ISSN 1330-3651(Print), ISSN 1848-6339 (Online)
UDC/UDK 658.71.015(560)

SECTOR SELECTION FOR ERP IMPLEMENTATION TO ACHIEVE MOST IMPACT ON SUPPLY CHAIN PERFORMANCE BY USING AHP-TOPSIS HYBRID METHOD

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Original scientific paper

Recently, studies about the Enterprise Resource Planning (ERP) have been increased and this research area has attracted more attention. Especially, in the global competition environment, enterprises have to focus on their Information Systems (IS) performance to have a competitive advantage; implementing an ERP system and improving the effectiveness of the system is the only way. However every sector reacts to ERP implementation differently. Purpose of this study is to rank the sectors according to their performance increments after successful ERP implementations by using AHP-TOPSIS hybrid method. As a result, general structure of Turkish companies will be pictured and the sectors which have the most chance to improve their performance by utilizing an ERP system will be defined. These findings will help the companies to plan the implementation process more precisely and help the managers of these companies to define their expectations more clearly. A numerical example is given to clarify the main developed result in this paper.

Keywords: *AHP-TOPSIS, ERP implementation, sector selection, supply chain performance*

Odabir sektora za primjenu ERP-a u cilju što boljeg djelovanja na učinak nabavnog lanca primjenom AHP-TOPSIS hibridne metode

Izvorni znanstveni članak

U zadnje se vrijeme povećao broj radova o planiranju resursa poduzeća (ERP) te je to područje istraživanja privuklo više pažnje. Naročito, kad se radi o svjetskoj konkurenciji, poduzeća se moraju usmjeriti na rad svojih informatičkih sustava (IS) ako žele steći prednost, a jedini način za to je primjena ERP sustava i povećanje njegove učinkovitosti. Međutim svaki pojedini sektor drugačije reagira na primjenu ERP-a. Cilj je ovoga rada rangirati sektore prema porastu učinkovitosti nakon uspješne primjene ERP-a, korištenjem AHP-TOPSIS hibridne metode. Kao rezultat, dobit će se slika opće strukture turskih kompanija i definirat će se sektori koji imaju najbolje izglede za poboljšanje radne učinkovitosti primjenom ERP sustava. Ti će rezultati pomoći kompanijama u preciznijem planiranju procesa implementacije i rukovodećim ljudima u jasnijem definiranju njihovih očekivanja. Daje se numerički primjer u svrhu razjašnjenja glavnog dobivenog rezultata u radu.

Ključne riječi: *AHP-TOPSIS, izbor sektora, primjena ERP-a, učinkovitost nabavnog lanca*

1 Introduction

In the modern world, competition is no longer between organizations, but among supply chains (SCs)[1]. Enterprises must compete against one another in order to survive. As the global economy continues to grow, enterprises are no longer competing independently but rely on their supply chain systems. Effective supply chain management (SCM) has therefore become a potentially valuable way of securing a competitive advantage and improving organizational performance [2-3]. New supply chain management concepts are helping managers to successfully run their firms in the new environment which is necessary to effectively respond to supplier and customer requirements and to achieve a better organizational performance. Therefore, implementing quick-response strategy is vital as modeled throughout the 1990's as stated by Hammond [4] and Lowson [5] to improve competitiveness.

Various performance metrics have been developed to measure, evaluate, and monitor the operation of the entire supply chain. Lockamy and McCormack [6] indicated in their research that there were only a small number of studies attempting to empirically link specific SCM practices such as quality assurance to SC performance. Additionally, the conceptualization of a supply chain quality assurance system is incomplete, leaving out the important central link of SC process decisions and performance metrics [7-8]. The appropriate performance metrics can be used to evaluate the probability of success in achieving the target, to provide advice or corrective suggestions to the organization, to provide a feedback system to the manager and to evaluate the internal input and output [9]. However, if the metrics within a supply chain lack consistency, it is difficult for managers to take the appropriate actions based on the performance evaluation [10].

