bağlamda, başarı faktörlerinden biri de tecrübeli danışmanlık firmaları ile çalışmaktır. Ancak, uygun ERP danışmanının seçimi zorlu bir süreçtir ve çok kriterli karar verme problemi olarak ele alınmaktadır. Bu tezde, Türkiye'de faaliyet gösteren bir imalat firmasında ERP danışmanlık firması seçim problemi ele alınmıştır. Danışmanlık firmasının seçiminde TOPSIS yöntemi, kriter ağırlıklarının belirlenmesinde ise Analitik Hiyerarşi Süreci (AHP) kullanılmıştır. Veriler, şirketteki proje yöneticileri ve kilit kullanıcılarla anket yapılarak toplanmıştır. ERP danışmanı seçiminde en fazla ağırlığa sahip olan kriter maliyettir. Önerilen çözüm yaklaşımı vasıtasıyla ele alınan üretim firmasında ERP danışmanlık firmasının seçimi etkin bir şekilde gerçekleştirilmiştir.

Anahtar kelimeler: ERP danışmanı seçimi, AHP, TOPSIS, Çok kriterli karar verme

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CHAPTER ONE

INTRODUCTION

Due to increasing competition, companies now attach more importance to digital transformation projects. With digital transformation projects, a transition to more reliable systems has been achieved and costs are being reduced. ERP systems provide benefits not only in cost control but also in many areas such as stock management, logistics activities and production. With ERP systems, it is possible to manage operational transactions with the software system. In order to reduce the error rate and have a more accurate process flow, ERP software has no longer become a choice but a necessity for companies.

Companies should first decide on the ERP software that is suitable for them. Afterwards, they need to choose a consultant company. Both decisions can be quite difficult and complex for companies. Failure to choose the appropriate ERP software or consultancy firm may result in extra costs for the company. Therefore, it is important that both decisions are made correctly.

Decision-making processes in the early stages heavily relied on the experiences and knowledge of individuals. It is evident that decisions made in this manner could lead to incorrect outcomes. With the advent of the modern world, decision-making processes are now based on more accurate and scientific theories (Ye et al., 2023).

According to the existing literature, there are three types of joint decision-making problems, i.e., multi-attribute decision-making (MADM) problems (Ye et al., 2023; Hwang & Yoon, 1981; Zhang, Zhan, Xu & R. Alcantud, 2019), multi-objective decision-making (MODM) problems (Ye et al., 2023; Horasan & Kilic, 2022; Zhang, Liao & Tang, 2022), and multi-criteria decision-making (MCDM) problems (Ye et al., 2023; Ren, Xu, & Gou, 2016; Zhang & Xu, 2014).

In this thesis, two multi-criteria decision-making methods, AHP and TOPSIS are employed for the ERP consultant company selection problem in a manufacturing firm

operating in Turkey. The criteria determined by the project managers and key users are weighted using AHP, and then the consultant company is selected by TOPSIS method. Thus, the company management decides on the consultancy firm that suits it.

The remainder of the thesis is organized as follows. In Chapter 2, ERP systems are defined, and benefits of ERP software to companies and the importance of ERP consultants are explained. In Chapter 3, an overview of the literature on ERP consultant company selection is presented. Chapter 4 explains the details of AHP and TOPSIS methods. A real-world application is presented in Chapter 5. We provide general information about the company where the application is made. We explain the details of the criteria used in the application. Finally, we rank the consultant companies according to the TOPSIS method. Finally, concluding remarks and future research directions are presented in Chapter 6.

CHAPTER TWO

ERP CONSULTANT SELECTION

2.1 ERP Definition

ERP is the general name of systems and software that enable businesses to manage their resources in an integrated manner and use them efficiently. ERP systems allow businesses to easily track and manage data management from a central location. They enable businesses to better understand their data and make better decisions. In addition, they integrate many business processes and enable data flow between them. By collecting common operational data from multiple sources, ERP systems eliminate data duplication and enable tracking through a single system.

ERP software provide significant advantages for companies. Some of these advantages include reducing costs, reducing inventory, and increasing productivity (May et al., 2013; Olson, 2004). ERP systems provide integration for enhanced workflow, standardization of certain business practices, improved order methods, inventory accounting, and better supply chain management (May et al., 2013; Mabert et al., 2003).

Various ERP software are used in the application; such as SAP B1, SAP 4/HANA, Canias, IFS, Microsoft Dynamics 365, Oracle, Netsis, Abas, Nebim. In this thesis, the problem of selecting a consultant company for SAP 4/HANA software is handled. All of the software serve the same purpose, but the ERP software and its modules to be used vary depending on the structure and needs of the companies.

The procurement process for ERP software is as important and challenging as selecting a consulting firm. Primarily, it is crucial to accurately identify the company's needs and clarify which modules are required. Process owners play a major role in defining the processes very well. In scenarios where analysis is carried out correctly, the purchasing process progresses to provide maximum benefit. An expert team from the software company will provide the right guidance.

2.2 Benefits of ERP Systems

With the globalization of the world, competition between companies is also increasing. For this reason, companies seek to evaluate systems or applications that provide them with an advantage. ERP systems are at the forefront of these considerations. They are highly important due to the issues of correct resource utilization and increased efficiency.

The benefits provided by ERP systems are as follows (Umble et al., 2003):

- Creating an integrated corporate perspective that encompasses all functions and departments.
- Establishing a corporate database where all transaction steps are entered, recorded, monitored, and reported.
- Increasing coordination and communication between departments through this integration.

ERP systems provides the following benefits to a business when it operates correctly (Büyükoçkan, 2011; Pınar & Erdem, 2001):

- Reduced Inventory Levels
- Improvement in Order Management System
- Reduction in Human Workforce Needs
- Decrease in Procurement Costs
- Increase in Revenues
- Improvement in Cash Flow
- Increase in Efficiency
- Increase in Flexibility
- Increase in Customer Service
- Increase in Customer Satisfaction and Engagement
- Reduction in Unnecessary Data and Processes
- Decrease in Information Technology Expenses
- Reduction in Stationery Costs due to Easy Data Entry and Access
- Easy, Accurate, and Rapid Access to Reliable Information

- Accurate Demand Forecasting
- Reduction in Communication and Logistics Expenses
- Reduction in System Maintenance and Repair Costs
- Consolidation of All Software into One System
- Improvement in Project Management
- Ease of Adapting to Changing Business Environment and Market Conditions
- Facilitating International Transactions with Support for Different Taxes, Invoicing, Currencies, Accounting, and Languages
- Increasing Competitiveness by Organizing Business Processes
- Emergence of New or Improved Business Applications
- Strengthening Decision-Making Mechanisms through Instant Data Access
- Seamless Integration of All Systems within the Organization
- Global Sharing of Information.

All these advantages contribute to increased efficiency, traceability, interdepartmental integration, cost reduction, performance improvement, enhanced communication with customers, and ensuring data reliability for businesses. Therefore, ERP systems are extremely important for institutions.

2.3 Importance of ERP Consultant Selection

There are many factors that affect the success of ERP projects. One of the most important of these factors is choosing the appropriate consultant company. Since the process of ERP projects is complex and very detailed, consultants who are experts in their field are needed to help at every step of the project. ERP projects are more likely to be successful with a professional team. Consulting companies usually have a project team that will work together with the company's project team. This team includes expert consultants for each module that is decided to be commissioned. The number of consultants depends on the complexity and structure of the firm's relevant processes. With the increasing use of ERP software in practice, the number of consulting companies and consultants is also increasing. There may be many criteria in choosing an ERP consultant company, depending on the needs of the companies.

The history of ERP consulting is based on the emergence of IT consulting with the use of computers by companies in the 1950s. One of the first examples of IT consulting was a feasibility study conducted by Arthur Andersen for General Electric in 1953-1954 (Galal et al., 2012; Bruckenberger et al., 2020).

