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SELECTION OF OPTIMAL ESTABLISHMENT PLACE USING AHP (ANALYTICAL HIERARCHY PROCESS): AN APPLICATION OF FURNITURE INDUSTRY

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ABSTRACT

For optimal decision for the selection of establishment place, there are various numerical methods. Among those, analytical hierarchy process, based on the multiple criteria decision making principle, is a fairly developed and new method. In this study, optimal establishment place selection problem in furniture industry, one of the subsectors in forest industry, has been investigated. First of all, information is given regarding method used for the selection of establishment place. Later the criteria affecting the problem solving process have been determined. The criteria were as the economy, production, market share and environment. For the establishment place, Amasya, Bayburt, Corum and Karabuk vicinities have been selected. AHP based problem was solved using expert choice (EC) software. The results were compared and sensitivity analysis was carried out. As a result, the economy was determined as the most important factor as 55% and the most appropriate place for establishment was recommended as Karabuk.

Keywords: Establishment Place Selection, Decision Making, Analytic Hierarchy Process..

OPTIMAL KURULUŞ YERI SEÇIMINDE AHP (ANALİTİK HİYERARŞİ PROSESİ): MOBİLYA ENDÜSTRİSİNDE BİR UYGULAMA

ÖZET

Optimal kuruluş yeri seçiminde birçok sayısal yöntemlerden yararlanılmaktadır. Bunlar arasında, çok kriterli karar verme ilkesine dayanan Analitik Hiyerarşi Prosesi daha gelişmiş yeni yöntemlerden biridir. Bu çalışmada, orman sanayi bir alt kolu olan mobilya endüstrisinde optimal işletme kuruluş yeri seçimi problemi araştırma konusu olarak ele alınmıştır. Öncelikle, işletme kuruluş yeri seçiminde kullanılan yöntemler hakkında bilgiler verilmiştir. Daha sonra problemin çözümü için sürece etkisi olan kriterler belirlenmiştir. Bu kriterler ekonomi, üretim, pazar payı ve çevredir. Kuruluş yeri olarak ise Amasya, Bayburt, Corum ve Karabuk illeri seçilmiştir. AHP tabanlı problem Expert Choice (EC) programı kullanılarak çözülmüş, duyarlılık analizleri yapılmış sonuçlar irdelenmiştir. Neticede kullanılan kriterlerden ekonomi %55 ile en önemli faktör olmuş ve en uygun işletme kuruluş yeri seçimi olarak da Karabuk ili önerilmiştir.

Anahtar Kelimeler: Kuruluş Yeri Seçimi, Karar Verme, Analitik Hiyerarşi Prosesi

1. INTRODUCTION

Today's rapidly changing and globalizing environment requires a successful enterprise to have a diverse decision-making process. This is not only about gathering and processing information, but also about taking the decisions by means of improved decision making methods. Decision-making is one of the keystones of an enterprise. Therefore, making right decisions is essential for enterprises to gain and maintain competitive advantage (Adıguzel, 2007).

In the most general sense, a decision making problem can be defined as the selection of the most suitable alternative among a set of alternatives based on at least one purpose or criterion.

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Accordingly, the element of a decision problem consists of the decision maker, alternatives, criteria, results, environment and the priorities of the decision maker. In the simplest term, a decision problem can be regarded as selection of an alternative among other alternatives based on a purpose or criterion (Dağdeviren, 2002).

Analytical Hierarchy Process (AHP) was developed by Saaty (Saaty, 1990). AHP is a multicriteria decision making tool used in solution of complex decision problems. AHP is a mathematichal method which takes into account the priorities of the group or individual with a capability to collectively evaluate the qualitative and quantitative variables (Dağdeviren et al, 2004).

The most important feature of AHP is its capability to include both objective and subjective opinions of the decision maker into the decision making process. In other terms, AHP is a method in which the knowledge, experience, opinions and intuitions of the individual are merged in a logical manner (Triantaphyllou, 1995). AHP has been widely studied in the literature, and in the last twenty years it has been used in almost all applications related with multi criteria decision making (MCDM) (Ho, 2008). This method is also suitable for applications such as site selection for establishments since it is possible to assess tangible and intangible criteria with this method (Imren, 2011).

In the literature search, AHP method is widely encountered in site selection for establishments; Yang and Lee (1997), Samarakoon et al (2001), Chen (2001), Kuo et al. (2002), Burdurlu et al.(2003), Kişioğlu (2004), Sauian (2006), Ada et al. (2006), Eleren (2006), Aydın (2009), Aydın et al (2009), Alp and Gündoğdu (2012), Erbıyık et al (2012), Ömürbek et al (2013).

The purpose of this study is to select the most suitable sites for furniture industry establishments. AHP method was used for establishment site selection, which is regarded as a multicriteria decision making problem. The factors affecting the site selection for establishments were determined after conducting literature surveys and interviews with a team of experts. A solution was sought for the site selection problem of an establishment in the construction and furniture sector, for the factory they plan to build.