The benefits of SCM include cost savings through reductions in inventory and costs of transaction across the SC, faster response to changes in the market demands, lower product development, and increased competitiveness and profitability [11]. In order to achieve these benefits, one should consider the performance of supply chain along with all its channels. For this purpose, it would be enough to use some performance measures to efficiently manage an effective SC. These measures have an important role since they affect strategic, tactical, and operational planning and control. Performance measurement and metrics are essential in setting objectives, evaluating performance, and determining future courses of actions [12].

The current trend of SCM is to apply information technology to integrate cross-enterprises and inter-enterprise processes [13]. The link between Information Technology (IT) use and the simultaneous design of business processes is a vital ingredient to bring a benefit from such development efforts. In fact, in practice it is often difficult to separate the origin of the benefit, whether it has derived from IT, a process change, or both [14]. The literature reveals the necessity for adopting IT to foster information sharing in a supply chain [15, 16], the use of Enterprise Resource Planning (ERP) systems [17, 18].

Often, organizations focus on improving their agility, such as the speed at which they can respond to consumers, improve service, enhance product quality and improve production efficiency. It is commonly accepted that IT should be used to fundamentally change the business [19]. Many organizations, therefore, seek to improve their competitiveness by utilizing advanced information technology, such as ERP systems. ERP systems have been considered an important development in the corporate use of IT in the 1990s, enhancing organizational cross-functional efficiency and effectiveness through the seamless integration of all the information flowing through a company [20]. ERP is the business backbone. It is a cross-functional enterprise system that integrates and automates many of the internal business processes of a company, particularly those within the manufacturing, logistics, distribution, accounting, finance, and human resource functions of the business. Thus, ERP serves as the vital backbone information system of the enterprise, helping a company achieve the efficiency, agility, and responsiveness required to succeed in a dynamic business environment [20]. ERP software typically consists of integrated modules that give a company a real-time cross-functional view of its core business processes, such as production, order processing, and sales, and its resources, such as cash, raw materials, production capacity, and people. However, properly implementing ERP systems is a difficult and costly process that has caused serious business losses for some companies, which underestimated the planning, development, and training that were necessary to reengineer their business processes to accommodate their new ERP systems. However, continuing developments in ERP software, including web-enabled modules and e-business software suites, have made ERP more flexible and user-friendly, as well as extending it outward to a company's business partners [21]. Therefore, nobody could imagine a modern enterprise without ERP.

Since expectations from an ERP system are so high and these systems require considerably high amount of investment, companies should define their goals clearly. Unsatisfied goals after the implementation phase will create a disappointment about this investment. Even though ERP systems improve the performance of the supply chain systems the amount of this improvement varies from sector to sector. Purpose of this study is to determine these differences and rank the sectors according to improvements they achieved because of the ERP implementation. By doing so useful information for the companies, the plan to implement an ERP system will be created. By the help of such information companies will state their expectations more clearly and they may plan their investments according to this information.

This study presents a hybrid model for most impact on supply chain performance by using AHP-TOPSIS hybrid model. In the first step, we present the concept of AHP and determine the weight of criteria. Then we introduce the steps of TOPSIS and develop the model [22]. A numerical example is also presented to better illustrate the model.

2 Preliminaries

2.1 Basic concept of AHP

The AHP is a general theory of measurement. It is used to derive relative priorities on absolute scale from both discrete and continuous paired comparisons in multilevel hierarchic structures. These comparisons may be taken from a fundamental scale that reflects the relative strength of preferences. The AHP has a special concern with deviation from consistency and the measurement of this deviation, and with dependence within and between the groups of elements of its structure. It has found its widest applications in MCDM. Generally, the AHP is a nonlinear framework for carrying out both deductive and inductive thinking without use of the syllogism [23].

The AHP proposed by Saaty [24] is a flexible method for selecting among alternatives based on their relative performance with respect to criteria [25]. The AHP resolves complex decisions by structuring the alternatives into a hierarchical framework. The hierarchy is constructed through pair-wise comparisons of individual judgments rather than attempting to prioritize the entire list of decisions and criteria. This process has been given as follows [26]:

- Describe the unstructured problem,
- Detailed criteria and alternatives,
- Recruit pair wise comparisons among decision elements,
- Use the eigenvalue method to predict the relative weights of the decision elements,
- Compute the consistency properties of the matrix, and
- Collect the weighted decision elements.