Many studies identify the characteristics of consultants. Among them, Arnoudse et al. (1989) define consultants in four skill groups. These are technical skills, human relations, business skills and consultancy skills (Maheshwari & Fillion, 2011). Yap et al. (1994) associate three characteristics with the success of consultants. These are consultant experience, consultant ability and consultant effectiveness (Maheshwari & Fillion, 2011).

In this study, two of the multi criteria methods, AHP and TOPSIS, are used for choosing ERP consultant. AHP is utilized to determine the weights of the criteria, and TOPSIS is employed to make the selection among the alternatives. Thus, the company has employed scientific methods in its decision-making process. Implementation details are explained in Chapter 5.

CHAPTER THREE

OVERVIEW OF THE LITERATURE

In this section, the literature on ERP consultancy company or ERP software selection using multi-criteria decision-making methods are overviewed.

For decades, the ERP systems have received substantial attention in the research community (Baker & Haddara, 2019). ERP systems are complex systems, requiring expertise, description, and knowledge in many fields (Demi & Haddara, 2018). ERP projects are considered one of the challenging investment projects for businesses due to their high costs, complexity, and long duration (Plaza, 2016). Consultants are crucial in ERP projects due to their industry knowledge and experience, helping to alleviate the project's burden (Yusuf et al., 2004).

One of the most important criteria in ERP project implementation process is consultant cost (Haddara, 2011). Therefore, selection of ERP consulting firm is important for businesses. Towards the end of the 1800s, there was an increase in research in the areas of consultant selection and the consultant role (McKenna, 1995). Chang et al. (2013) proposed in their study that consultants are needed to provide the expertise that the client lacks (Bruckenberger et al., 2020). According to the research, only 20% of ERP installations are fully successful, and in 20% of them, the project is never implemented (Umble et al., 2003).

A summary of the related literature is presented in the following.

Cheung et al. (2002) conduct a survey to determine the criteria and weights of 7 out of 27 project categories using AHP. In their study, 12 criteria are evaluated. Since each customer's expectations are different, the criteria weights vary from project to project. Based on the selected criteria, a multi-criteria model based on AHP is developed.

Kumar et al. (2003) identify and examine critical points in ERP project management in their study. They also investigate selection criteria for ERP projects. The study is based on data obtained from ERP project managers in 20 institutions in Canada. Their

data collection method is survey. According to the results, the most important three criteria for ERP and consultant selection are identified as functionality, system reliability, and alignment with the current company. Additionally, selection criteria for project managers and success criteria for projects are determined. The criteria for selecting a consulting firm are reputation, ERP experience, process engineering experience, industry-specific knowledge, methodology/approach, cost, partner of choice, and partner of the ERP vendor.

Tsai et al. (2007) examine user satisfaction with service quality in the selection of ERP consultants. The weights of criteria for consultant firm alternatives are determined using AHP. The survey results evaluated user satisfaction with service quality in the selection of ERP consultants in the first part. In the second part, the improvement of consultant selection in ERP projects is evaluated in terms of performance. A study is conducted to select the most suitable one from 5 consulting firms based on the criteria. Additionally, the DeLone and McLean's (1992) information system success model is utilized in the study. According to the results, ERP performance is influenced by consultant fee, consultant's knowledge in the field, and experience in similar sectors in the selection of consultants in ERP projects.

Tsai et al. (2009) examine the effects of ERP consultant selection criteria on ERP project processes and performance in their study. In 2005, 4300 questionnaires were sent to manufacturers, service sector companies, banks, and publicly owned institutions in the top 5000 companies in Taiwan. Among the usable responses, 207 companies are analyzed. Likert Scale is used for the evaluation. ANOVA and regression analysis are applied to examine the impact of the ERP consultant selection on ERP project management, and the impact of the ERP project management on the IS success model. According to the results, domain knowledge of the consultant, ERP project implementation experience, experience in similar sectors and support services are the main criteria, and these criteria increase the success of the ERP project.

Ünal & Güner (2009) examine the ERP consultant selection process for a textile company using the AHP methodology. After consulting with company managers and

experts to select the right consultant, they identify 9 criteria. These are: functionality, implementation approach, support, costs, organizational credibility, experience, flexibility, customer focus, and future strategy. Based on these criteria, three ERP consultants are evaluated, with the cost criterion being kept separate and used in the final stage.

Büyükozkan (2011) begins her study with providing general information about ERP, and then identifies factors affecting the success and failure of ERP. Subsequently, the selection of the ERP consulting firm, which is one of the factors affecting ERP success, is analyzed in detail. Within this analysis, decision support systems that facilitate decision-making are explained in detail. Then, AHP, Fuzzy AHP, ANP, Fuzzy ANP, TOPSIS and Fuzzy TOPSIS methods are explained. Finally, Within the scope of the study, an application is presented in which a machinery manufacturing company that purchases Uygunsoft software chooses one of three consultancy companies. In the application, the most suitable firm is selected using Fuzzy ANP and Fuzzy TOPSIS methods.

Vayvay et al. (2012) handle a real-life problem for ERP consultant selection in Turkey. AHP, fuzzy AHP, and ANP methods are used to solve the problem. After being examined in all three methods, the results are evaluated and their shortcomings are discussed. When the results are compared, it is observed that both AHP and fuzzy AHP yield the same results, but ANP more accurately weighted the sub-criteria as it considered the interactions within the criteria, which the other methods don't. The criteria are determined as cost, work experience, education level, and communication ability, and a decision is made to choose among three consulting firms.

Alhakhani & Alneum (2012) analyze through consultant roles and responsibilities in the consultancy recruitment process. One of the most important factors in the ERP process management is the consultant company and consultant competence. The literature review of consultancy services has been examined and the details of why an ERP consultant is needed are explained in the study. In addition, a case study is conducted in Saudi Arabia.

Martinovic & Delibasic (2014) select the best consultancy firm for the SAP ERP project by using the AHP-IBA model. They propose an extension to the traditional AHP method by applying Interpolative Realization of Boolean algebra (IBA). AHP is employed to determine the criteria weights, and IBA is utilized to model the logical interactions among criteria. They suggest that modeling logical interactions between attributes is more accurate in the decision-making process. An application is made in a company operating in Serbia.

López & Ishizakab (2017) use Group Analytic Hierarchy Process Sorting (GAHPSort) for ERP consultancy selection. A case on cloud-based ERP system selection in a Spanish firm is presented. The company inspects and controls the appliance of a wide variety of standards and industrial regulations. The work is based on two steps: First, the cloud-based ERP vendors are sorted with GAHPSort into two classes: accepted or rejected. Secondly, a single solution is selected with Analytic Network Process (ANP) among accepted vendors.

Avikal et al. (2022) use Fuzzy Analytical Hierarchy Process (F-AHP) and COPRAS-G methods for ERP consultant selection. An application is made in an Indian organization. The COPRAS-G method is used to determine the weights of the F-AHP criteria and the selection of the consultant company. The data is obtained through surveys from the Indian industry. AHP sensitivity analysis is performed in the study to test the accuracy of the results. The results reveal that hybrid solutions provide more effective results in multi-criteria decision-making methods.

There are some studies specifically related to consulting services, apart from the selection of ERP consulting firms. Among these studies, Alhakbani & Mohammed (2012) identify the reasons for hiring and not hiring ERP consultants in Saudi companies. Businesses spend a lot of resources on hiring consultants. The roles, responsibilities, characteristics and job requirements of consultants are investigated in the study. A literature review on consultancy services is also presented. It reveals the reasons for hiring an external ERP consultant, and describes its advantages and

disadvantages. A case study is presented on two companies and the results are evaluated.

Simon et al. (2010) investigate the factors that will lead to ERP consultancy success. As a result of the study, they were grouped under eight main focus areas and a consultancy service model containing best practices was developed. The basis of the study is based on survey data. Key success factors include; adaptability, values, consulting success factors, profitability, project management practices, consulting skills, customer focus, leadership.