2. MATERIAL AND METHOD

2.1 Material

M.Ç. Construction company, operating in the sector, is the subject of the present study. An establishment site is to be selected by the company for their factory in which wooden construction and decoration materials will be manufactured for use in the construction sector. For this purpose, a team of experts was organized among the engineers and architects for site selection, alternatives for the field of activity were determined and site selection criteria were utilized. Criteria evaluation form was prepared for the experts as a means to determine the importance values of criteria and alternatives.

Solution of the problem using suitable techniques is a requisite for site selection, which is regarded as a multicriteria decision making problem. For this purpose, AHP was applied as an MCDM method in selection of factory establishment site for M.Ç. Construction Company, and solutions were sought. Expert Choice 11.5 software package was used in implementation of AHP method.

2.2 Method

For implementation of AHP method in site selection for the establishment, team members were asked questions with questionnaire forms and these questionnaire data were then transferred to the software environment. As a means to enable the team members to make unbiased evaluations, the interviews were conducted separately. The evaluation of criteria clusters was performed in consideration of 1-9 evaluation scale, based on the questions prepared for determination of the relative importance of the criteria clusters for each other with regard to the purpose of the study.

After specifying the candidate region/city, determination of the criteria is required. The criteria available for factory establishment site selection in the literature were used in determination of the criteria for the current study. The team members, who also take part in the management of company, were conferred during the

determination of alternatives. In the first step of hierarchy, Amasya, Bayburt, Corum and Karabuk were assigned as the candidate residential areas for site selection.

After determination of the alternatives and criteria, hierarchy-building step was conducted. Information as to what the decision problem is, the criteria providing basis for evaluation, as well as the alternatives were demonstrated on the hierarchy which was built. The aim in the hierarchy is to determine the most suitable residential area for the factory establishment site. Four criteria with a sub-criterion for each criterion, are available. A selection was made among these four establishment sites after evaluation of these criteria and their sub-criteria.

The main criteria in AHP were linked within themselves and with their subcriteria, also each subcriterion was linked to each other and the alternatives. The transportation and shipping subcriterion in the economy criterion was also linked to raw material subcriterion under production criterion, proximity-to-market subcriterion under the market criterion and waste subcriterion under the environment criterion. Additionally, criteria such as social structure, life standards, rival companies and conditions of competition were evaluated within the market share criterion and related subcriteria, and their importance values were assigned.

3. APPLICATION AND FINDINGS

The main criteria, affecting the site selection for establishment, determined by members of company's board of directors and the group of experts after literature survey, as well as related measures were defined as: economy, production, market share and environment. Each main criterion has its subcriteria, and four alternatives are available for site selections which are defined by the same group. The cost and location of the land, establishment and organizational expenses, transportation and shipping costs, incentives are the subcriteria for economy criterion; raw material and auxiliary product supply, workforce supply, technology, capacity, proximity to power and water resources are the subcriteria for production criterion; proximity to market and new marketing fields are the subcriteria for market share criterion; waste raw material and chemicals, fire hazard and safety, climate, legal framework and liabilities are the subcriteria for environment criterion. Criteria evaluation form was prepared and related people were asked questions to define the importance values of these criteria. Importance values and definitions, corresponding to these values, were organized. The basic 1-9 scale (Table 1), adopted by the experts for AHP and applied by Saaty, was used in the application of AHP.

Table 1. Basic scale (Saaty, 1990).

Numarical scale	Verbal scale
1	Equal Importance
3	Moderate Importance
5	Strong Importance
7	Very Strong Importance
9	Extreme Importance
2,4,6 and 8	Intermediate values

Expert Choice (EC) software package was effectively utilized for application of AHP method and related calculations. Consistency ratios were checked one by one by the experts in computer environment and the data in the forms were transferred to the software environment accordingly. The main purpose was to determine the best alternative for establishment site using the criteria and associated subcriteria. Criteria, subcriteria and alternatives were set in the EC software, and the hierarchy model, shown in Figure 1, was built.