The AHP method provides a structured framework for setting priorities on each level of the hierarchy using pair-wise comparisons that are quantified using a $1 \div 9$ scale as demonstrated in Tab. 1.

Table 1 The $1 \div 9$ Fundamental Scale

Importance intensity	Definition
1	Equal importance
3	Moderate importance of one over another
5	Strong importance of one over another
7	Very strong importance of one over another
9	Extreme importance of one over another
2, 4, 6, 8	Intermediate values

3 AHP-TOPSIS hybrid method

To rank a set of alternatives, the AHP-TOPSIS Hybrid method as outranking relation theory was used to analyze the data of a decision matrix. We assume m alternatives and n decision criteria. Each alternative is evaluated with respect to the n criteria. All the values assigned to the alternatives with respect to each criterion form a decision matrix.

In this study, our model integrates two well – known models, AHP-TOPSIS Hybrid methods. The procedure for AHP-TOPSIS Hybrid methods ranking model has been given as follows:

Let $A = \{A_1, A_2, \dots, A_m\}$ be a set of alternatives and $C = \{C_1, C_2, \dots, C_n\}$ be a set of criteria. We modify the selection process to a nine-step, AHP-TOPSIS hybrid procedure, presented as follows:

Step 1. Identify the Alternative.

We provide a list of alternatives denoted by $A = \{A_1, A_2, \dots, A_m\}$

Step 2. Identify the criteria.

The criteria could be denoted by $C = \{C_1, C_2, \dots, C_n\}$. Identification of criteria.

Step 3. Determine the weight of criteria based on the opinion of experts (W_i) by using AHP method.

The decision group or decision makers are given the task of forming individual pair-wise comparisons by using standard scale of nine levels.

Step 4. Determine the decision matrix:

$$\boldsymbol{D} = \begin{bmatrix} c_{11} & c_{12} & c_{13} & \dots & c_{1n} \\ c_{21} & c_{22} & c_{23} & \dots & c_{2n} \\ c_{31} & c_{32} & c_{33} & \dots & c_{3n} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ c_{m1} & c_{m2} & c_{m3} & \dots & c_{mn} \end{bmatrix}. \quad (1)$$

A_i denotes the alternative, represents i^{th} criterion, related to i^{th} alternative; C_{ij} is a value indicating the performance rating of each alternative with respect to each criterion.

Step 5. Determine the normalized decision matrix.

$$r_{mn} = \frac{c_{mn}}{\sqrt{\sum_{m=1}^{n} c_{mn}^2}}. \quad (2)$$

Step 6. Determine the weighted normalized decision matrix.

$$\boldsymbol{v}_{mn} = w_m \times r_{mn}, n = 1, 2, ..., N, m = 1, 2, ..., M.$$

Here W_i represents the weight of the i^{th} criterion.

Step 7. Determine the positive and negative ideal solution.

In this step, the positive ideal solution (PIS) and negative ideal solution (NIS) have to be determined. A^* is PIS and A^- is NIS. Then A^* and A^- are equal to:

$$A^* = \left\{v_1^*, v_2^*, ..., v_n^*\right\} = \\ = \left\{(\underbrace{\max}_{n} v_{mn} \mid m \in M'), (\underbrace{\max}_{n} v_{mn} \mid m \in M'')\right\}. \quad (3)$$

$$A^- = \left\{v_1^-, v_2^-, ..., v_n^-\right\} = \\ = \left\{(\underbrace{\max}_{n} v_{mn} \mid m \in M'), (\underbrace{\max}_{n} v_{mn} \mid m \in M'')\right\}. \quad (3)$$

Step 8. Determine the separation measures between the alternatives.

The separation measures, S_i^* and S_i^-, of each alternative from PIS and NIS, are calculated.

$$D_n^* = \sqrt{\sum_{m=1}^{k} (v_{mn} - v_m^*)^2}, n = 1, 2, ..., N, \quad (5)$$

$$D_n^- = \sqrt{\sum_{m=1}^{k} (v_{mn} - v_m^-)^2}, n = 1, 2, ..., N. \quad (6)$$

Step 9. Determine the final ranking.