Bologa & Lupu (2014) discuss the use of social learning networks to increase efficiency in ERP consulting companies. In the study, ways to accelerate the social information sharing process to increase efficiency in the ERP consultancy sector are investigated. Data are collected during 12 training sessions from 2004 to 2011 in partnership with the Eastern European University Computer Department and IBM. As a result of the study, a learning community is designed that reduced the time required to involve junior ERP consultants in the project, and statistical data is produced that increased productivity by using the ERP consulting company's corporate learning networks. They also discuss the positive effects of social networks that can be established between private companies and universities.

Scholtz et al. (2011) investigate the competencies of South African ERP consultants. After determining ERP consultant competencies through a survey among consultants, deficiencies are identified and a competency set is recommended for South Africa. The technical competencies determined as a result of this study are summarized in Table 3.1.

Table 3.1 Key Competencies for ERP Consultants (Scholtz et al., 2011)

Rank	Competency Category	Competency
1	Interpersonal	Communication skills Time management skills Ability to listen Problem Solving
2	Business	Knowledge of business functions Financial accounting ability
3	Business Process Management (BPM)	Process modelling knowledge
4	ERP implementation and configuration	Implementation knowledge Knowledge of ERP implementation methodologies Interface knowledge General configuration knowledge
5	ERP transactions	The ability to create master data and perform transactions in procurement The ability to create master data and perform transactions in other modules
6	ERP management	Ability to analysis the impact of integrated information on decision making Ability to prepare management reports from ERP
7	General Management	General IT management skills Project management skills
8	Information Systems	Database knowledge and skills Networking knowledge and skills Business analysis skills SQL skills
9	ERP theory and concepts	Knowledge of ERP theory and concepts Knowledge of ERP architectures
10	ERP security	Internet and e-business security knowledge
11	Programming	Knowledge of good programming techniques

CHAPTER FOUR

METHODOLOGY

In this thesis, the problem of ERP consultancy company selection in a manufacturing firm operating in the commercial refrigerator industry in Turkey is handled. Technique for Order Preference by Similarity to Ideal (TOPSIS) is employed in selection of the consultancy firm, and Analytical Hierarchy Process (AHP) is utilized in determining the weights of the criteria.

There exist several methods in the literature available for multi-criteria decision-making. These methods have their own advantages and disadvantages compared to each other. It is important to choose the method that best suits the decision-making problem at hand. In multi-criteria decision-making problems, the criteria are identified as a priority.

Multi-criteria decision-making techniques/methods especially AHP and TOPSIS are applied in various fields. For instance, some of the studies conducted in the field of sustainability. Among them, Daimi & Rebai (2023) examine the transportation sustainability of 29 exhibitions in eight regions in Tunisia. AHP and ANP methods are used to evaluate public transport companies. Ayub et al. (2024) investigate the selection process of sustainable waste treatment in their study. Najm et al. (2024) evaluate four different municipal solid waste treatment processes using AHP. In the study, they investigate three different by-product materials that can serve as alternatives to cement. The approach aims to ensure the sustainability of cement production. TOPSIS method is employed to compare the by-product materials. Menon & Ravi (2022) conducted a study on sustainable supplier selection at an electronics casing company using AHP and TOPSIS methods.

The literature also includes studies conducted in the field of agriculture using AHP and TOPSIS methods. Among them, Veisi et al. (2022) use AHP to select an irrigation system based on its sustainability impact on agriculture. The criteria weights are determined through a survey. In another study, Veisi et al. (2016) employ AHP to

determine the most important criteria for sustainable agriculture in Iran. They gather the opinions of 57 stakeholders and several experts for this purpose. Liu et al. (2019) develop an enhancement in TOPSIS for evaluating water source carrying capacity in China. The study analyzes the data between 2009 and 2018. Liu et al. (2023) use weighted TOPSIS method to assess the resilience of a combined regional agricultural water and soil resource (CRAWSR) system in China.

A few examples of the studies on business analytics are as follows. Lee & Kozar (2006) study the quality factors of a website and their relative importance in selecting a website, as well as the relationship between these factors and financial performance. They use AHP application extended IS success model, a multi-criteria decision-making method. The importance levels of alternative websites are determined in the study. Baghapour et al. (2020) conduct a study on evaluating big data collected to monitor water quality in Iran. They propose a new software-based approach to address uncertainties caused by missing data. The study employs four methods; AHP, fuzzy OWA, TOPSIS and fuzzy TOPSIS. Ilieva et al. (2020) conduct a study in IT sector to determine and prioritize criteria in the recruitment process using AHP and TOPSIS methods. They present a decision-making model for the recruitment process based on the data collected from and analyzed on social networks.

Some studies conducted in the field of construction industry. For instance, Andreolli et al. (2022) aim to design the decision-making processes for strengthening industrial buildings against earthquakes and use AHP. They address not only engineering assessments but also socio-economic issues in their study. Kamaruzzaman et al. (2018) contribute to efforts by the Malaysian government to renovate existing buildings, reduce energy consumption and decrease CO₂ emission intensity. The goal is to strengthen 100 government buildings. AHP method is used to determine and prioritize the evaluation criteria. Marzouk et al. (2023) conduct a study to evaluate strategies for strengthening mosque buildings. The operational performance of mosque buildings was assessed using TOPSIS method, based on five main criteria. Amorocho & Hartmann (2022) use pairwise comparison and TOPSIS method for the renovation of residential buildings across Europe. Two studies are conducted based on a five-story

building in Spain in the case analysis. Alternatives are ranked and weighted to obtain a common view on the renovation of buildings.

There exist studies in the field of health sector using AHP and TOPSIS. Fatima et al. (2023) conduct a study by using AHP and TOPSIS methods to identify and prioritize the key stress factors among doctors working in the private and government hospitals in India during COVID-19. They weight the most common stress factors through a survey and compare and prioritize stress factors using TOPSIS method. Pecchia et al. (2013) contribute to improving communication between horizontal and vertical positions at one of the largest state hospitals in Italy. They use AHP to determine and prioritize the needs of units, aiming to achieve effective communication.

4.1 AHP

AHP is an easy way of using a combination of qualitative and quantitative analysis methods to make decisions about more obscure, fuzzy, or complex decision-making problems (Lin et al., 2024; Sayed & Sinna, 2021). AHP is advantageous as it allows decision-makers to quantify their experiences and evaluations, prioritize these data, and compare criteria accurately (Lin et al., 2024; Serag & Al-Tony, 2013). The scheme of the decision-making process is presented in Figure 4.1 (Zografos, 2005).

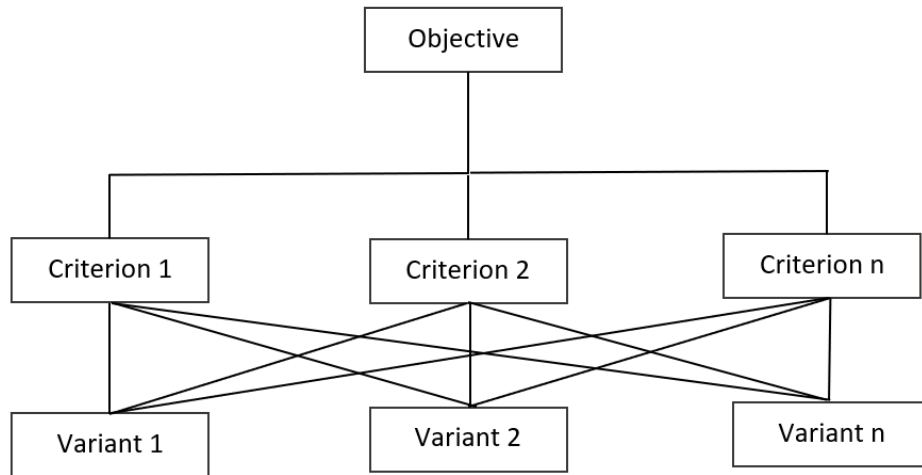


Figure 4.1 Decision making process of AHP

Developed by Thomas L. Saaty in the late 1970s, AHP is a decision-making method used to solve complex problems involving multiple criteria. The method is explained in the following steps (Caputo et al., 2013; Saaty, 1990).

- Step 1. Problem is defined and information types are determined.
- Step 2. A hierarchical structure is established, with objectives at the top. Below, fundamental and sub-criteria are listed. At the bottom of the hierarchy, alternatives are included.
- Step 3. The relative importance among n criteria is defined in the pairwise comparison matrix. This results in an n -by- n matrix $A(\mathbf{a}_{ij})$ with $(i, j = 1, 2, \dots, n)$.

$$A = \begin{bmatrix} \mathbf{a}_{11} & \cdots & \mathbf{a}_{1n} \\ \vdots & \ddots & \vdots \\ \mathbf{a}_{n1} & \cdots & \mathbf{a}_{nn} \end{bmatrix} \quad (4.1)$$

where $\mathbf{a}_{ij} > 0$, $\mathbf{a}_{ij} = 1/\mathbf{a}_{ji}$, $\mathbf{a}_{ii} = 1$, and \mathbf{a}_{ij} is the user-defined rating of relative importance of criterion i respect to criterion j . In case criteria i and j are of equal relative importance then $\mathbf{a}_{ij} = \mathbf{a}_{ji} = 1$.

In the AHP method, ranking is done according to the Saaty Scale. Thus, scoring is done using the numerical data (see Table 4.1).

Table 4.1 Saaty's Evaluation Scale

Importance	Definition	Explanation
1	Equal importance	Both elements have the same significance
3	Moderate importance	Experience and judgment slightly favour one element over another
5	Strong importance	Experience and judgment significantly favour one element over another
7	Very strong importance	The dominance of one element is confirmed in practice
9	Extreme importance	The dominance of the highest degree
2, 4, 6, 8	Intermediate values between adjacent scale values	Need a compromise or further division

- Step 4. The numerical weights of matrix A for criteria C_1, C_2, \dots, C_n are calculated, resulting in the weight vector.

$$W = [w_1, w_2, \dots, w_n]^T \quad (4.2)$$

The sum of each row of the normalized matrix is divided by the size of the matrix to obtain the average. These values are the importance weights for each criterion. These weights form the weight vector.

$$w_i = \frac{1}{n} \sum_j \left(\frac{a_{ij}}{\sum_i a_{ij}} \right) \quad (4.3)$$

- Step 5. After making pairwise comparisons and determining their priorities, the consistency of the comparison matrices is calculated. To determine whether matrix A is consistent, the Consistency Index (CI) is calculated.

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (4.4)$$

where λ_{max} is the maximum eigenvalue.

$$\lambda_{max} = \frac{1}{n} \sum_{i=1}^n \frac{(Aw_i)}{w_i} \quad (4.5)$$

The value of CI is compared to a Random Index (RI) through the Consistency Ratio $CR = CI/RI$. To calculate consistency, the value of the Random Index (RI) needs to be known. For instance, in case $n = 2$ then $RI = 0$, for $n = 6$ then $RI = 1.25$, for $n = 7$ then $RI = 1.35$, for $n = 15$ then $RI = 1.58$. In case $CR < 0.1$, the degree of consistency is satisfactory.

- Step 6. A pairwise comparison matrix is created for the criteria, and the priority vector of decision alternatives is calculated. This priority vector can also be defined as the weight vector for the criteria.
- Step 7. A normalized relative rating b_{ij} is computed for each i^{th} candidate alternative respect to any judgement criterion C_j , in comparison with the other alternatives.
- Step 8. R_i ranking score calculation for the i^{th} candidate alternative is as follows.

$$R_i = \sum_j b_{ij}w_j \quad (4.6)$$

The application of AHP to the criteria for this article will be explained in Chapter 5.

4.2 TOPSIS

TOPSIS is one of the useful and powerful multi attribute decision making techniques to manage real-world problems (Ertuğrul & Karakaşoğlu, 2009; Yoon & Hwang, 1985). TOPSIS was proposed by Hwang and Yoon (1981) (Ertuğrul & Karakaşoğlu, 2009; Yoon & Hwang, 1985). According to this technique, the best alternative would be the one that is the nearest to the positive ideal solution and the

farthest from the negative ideal solution (Ertuğrul & Karakaşoğlu, 2009; Yoon & Hwang, 1985).

The steps of the TOPSIS method are summarized in the following (Ertuğrul & Karakaşoğlu, 2009).

Step 1. Normalization of the decision matrix:

$$r_{ij} = \frac{w_{ij}}{\sqrt{\sum_{j=1}^J w_{ij}^2}} \quad i = 1, 2, 3, \dots, n \quad (4.7)$$

Step 2. Creation of the weighted normalized matrix:

$$v_{ij} = w_i * r_{ij} \quad j = 1, 2, 3, \dots, J, i = 1, 2, 3, \dots, n \quad (4.8)$$

Step 3. Determination of Positive Ideal solution (PIS) and Negative Ideal solution (NIS) values:

$$A^* = \{v_1^*, v_2^* \dots, v_n^*\} \quad \text{maximum values} \quad (4.9)$$

$$A^- = \{v_1^-, v_2^- \dots, v_n^-\} \quad \text{minimum value} \quad (4.10)$$

Step 4. Determination of distance values to Positive Ideal and Negative Ideal points:

$$d_i^* = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^*)^2} \quad , j = 1, 2, \dots, J \quad (4.11)$$

$$d_i^- = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^-)^2} \quad , j = 1, 2, \dots, J \quad (4.12)$$

Step 5. Calculating the closeness of alternatives according to the Positive Ideal Solution:

$$CC_i = \frac{d_i^-}{d_i^+ + d_i^-}, i=1,2,\dots, J \quad (4.13)$$

Step 6. The CC_i values are compared to rank the alternatives.



CHAPTER FIVE

APPLICATION

In this study, critical characters were determined for the selection of a consultant company in a refrigeration company in Türkiye that will switch to the SAP program. In this study, the problem of ERP consultancy company selection in a manufacturing firm operating in Turkey is handled. TOPSIS method is employed in selection of the consultancy firm, and AHP is utilized in determining the weights of the criteria.

5.1 Company Profile

The company offers comprehensive range of solutions in the global commercial refrigeration market, continuing to grow as one of the largest companies in the industry with a diverse product and service portfolio and extensive expertise. Serving leading global and regional brands in the beverage, ice cream, and food service/retail sectors, the company offers many products with optional or custom manufacturing features designed to meet different customer needs and market requirements globally.

In addition to a wide range of cooling products, the company provides complete and customized sales tools for sales points to support customers' business strategies. The concept supports its customers from product development and manufacturing to after-sales support.

The production facility in Turkey has a capacity of 450,000 units/year, supplying 165 varieties of products to more than 700 customers in 78 countries and is among the top 500 companies in Turkey. It has a strong reputation as a reliable and innovative supplier of refrigerators and freezers for over 50 years. Its annual production capacity is 550,000 units.

The company aims to transition from the current ERP program, Netsis to SAP S/4 HANA as part of its digital transformation project. In this way, it will progress more quickly towards its goal of becoming a leading company in target markets in Turkey

and around the world, characterized by continuous growth and the highest level of satisfaction for its customers, employees, and shareholders. It will achieve business excellence by creating value for society and the environment.

5.2 Criteria Definitions

In this study, 7 criteria are used for the evaluation. These are; (C1) reputation, (C2) ERP implementation experience in a similar industry, (C3) cost, (C4) ERP project experience, (C5) support services, (C6) implementation time and (C7) environmental sustainability.

- Reputation

Reputation is the perception of a company by its customers, employees, investors, suppliers and society at large. A good company reputation provides many benefits for the success of the company. Especially in the service sector, the company's reputation in its sector is very important. Kumar et al. (2003) and Tsai et al. (2007) specify that the most important criteria in selecting consultants for ERP projects are; reputation, ERP project experience, partner of the ERP vendor and cost. Avikal et al. (2022) indicate that reputation is the most important criteria for the consultant selection.