In the final step, the relative closeness coefficient of an alternative is defined as follows:

$$CC_n^* = \frac{D_n^-}{D_n^* + D_n^-}, n = 1, 2, ..., N. \quad (7)$$

4 Numerical examples

In this section, we will describe how an AHP-TOPSIS hybrid model was applied via an example. Starting with a literature survey key performance indicators (KPI) have been determined for the SCM. These KPIs are the most common performance metrics found in the literature. There are many metrics in the SCOR model. Along those metrics the ones related with in-bound/out-bound logistics success, service levels/accuracies, delivery times, cycle-times at different levels have been selected. These particular ones have been selected by considering their availability in the ERP systems [27]. SC system performance has been measured according to criteria (C_k) as follows:

C_1: Greater flexibility, C_2: Increased efficiency, C_3: Improved communication, C_4: Lower operating costs, C_5: Increased Revenue, C_6: Reduced cycle times, C_7: Better collaboration, C_8: Higher profit margins, C_9: Higher customer satisfaction, C_{10}: Inbound logistics performance, C_{11}: Outbound logistics performance, C_{12}: Human Resource Management performance.

These criteria have been used to evaluate the performance gain from ERP implementation of companies, which operate in different sectors. These sectors have been defined as alternatives (A_n), which are:

A_1: Computer/electronics, A_2: Furniture, A_3: Food, A_4: Textiles/apparel, A_5: Chemicals, A_6: Service.

According to a previous study completed by the authors [28] ERPs effects on SC performance have been measured with a questionnaire study. At the time of this study sectors of these companies and their expectations and gained performances from ERP systems have been investigated with the ERP implementation project leaders. In the context of that study expert opinions have been taken about the priority of the performance criteria and sector differences from the view point of ERP success. Distribution of the companies investigated prior to this study has been given in Tab.2.

Table 2 Distribution according to sectors

Sectors	Frequency	Percent
Computer/Electronics	4	5,3
Furniture	18	24,0
Food	18	24,0
Textiles/apparel	6	8,0
Chemical	11	14,7
Service	18	24,0

Now to utilize the proposed AHP-TOPSIS hybrid model to prioritize alternatives, the following steps were taken:

According to analysis results supply chain performance criteria have been ranked according to their importance on the ERP implementation based performance gain on the supply chain by using AHP method. This importance ranking can be seen in Tab. 3.

Table 3 Ranking results of supply chain performance criteria by using AHP

Criteria (C_n)	Importance
Greater flexibility (C_1)	1,963
Increased efficiency (C_2)	1,963
Improved communication (C_3)	0,183
Lower operating costs (C_4)	1,264
Increased revenue (C_5)	1,353
Reduced cycle times (C_6)	0,328
Better collaboration (C_7)	0,336
Higher profit margins (C_8)	1,913
Higher customer satisfaction (C_9)	0,918
Inbound logistics performance (C_{10})	0,715
Outbound logistics performance (C_{11})	0,715
Human resource management performance (C_{12})	0,452

These results implie that the C_1, C_2 and C_8 have the most impact on the supply chain performance gain resulting from the ERP implementation followed by the C_4, C_5 and C_9; where C_3 has the least impact according to decision makers.Weightings analysis of these criteria has a CR value of 0,093, which is less than 1. This shows that the weightings are consistent.

After the weights of the criteria the ratings of the alternatives were determined, the PIS and NIS. The separation measures, S_i^* and S_i^-, negative and positive separation measures based on normalized for each alternative and the relative closeness coefficient were calculated as follows:

Table 4 Decision matrix

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
A_1	4	6	5	5	4	4	7	4	6	6	6	4
A_2	3	4	6	5	5	6	7	6	7	7	7	3
A_3	4	6	7	5	5	4	5	6	6	6	6	3
A_4	5	5	7	6	5	5	6	7	6	6	6	4
A_5	2	6	5	4	4	3	4	4	4	6	7	2
A_6	7	5	4	3	4	2	7	4	5	7	6	4

$$A^+ = \{0{,}642,\ 0{,}455,\ 0{,}498,\ 0{,}514,\ 0{,}451,\ 0{,}583,\ 0{,}468,\ 0{,}538,\ 0{,}497,\ 0{,}447,\ 0{,}447,\ 0{,}478\}$$