In this study, a scale between 1 and 10 is used for the reputation criterion. If the consultancy company's references are among the top 500 companies in Turkey, its reputation is evaluated to be higher. Since the number of references in the top 500 list of Turkey's most prestigious ERP consultancy companies does not exceed 20, the reputation scale was created as in the following table (Capital, 2022).

Table 5.1 The scale for the reputation

<i>Number of references in top 500 companies</i>	<i>Scale Score</i>
1	1
2	2
3-4	3
5-6	4
7-8	5
9-10	6
11-12	7
13-14	8
15-20	9
Greater than 20	10

- Similar sector experience

Similar sector experience is a very useful criterion when choosing a consulting company. Even though the company is successful in its business, sector knowledge and experience are very important, especially when choosing ERP system. It ensures that processes are constructed correctly based on past experiences..

A scale between 1 and 5 is used for the “similar sector experience” criterion. There are nearly 15 companies using SAP in the air conditioning sector in Turkey. Since this number is quite limited, not only companies receiving digital transformation project support but also companies receiving process support or support services are considered as references. The scale for the “Similar sector experience” is reported in the following.

Table 5.2 The scale for the similar sector experience

<i>Number of reference companies in the air conditioning sector</i>	<i>Scale Score</i>
1	1
2	2
3	3
4	4
Greater than 5	5

- Cost

For companies, cost is of great importance in terms of the profitability, competitiveness and long-term environmental sustainability of the business. The company attaches great importance to costs, not only in choosing a consultancy firm but in every aspect, and aims to provide maximum benefit with minimum cost. If the cost breakdown is to be made for ERP consultant selection; Transportation and accommodation expenses of the consultants, ERP software purchase fee and the new labor cost needed by the company for the project must be included. ERP applications are difficult and costly projects for companies. Because it touches on behavioral, social and technical issues (Bruckenberg et al., 2020).

The cost covers the implementation of the project and a 1-year support period. For confidentiality reasons, costs are not directly shared by the company. Therefore, cost scoring is calculated using a \$5000 multiplier.

- ERP project experience

ERP project experience is important when choosing a consultancy firm. It is thought that as the number of completed projects increases, the experience gained also increases. A useful inference will be obtained with the assumption that consultant experience increases in proportion to the number of projects.

A scale between 1 and 10 is used for the “ERP project experience” criterion. Scoring is done according to the number of S/4HANA projects that went live. S/4HANA has been on the market for about 10 years. The scale is reported in the following table.

Table 5.3 The scale for the ERP project experience

<i>S/4HANA project that has been migrated live</i>	<i>Scale Score</i>
1-10	1
11-30	2
31-60	3
61-90	4
91-120	5
121-150	6
151-200	7
201-250	8
251-300	9
Greater than 300	10

- Support service

One of the most important issues for the service sector is support service. It is necessary to get good support so that the process can continue in the best way after the end of the project. While the live transition phase of the project is important, support services are also an important criterion that should not be ignored.

A scale between 1 and 10 is used for the “support service” criterion. The calculation has been based on the number of companies they have successfully transitioned to live operation within the scope of the S/4HANA project, and for which they have been providing partial or regular support for over a year. The scale is presented in the following table.

Table 5.4 The scale for the support service

<i>The ratio of companies continued to be supported</i>	<i>Scale Score</i>
%1-%5	1
%6-%10	2
%11-%20	3
%21-%30	4
%31-%40	5
%41-%50	6
%51-%60	7
%61-%70	8
%71-%90	9
Greater than %90	10

- Implementation time

Every project has a start and end date. Since there will be a radical change in ERP projects and all processes will change, it is very important to meet the deadlines. The processes that will put the project at risk must be determined very well and progressed in accordance with the deadline.

A scale between 1 and 10 is used for the “implementation time” criterion. In ERP projects, failure to adhere to deadlines can sometimes result in project delays or even failure. This study evaluates consulting firms based on the failure rates in meeting the deadlines of the projects they carried out. This information is obtained from relevant stakeholders in the industry.

Table 5.5 The scale for the implementation time

<i>Failure rate</i>	<i>Scale Score</i>
Less than %1	10
%1-%10	9
%11-%15	8
%16-%20	7
%21-%25	6
%26-%30	5
%31-%40	4
%41-%60	3
%61-%80	2
Greater than %80	1

- Environmental sustainability

Environmental sustainability is one of the most important issues of today, and a lot of research has been conducted on this subject in recent years. In this study, it was seen that the corporate environmental sustainability studies of consulting companies are of great importance. Corporate environmental sustainability is an approach where companies integrate economic success with social responsibility and environmental protection to create long-term value. We can include climate change, circular economy, social responsibility, water and waste management in the environmental sustainability studies of ERP consultancy companies.

A scale between 1 and 10 is used for “the environmental sustainability” criterion. The assessment is carried out as follows: 1 point for the in-house training sessions, 2 points for the environmental activities, 3 points for the certifications obtained by the company related to environmental sustainability, and 4 points for publishing corporate sustainability reports. Total points are then calculated accordingly. The scale is reported in the following table.

Table 5.6 The scale for the environmental sustainability

<i>Total Point</i>	<i>Score Scale</i>
1-2	1
3-4	2
5-7	3
8-10	4
11-13	5
14-16	6
17-19	7
20-25	8
26-30	9
Greater than 30	10

5.3 Application of AHP

For the AHP Method applied at the decision stage of the Project, 7 basic criteria were determined and evaluated according to the Saaty's Importance Scale by considering the interviews with candidate consultant companies, references and the information obtained throughout the process.

It is among the primary expectations of companies that the consultancy firm has the following basic features (see Table 5.1).

Table 5.7 Selection criteria

	Criteria	References
C1	Reputation	Kumar et al. (2003)
C2	ERP implementation experience in similar industry	Tsai et al. (2007)
C3	Cost	Hecht (1997)
C4	ERP project experience	Kumar et al. (2003) and Tsai et al. (2007)
C5	Support services	Hecht (1997)
C6	Implementation time	Gürbüz, Alptekin (2012)
C7	Environmental sustainability	

As the ERP software product market develops day by day, the number of companies providing consultancy services is also increasing. One of the most important elements

of success in ERP system applications is the selection of the appropriate consultancy firm. Choosing an inappropriate consultancy firm will result in loss of efficiency and time, as well as increased costs.

- *Pair-wise comparison matrix*

After deciding to apply AHP in the consultant company selection process, the 7 factors with the highest priority level were determined in the prioritization meeting held under the leadership of the project manager, and their importance levels were compared with each other using the scoring table suggested by Saaty (1980). Importance levels were determined by surveying the IT senior manager, project manager, and 10 key users.

The Pair-wise comparison matrix formed as a result of the evaluation and scoring of the 7 factors determined at the prioritization meeting is presented in Table 5.2.

Table 5.8 The Pair-wise Comparison Matrix

	C1	C2	C3	C4	C5	C6	C7
C1	1	1/2	1/4	1/2	1/5	6	6
C2	2	1	1/3	1/2	1/4	5	6
C3	4	3	1	5	4	6	8
C4	2	2	1/5	1	1/3	5	8
C5	5	4	1/4	3	1	6	8
C6	1/6	1/5	1/6	1/5	1/6	1	2
C7	1/6	1/6	1/8	1/8	1/8	1/2	1

- *The Normalized Matrix*

Formation of a new matrix by dividing each cell value by sum of the columns is called normalization (see Table 5.3).

Table 5.9 Normalized matrix comparisons criteria

	C1	C2	C3	C4	C5	C6	C7
C1	0.07	0.05	0.11	0.05	0.03	0.20	0.15
C2	0.14	0.09	0.14	0.05	0.04	0.17	0.15
C3	0.28	0.28	0.43	0.48	0.66	0.20	0.21
C4	0.14	0.18	0.09	0.10	0.05	0.17	0.21
C5	0.35	0.37	0.11	0.29	0.16	0.20	0.21
C6	0.01	0.02	0.07	0.02	0.03	0.03	0.05
C7	0.01	0.02	0.05	0.01	0.02	0.02	0.03

- *Eigenvector*

The eigenvector for the criteria is reported in Table 5.4.

Table 5.10 The Eigenvector

<i>Criteria</i>	<i>The Eigenvector</i>
Reputation	0.095
ERP implementation experience in similar industry	0.113
Cost	0.362
ERP project experience	0.134
Support services	0.241
Implementation time	0.033
Environmental sustainability	0.022

- *Eigenvalue Calculation*

The eigenvalues calculated for each criterion are presented in Table 5.5, and illustrated in Figure 5.1.

Table 5.11 The Eigenvalues

<i>Criteria</i>	<i>Eigenvalue</i>
<i>Reputation</i>	0.69
ERP implementation experience in similar industry	0.85
Cost	3.09
ERP project experience	1.05
Support services	2.03
Implementation time	0.24
Environmental sustainability	0.17

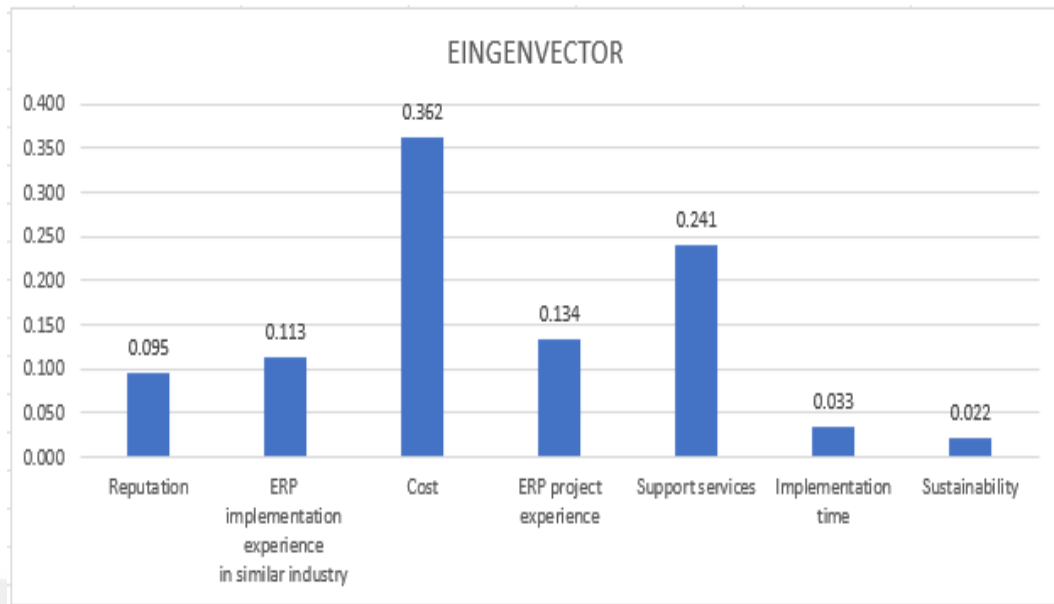


Figure 5.1 The criteria weights

- *Largest Eigenvalue Calculation*

It is calculated by dividing the eigenvalue by the eigenvector on a criterion basis and summing the results.

$$\lambda_{\max} = 7.77$$

- *Consistency Index Calculation*

$$CI = (\lambda_{\max} - n) / (n-1) = 0.13$$

- *Consistency Ratio Calculation*

$$CR = CI/RI = 0.095$$

We observe that the consistency ratio value is less than 0.1 indicating that the scoring of the criteria is consistent.

According to the results, the criteria weights range widely. The highest weight is for cost, followed by service quality. Criteria of moderate importance include

reputation, ERP implementation experience in a similar industry, and ERP project experience. The criteria with the lowest weights are implementation time and environmental sustainability.

5.4 Application of TOPSIS Method

After determining the weights and scores using AHP, the TOPSIS method is employed to evaluate five ERP consulting firms in this study by following the steps.

- *The Decision Matrix*

The Decision Matrix presented in Table 5.6.

Table 5.12 The Decision Matrix

	Benefit	Benefit	Cost	Benefit	Benefit	Benefit	Benefit
Weights	0.095	0.113	0.362	0.134	0.241	0.033	0.022
Alternatives	C1	C2	C3	C4	C5	C6	C7
A	9	4	4900	8	8	9	6
B	6	1	3500	2	9	8	4
C	7	3	4700	7	7	9	7
D	9	2	4200	4	8	9	5
E	6	1	3000	3	5	8	3

- *The Normalized Matrix*

The Normalized Matrix is reported in Table 5.7.

Table 5.13 The Normalized Matrix

	Benefit	Benefit	Cost	Benefit	Benefit	Benefit	Benefit
Weights	0.095	0.113	0.362	0.134	0.241	0.033	0.022
Alternatives	C1	C2	C3	C4	C5	C6	C7
A	0.535	0.718	0.532	0.671	0.476	0.467	0.516
B	0.357	0.180	0.380	0.168	0.535	0.415	0.344
C	0.416	0.539	0.510	0.587	0.416	0.467	0.602
D	0.535	0.359	0.456	0.336	0.476	0.467	0.430
E	0.357	0.180	0.325	0.252	0.297	0.415	0.258

- *The Weighted Normalized Matrix*

Weighted normalized matrix is presented in Table 5.8.

Table 5.14 The Weighted Normalized Matrix

	Benefit	Benefit	Cost	Benefit	Benefit	Benefit	Benefit
Weights	0.095	0.113	0.362	0.134	0.241	0.033	0.022
Alternatives	C1	C2	C3	C4	C5	C6	C7
A	0.051	0.081	0.193	0.090	0.115	0.016	0.012
B	0.034	0.020	0.138	0.022	0.129	0.014	0.008
C	0.039	0.061	0.185	0.079	0.100	0.016	0.013
D	0.051	0.040	0.165	0.045	0.115	0.016	0.010
E	0.034	0.020	0.118	0.034	0.072	0.014	0.006

- *Positive and Negative Ideal Solutions (PIS/ NIS)*

Positive and negative ideal solutions are reported in Table 5.9.

Table 5.15 Positive and Negative Ideal Solutions

	Benefit	Benefit	Cost	Benefit	Benefit	Benefit	Benefit
Weights	0.095	0.113	0.362	0.134	0.241	0.033	0.022
Alternatives	C1	C2	C3	C4	C5	C6	C7
A	0.051	0.081	0.193	0.090	0.115	0.016	0.012
B	0.034	0.020	0.138	0.022	0.129	0.014	0.008
C	0.039	0.061	0.185	0.079	0.100	0.016	0.013
D	0.051	0.040	0.165	0.045	0.115	0.016	0.010
E	0.034	0.020	0.118	0.034	0.072	0.014	0.006
A+	0.051	0.081	0.118	0.090	0.129	0.016	0.013
A-	0.034	0.020	0.193	0.022	0.072	0.014	0.006

- *Distance from Each Alternative to the PIS and NIS*

Distance from Each Alternative to the PIS and NIS are reported in Table 5.10.

Table 5.16 Distance from Each Alternative to the PIS and NIS

	Benefit	Benefit	Cost	Benefit	Benefit	Benefit	Benefit		
Weights	0.095	0.113	0.362	0.134	0.241	0.033	0.022		
Alternatives	C1	C2	C3	C4	C5	C6	C7	Si+	Si-
A	0.051	0.081	0.193	0.090	0.115	0.016	0.012	0.076	0.102
B	0.034	0.020	0.138	0.022	0.129	0.014	0.008	0.094	0.079
C	0.039	0.061	0.185	0.079	0.100	0.016	0.013	0.077	0.076
D	0.051	0.040	0.165	0.045	0.115	0.016	0.010	0.078	0.062
E	0.034	0.020	0.118	0.034	0.072	0.014	0.006	0.102	0.076
A+	0.051	0.081	0.118	0.090	0.129	0.016	0.013		
A-	0.034	0.020	0.193	0.022	0.072	0.014	0.006		

- *Closeness of the Alternatives to the Ideal Solution*

Closeness of the alternatives to the Ideal Solution are reported in Table 5.11.