$$A^- = \{0{,}183,\ 0{,}303,\ 0{,}283,\ 0{,}257,\ 0{,}361,\ 0{,}194,\ 0{,}267,\ 0{,}308,\ 0{,}284,\ 0{,}383,\ 0{,}286,\ 0{,}239\}$$

$$S_1^\alpha = 0{,}544 \quad S_2^\alpha = 0{,}580 \quad S_3^\alpha = 0{,}449 \quad S_4^\alpha = 0{,}303 \quad S_5^\alpha = 0{,}824 \quad S_6^\alpha = 0{,}535$$

$$S_1^- = 0{,}469 \quad S_2^- = 0{,}477 \quad S_3^- = 0{,}501 \quad S_4^- = 4413 \quad S_5^- = 0{,}247 \quad S_6^- = 0{,}687$$

After the final analysis under the weighted criteria, sectors represented by alternatives have been ranked according to the perceived amount of performance gains because of the ERP implementation by using AHP-TOPSIS hybrid method. These rankings are given in Tab.5.

Table 5 Ranking results of alternatives

Alternatives (A_n)	Importance
Computer/electronics (A_1)	0,463
Furniture (A_2)	0,451
Food (A_3)	0,527
Textiles/apparel (A_4)	0,549
Chemicals (A_5)	0,231
Service (A_6)	0,562

These rankings have been made according to the overall performance gains. With supply chain performance gain from ERP implementation in mind A_6 and A_4 sectors in Turkey seem to acquire the most gain, followed by A_3. A_5 seems to gain the least performance improvement from the ERP implementation.

5 Conclusion

Nowadays competition is the main reason which affects the operational strategies of the enterprises. Each company focuses on its SC to improve its efficiency to maintain its competitive advantage on the market. Implementing an ERP system is the most popular choice to improve the supply chain performance. But this implementation process and its gains differ in each company. Since this software requires a considerably high amount of budget and has a risk of implementation failure chance decision to go with it requires a serious planning effort at the beginning. Beyond the factors that need to be planned at the implementation phase, companies have to state their expectations clearly at the beginning, which means they must know to what extend an ERP system will improve their supply chain performance. Purpose of this study is to investigate the performance gain differences in different sectors resulted from ERP.

In this paper, we present a hybrid model using both AHP and TOPSIS hybrid model to measure the performance gains of each company. Required metrics have been proposed in this study and they have been weighted by using AHP-TOPSIS models to give supply chain managers a guide to evaluate their performances. In this hybrid model, AHP is used to assign weights to the criteria, while TOPSIS is employed to calculate the full-ranking of the alternatives. The AHP-TOPSIS hybrid model was used to aggregate the rating of DMs. This weighting has been made by the experts according to ERP systems advantages on the performance.

After weighting the performance criteria, different sectors have been evaluated by the experts. As a result of this phase sectors in Turkey have been ranked according to their potential of performance gain because of an ERP system. This ranking has of course the effect on Turkey's company structures. Families are operating most of Textile and food sector companies in Turkey. These companies are being managed with traditional family approaches, which state them as the companies, which have the most potential of gain in performance because of an ERP system. This structure may change according to the size of companies and of course inter country analyses are needed to state the differences between the countries.

As a result of this study performance gain differences among different sectors have been stated. These results will act as an informatory guide for managers of supply chains who plan to implement an ERP system and want to state their expectations clearly prior to the implementation. Also some ERP related supply chain performance metrics have been given with their weights to be used for supply chain performance measurement. These performance indicators will help the companies to evaluate their current situation, and compare it with the expected gains from the ERP systems.

Performance gain differences from an ERP system between different sized enterprises can be investigated as a future study by the use of criteria stated in this research. Also, cross-country comparisons can be made to state any possible differences between different countries. The AHP-IFT hybrid model has capability to deal with similar types of the same situations.

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Location

Situated on the eastern coast of Spain, Valencia was founded in 138BC as a Roman colony. The city, which is the third largest in Spain, has the biggest port on the Mediterranean Sea. A large historic city centre makes Valencia a popular tourist destination with many ancient monuments, museums and sights of interest. Valencia is famous for "Les Falles" – four days and nights of city wide celebrations held each year during March in commemoration of Saint Joseph. Visitors are also drawn to the region for its food with Paella having originated from the city.

Conference Venue

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These meetings have attracted outstanding contributions from leading researchers from around the world. The papers selected for presentation and included in the Conference Proceedings have been permanently stored in the WIT eLibrary as Transactions of the Wessex Institute (see http://library.witpress.com). These collected papers provide an invaluable record of the development of science and policy pertaining to air pollution.

The conferences in this series have discussed and considered many important air pollution issues and the international nature of the attendees has ensured that the conference findings and conclusions enjoy a wide and rapid dissemination amongst the air pollution science and policy communities. Air pollution issues remain one of the most challenging problems facing the international community. The series has demonstrated the wide spread nature of the air pollution phenomena and has explored in depth the impacts of air pollution on human health and the environment.

The series also recognised, at a very early stage, that science alone will not improve a polluted atmosphere. The scientific knowledge derived from well designed studies needs to be allied with further technical and economic studies in order to ensure cost effective and efficient mitigation. In turn, the science, technology and economic outcomes are necessary but not sufficient. Increasingly, the conference has recognised that the outcome of such research needs to be contextualised within well formulated communication strategies that help policy makers and citizens to understand and appreciate the risks and rewards arising from air pollution management. Consequently, the series has enjoyed a wide range of high quality papers that develop the fundamental science of air pollution and an equally impressive range of presentations that places these new developments within the frame of mitigation and management of air pollution.

This important conference brings together contributions from scientists from around the world to present recent work on various aspects of air pollution phenomena. Notable in each of the conferences in this series has been the opportunity to foster scientific exchange between participants. New collaborations amongst scientists, and between scientists and policy makers or regulators have arisen through contacts made in this series. Each meeting has provided a further opportunity for identifying new areas of air pollution science demanding collaborative investigation.

The conference papers deal with a rich variety of topics. The presentation of case studies of specific regions and cities, including those in emerging countries are particularly encouraged.

Conference Topics

- Air pollution modelling
- Monitoring and measuring
- Air quality management
- Indoor air pollution
- Aerosols and particles
- Emission studies
- Air Pollution chemistry
- Source identification
- Global and regional studies
- Exposure and health effects
- Economics of air pollution control
- Policy and legislation
- Case studies
- Innovative technologies

Benefits of Attending

Conference Proceedings Papers presented at Air Pollution 2015 will be published by WIT Press in Volume 198 of WIT Transactions on Ecology and the Environment (ISSN: 1746-448X Digital ISSN: 1743-3541) WIT Press ensures maximum worldwide dissemination of your research through its own offices in Europe and the USA, and via its extensive international distribution network.

Delegates will have the choice of receiving the conference book as either hard cover or digital format on a USB flash drive. The USB flash drive will, in addition, contain papers from previous conferences in this series.

Indexing and Archiving Papers presented at Wessex Institute conferences are referenced by CrossRef and regularly appear in notable reviews, publications and databases, including referencing and abstracting services such as SCOPUS, Compendex, Thomson Reuters Web of Knowledge and ProQuest. All conference books are archived in the British Library and American Library of Congress.

Digital Archive All conference papers are archived online in the WIT eLibrary (http://library.witpress.com) where they are easily and permanently available to the international scientific community.

Journal Papers After the conference, presenters at Air Pollution 2015 will be invited to submit an enhanced version of their research for possible publication in the International Journal of Sustainable Devlopment and Planning published by the Wessex Institute.

Reviews Abstracts and papers are reviewed by members of the International Scientific Advisory Committee and other experts.

Open Access Open Access allows for the full paper to be downloaded from the WIT eLibrary archives, offering maximum dissemination. Authors who choose this option will also receive complimentary access for one year to the entire WIT eLibrary.

Networking Participants can present their research and interact with experts from around the world, becoming part of a unique community.

Reduced Fee for PhD Students The Wessex Institute believes in the importance of encouraging PhD students to present and publish innovative research at their conferences. As a result, the Institute offers PhD students a much reduced conference fee.

Citations When referencing papers presented at this conference please ensure that your citations refer to **Volume 198 of WIT Transactions on Ecology and the Environment** as this is the title under which papers appear in the indexing services.