Table 5.17 The Best Alternative

Alternatives	S^*	S^-	C_i^*	Ranking
A	0.076	0.102	0.573	1
B	0.094	0.079	0.457	3
C	0.077	0.076	0.496	2
D	0.078	0.062	0.442	4
E	0.102	0.076	0.425	5

The alternative with the largest C_i^* is the best one. According to the numerical results, the consulting firms should be preferred in the following order: A, C, B, D, and E.

CHAPTER SIX

CONCLUSIONS

Nowadays, with the increasing importance of ERP software, ERP projects have gained more importance. With a successful ERP transition, companies can reduce costs and increase efficiency. First of all, the factors affecting the success of ERP projects should be determined in the implementation process. One of the most important factors is the selection of consultancy company. After choosing the right ERP program, choosing the proper consultancy company is critical.

In this study, an ERP consultancy company is selected for a refrigerator manufacturing company operating in Turkey. Firstly, the criteria are determined and weighted by using AHP. Importance levels of the criteria are evaluated by the project manager and key users. Afterwards, alternative consultancy companies are ranked using TOPSIS method. Consequently, the most suitable consultancy firm that meets the company's expectations is selected. According to the findings, factors that directly affect the cost are generally very important for companies. However, different from the other studies in the relevant field, environmental sustainability criterion is used in this study in selection of ERP consultancy companies and it is emphasized that companies should increase their awareness of environmental sustainability.

In future studies, it may be possible to take different criteria into account when choosing an ERP consultancy company, along with the innovations brought by the globalizing world.

REFERENCES

- Alhakbani, N. A., & Alnuem, M. A. (2012). Consultancy services to ERP systems: case studies from Saudi Arabia. *Journal of Theoretical and Applied Information Technology*, 37(1), 116-124
- Amorocho, J. A. P., & Hartmann, T. (2022). A multi-criteria decision-making framework for residential building renovation using pairwise comparison and TOPSIS methods. *Journal of Building Engineering*, 53, 104596.
- Andreolli, F., Bragolusi, P., D'Alpaos, C., Faleschini, F., & Zanini, M. A. (2022). An AHP model for multiple-criteria prioritization of seismic retrofit solutions in gravity-designed industrial buildings. *Journal of Building Engineering*, 45(3-4), 103493.
- Arnouldse, D. M., Ouellette, L.P., & Whalen, J. D. (1989). *Consulting Skills for Information Professionals*. Homewood, IL: Dow Jones-Irwin.
- Avikal, S., Nigam, M., & Ram, M. (2022). A hybrid multi criteria decision making approach for consultant selection problem in ERP project. *International Journal of Systems Assurance Engineering and Management*, 13(2), 941-950.
- Ayub, Y., Moktadir, Md. A., & Ren, J. (2024). Sustainable waste valorization process selection through AHP and advanced Interval Valued Fermatean Fuzzy with integrated CODAS. *Process Safety and Environmental Protection*, 185, 408-422.
- Baghapour, M. A., Shooshtarian, M. R., & Zarghami, M. (2020). Process Mining Approach of a New Water Quality Index for Long-Term Assessment under Uncertainty Using Consensus-Based Fuzzy Decision Support System. *Water Resources Management*, 34, 1155–1172.

Baker, R. C., & Haddara, M. (2019). *Exploring Consultants' Role in ERP Systems Implementations*, 12th IADIS International Conference Information Systems, Oslo, Norway.

Bologa, R., & Lupu, A. R. (2014). Organizational learning networks that can increase the productivity of IT consulting companies. A case study for ERP consultants. *Expert Systems with Applications*, 41, 126-136.

Büyüközkan, M. (2011). *ERP danışman firma seçiminde fuzzy ANP ve fuzzy TOPSIS yöntemlerinin karşılaştırılması*. Phd Thesis, Yıldız Teknik University, İstanbul.

Capital 500–Türkiye'nin en büyük 500 şirketi, 2022, from <https://www.capital.com.tr/listeler/capital-500>.

Caputo, A. C., Pelagagge, P. M., & Salini, P. (2013). AHP-based methodology for selecting safety devices of industrial machinery. *Safety Science*, 53, 202-218.

Chang, J. Y. T., Wang, E. T. G., Jiang, J. J. & Klein, G. (2013). Controlling ERP consultants: Client and provider practices. *The Journal of Systems and Software*, 86, 1453– 1461.

Cheung, F. K. T., Kuen, J. L. F., Skitmore, M. (2002). Multi-criteria evaluation model for the selection of architectural consultants. *Construction Management and Economics*, 20, 569–580.

Daimi, S., & Rebai, S. (2023). Sustainability performance assessment of Tunisian public transport companies: AHP and ANP approaches. *Socio-Economic Planning Sciences*, 89, 101680.

Delone, W. H., & McLean, E.R. (1992). Information Systems Success: the quest for the dependent variable. *Information Systems Research*, 3(4), 60-95.

- Demi, S., & Haddara, M. (2018). Do Cloud ERP Systems Retire? An ERP Lifecycle Perspective. *Procedia Computer Science*, 138, 587-594.
- El Sayed, M. A., & Abo-Sinna, M. A. (2021). A novel approach for fully intuitionistic fuzzy multi-objective fractional transportation problem. *Alexandria Engineering Journal*, 60, 1447-1463.
- Ertuğrul, İ., & Karakaşoğlu, N. (2009). Performance evaluation of Turkish cement firms with fuzzy analytic hierarchy process and TOPSIS methods. *Expert Systems with Applications*, 36, 702-715.
- Fatima, M., Sherwani, N.U.K., & Singh, V. (2023). Comparative analysis among doctors working in private and government hospitals in identifying and prioritizing essential stress factors during COVID-19- an AHP-TOPSIS approach. *Intelligent Pharmacy*, 1, 17-25.
- Galal, K., Richter, A., & Wendlandt, V. (2012). IT consulting and outsourcing firms: Evolution, business models and future prospects. *The Oxford handbook of management consulting*. England: Oxford University Press.
- Gürbüz, T., Alptekin, S. E., & Alptekin, G. I. (2012). A hybrid MCDM methodology for ERP selection problem with interacting criteria. *Decision Support Systems*, 54, 206-214.
- Haddara, M. (2011). *ERP adoption cost factors in SMEs*. In European and Mediterranean Conference on Information Systems (EMCIS 2011), Athens, Greece.
- Hecht, B. (1997). Choose the right ERP software. *Datamation*, 43(3), 56-58.
- Horasan, M. B., & Kilic, H. S. (2022). A multi-objective decision-making model for renewable energy planning: The case of Turkey. *Renewable Energy*, 193, 484–504.

- Hwang, C. L., & Yoon, K. (1981). *Multiple attribute decision making methods and applications*. Newyork; Springer.
- Ilieva, G., Yankova, T., Hadjieva, V., Doneva, R., & Totkov, G. (2020). Cloud service selection as a fuzzy multi-criteria problem. *TEM Journal*, 9(2), 484-495.
- Jæger, B., Bruckenberg, S. A., & Mishra, A. (2020). Critical Success Factors for ERP Consultancies. *Scandinavian Journal of Information Systems*, 32(2), 169-202.
- Kamaruzzaman, S. N., Lou, E. C. W., Wong, P. F., Wood, R., & Che-Ani, A. I. (2018). Developing weighting system for refurbishment building assessment scheme in Malaysia through analytic hierarchy process (AHP) approach. *Energy Policy*, 112, 280-290.
- Kumar, V., Maheshwari, B., & Kumar, U. (2003). An investigation of critical management issues in ERP implementation: empirical evidence from Canadian organizations. *Technovation*, 23, 793–807.
- Lin, Q., Zhang, K., Huang, D., Grifoll, M., & Feng, H. (2024). Evaluating the impact of Trans-Asian railway on logistics mode selection between Thailand and China: An AHP-TOPSIS approach. *Alexandria Engineering Journal*, 98, 147–158.
- Lee, Y., & Kozar, K. A. (2006). Investigating the effect of website quality on e-business success: An analytic hierarchy process (AHP) approach. *Decision Support Systems*, 42, 1383–1401.
- Liu D., Qi, X., Fu, Q., Li M., Zhu W., Zhang L., Faiz M., Khan M. I., Li T., & Cui S. (2019). A resilience evaluation method for a combined regional agricultural water and soil resource system based on Weighted Mahalanobis distance and a Gray-TOPSIS model. *Journal of Cleaner Production*, 229, 667-679.

- Lv, B., Liu, C., Li, T., Meng, F., Fu, Q., Ji, Y., & Hou, R. (2023). Evaluation of the water resource carrying capacity in Heilongjiang, eastern China, based on the improved TOPSIS model. *Ecological Indicators*, 150, 110208.
- López, C., & Ishizakab, A. (2017). GAHPSort: A new group multi-criteria decision method for sorting a large number of the cloud-based ERP solutions. *Computers in Industry*, 92-93, 12-24.
- Mabert, V. A., Soni., A., & Venkataramanan, M. A. (2003). The impact of organization size on enterprise resource planning (ERP) implementations in the US manufacturing sector. *Omega*, 31, 235-246.
- May, J., Dhillon, G., & Caldeira, M. (2013). *Defining value-based objectives for ERP systems planning. Decision Support Systems*, 55, 98-109.
- McKenna, C. D. (1995). The origins of modern management consulting. *Business and Economic History*, 24(1), 51-58.
- Maheshwari, S. K., & Fillion, G. (2011). Academy Of Information And Management Sciences Journal. *DreamCatchers Group, LLC*, 15.
- Menon, R. R., & Ravi, V. (2022). Using AHP-TOPSIS methodologies in the selection of sustainable suppliers in an electronics supply chain. *Cleaner Materials*, 5, 100130.
- Martinovic, N., & Delibasic, B. (2014). Selection of the best consultant for SAP ERP project using combined AHP-IBA approach. *Yugoslav Journal of Operations Research*, 24(3), 383–398.
- Marzouk, M., El-Maraghy, M., & Metawie, M. (2023). Assessing retrofit strategies for mosque buildings using TOPSIS. *Energy Reports*, 9, 1397–1414.

- Najm, O. F., Mohamed, O. A., & Hijah, E. S. (2024). Efficiency of self-compacting concrete made with variable sustainable cementitious materials: A TOPSIS algorithm approach. *Materials Today: Proceedings*.
- Olson, D. (2014). *Managerial Issues of Enterprise Resource Planning Systems* (1th ed.). Boston: McGraw-Hill International.
- Pecchia, L., Melillo, P., Marzano, A., Delfino, R., Vanzanella, C., Viggiani, V., & Triassi, M. (2013). Interactive management control via analytic hierarchy process (AHP). An empirical study in a public university hospital. *IFAC Proceedings Volumes*, 46, 555-560.
- Ren, P., Xu, Z., & Gou, X. (2016). Pythagorean fuzzy TODIM approach to multi-criteria decision making. *Applied Soft Computing*, 42, 246–259.
- Pınar, İ. & Erdem, K. S. (2001). *Kurumsal Kaynak Planlaması (ERP) Kullanıcısı İşletmelerin Memnuniyetlerini Ölçmeye Yönelik Bir Araştırma*, 31, 71-95.
- Plaza, M. (2016). Balancing the costs of human resources on an ERP project. *Omega*, 59, 171–183.
- Saaty, T. L. (1977). A scaling method for priorities in hierarchical structures. *Journal of Mathematical Psychology*, 15, 234-281.
- Saaty, T. L. (1980). *The Analytic Hierarchy Process*. McGraw-Hill International, New York, U.S.A.
- Saaty, T. L. (1990). How to make a decision: the analytic Hierarchy process. *European Journal of Operational Research*, 48, 9-26.
- Scholtz, B., Cilliers, C., & Calitz, A.P. (2011). *Critical Competencies for South African ERP Consultants*. Proceedings the International Business Conference (IBC 2011), 70–93.

- Serag, M. S., & Al-Tony, F. E. (2013). Modeling international freight transport through the ports and lands of Arab countries. *Alexandria Engineering Journal*, 52, 433-445.
- Simon A., Schoeman, P., & Sohal, A. S. (2010). Prioritised best practices in a ratified consulting services maturity model for ERP consulting. *Journal of Enterprise Information Management*, 23(1), 100–124.
- Thong, J. Y. L., Yap, C. S., & Raman, K. S. (1994). Engagement of External Expertise in Information Systems Implementation. *Journal of Management Information Systems*, 11, 209- 231.
- Tsai, W. H., Lin, T. W., Chen, S. P., & Hung, S. J. (2007). Users' service quality satisfaction and performance improvement of ERP consultants selections. *International Journal of Business and Systems Research*, 1, 280–301.
- Tsai, W. H., Shen, Y. S., & Lee, P. L. (2009). *An Empirical Investigation of the Impacts of ERP Consultant Selections and Project Management on ERP IS Success Assessment*. 2009 IEEE International Conference on Industrial Engineering and Engineering Management.
- Umble, E., Haft, R.R., & Umble, M. M. (2003). Enterprise Resource Planning: Implementation Procedures and Critical Success Factors. *European Journal of Operational Research*, 146, 241-257.
- Ünal, C., & Güner, M. G. (2009). Selection of ERP Suppliers using AHP tools in the clothing industry. *International Journal of Clothing Science and Technology*, 21, 239-251.
- Vayvay, O., Ozcan, Y., & Cruz-Cunha, M. M. (2012). ERP consultant selection problem using AHP, fuzzy AHP and ANP: A case study in Turkey. *Journal of Business Management and Economics*, 3(3), 106-117.

- Veisi, H., Liaghati, H., & Alipour A. (2016). Developing an ethics-based approach to indicators of sustainable agriculture using analytic hierarchy process (AHP). *Ecological Indicators*, 60, 644-654.
- Veisi H., Dihimfard, R., Shahmohammadi, A., & Hydarzadeh, Y. (2022). Application of the analytic hierarchy process (AHP) in a multi-criteria selection of agricultural irrigation systems. *Agricultural Water Management*, 267, 107619.
- Ye, J., Sun, B., Bao, Q., Che, C., Huang, Q., & Chu, X. (2023). A new multi-objective decision-making method with diversified weights and Pythagorean fuzzy rough sets. *Computers & Industrial Engineering*, 182, 109406.
- Yoon, K., & Hwang, C. L. (1985). Manufacturing Plant Location Analysis By Multiple Attribute Decision Making: Part I-Single Plant Strategy. *International Journal of Production Research*, 23, 345-359.
- Yusuf, Y., Gunasekaran, A., & Abthorpe, M. S. (2004). Enterprise information systems project implementation: a case study of ERP in Rolls-Royce. *International Journal of Production Economics*, 87, 251–266.
- Zhang, L., Zhan, J. M., Xu, Z. S., & R. Alcantud, J. C. (2019). Covering-based general multigranulation intuitionistic fuzzy rough sets and corresponding applications to multi-attribute group decision-making. *Information Sciences*, 494, 114–140.
- Zhang, Z., Liao, H., & Tang, A. (2022). Renewable energy portfolio optimization with public participation under uncertainty: A hybrid multi-attribute multi-objective decision-making method. *Applied Energy*, 307, 118267.
- Zhang, X., & Xu, Z. (2014). Extension of TOPSIS to multiple criteria decision making with pythagorean fuzzy sets. *Journal of Intelligent Systems*, 29(12), 1061–1078.

Zografos, K. G. (2005). *Analytic Hierarchy Process (AHP): It's application in FTS business model assessment*. Conference On “Flexible Mobility Services: Business Models, Organizational and Contractual Issues”, Cremona.