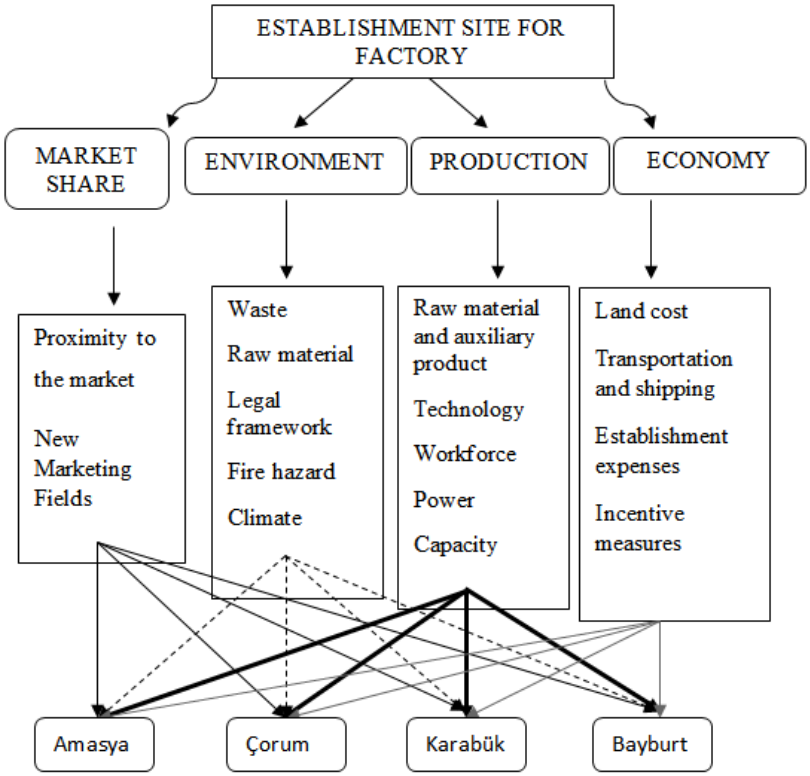

Figure 1. EC hierarchy model for furniture factory establishment site selection.

The values of paired comparison matrix and the matrix, in which each main criterion or alternative is compared with the others, were defined in line with the expert opinions and the specified values. Column totals are obtained as the sum of table values in each column of the defined matrix. Each column element of the matrix is divided with the sum of its column as shown in Table 2., and the resulting values are converted to decimal fractions. Each row total is divided with 4 for the mean value. This was facilitated by EC software, and more accurate results were obtained.

Table 2. Row totals of main criteria.

Criteria	Economy	Production	Market Share	Environment
Economy	1÷176/105= 0,597	3 ÷ 35/8 = 0,686	7÷19= 0,368	5 ÷ 31/3 = 0,484
Production	1/3÷176/105 =0,199	1÷35/8= 0,229	8÷19= 0,421	4 ÷ 31/3 = 0,387
Market Share	1/7÷176/105 =0,085	1/8÷35/8= 0,028	1÷19= 0,053	1/3÷31/3= 0,032
Environment	1/5÷176/105 =0,119	1/4÷35/8= 0,057	3÷19= 0,158	1 ÷ 31/3 = 0,097
Total	1	1	1	1

Table 3. Weight values of the main criteria.

The Importance Levels of Main Criteria	Weight (W)
Economy	0,548
Production	0,303
Market Share	0,102
Environment	0,047
	T.O = 0,07

According to Table 3., the importance levels of main criteria are ranked in the following order: economy, production, environment, market share. As seen in the figure, total weight value of the criteria is ‘’1’’. The comparison is consistent as TO = 0,07 < 0,1. In the following stages, each criterion was evaluated using their subcriteria and paired comparison matrix, and the same procedures were repeated.

Table 4. Weights of economy criterion's subcriteria with respect to alternatives

Economy / Alternatives	Land cost	Transportation and shipping	Establishment expenses	Incentive measures	W
Amasya	0,168	0,118	0,143	0,195	0,154
Corum	0,328	0,311	0,308	0,138	0,256
Karabuk	0,383	0,507	0,473	0,391	0,444
Bayburt	0,120	0,064	0,077	0,276	0,145
W	0,146	0,466	0,096	0,292	

As seen in Table 4., the ranking of the establishment sites selected for the company on the basis of economy criterion is as follows: Karabuk, Corum, Amasya and Bayburt. Economically Karabuk Province has an advantage over others. The calculation format, used here, is also used for other alternatives, criteria and sub-criteria.

Table 5. Weights of subcriteria under production criterion with respect to alternatives

Production / Alternatives	Raw material and auxiliary product	Workforce	Technology	Capacity	Power	W
Amasya	0,228	0,169	0,275	0,247	0,33	0,236
Corum	0,167	0,454	0,156	0,205	0,175	0,237
Karabuk	0,535	0,302	0,485	0,476	0,418	0,453
Bayburt	0,071	0,074	0,083	0,072	0,078	0,074
W	0,251	0,183	0,113	0,396	0,058	

As seen in Table 5. the ranking for production criteria is as follows: Karabuk, Corum, Amasya and Bayburt. Although Corum Province holds importance in terms of workforce, Karabuk Province outweighs Corum Province by today's production technology and the need for power.

Table 6. Weights of subcriteria of market share criterion with respect to alternatives.

Market Share / Alternatives	New Marketing Fields	Proximity to the market	W
Amasya	0,212	0,169	0,185
Corum	0,410	0,454	0,439
Karabuk	0,269	0,302	0,290
Bayburt	0,109	0,074	0,087
W	0,333	0,667	

The company's market share can be affected by the rival companies' site preferences and location decisions for their new investments. Also the influence of socio-economy on the market share is unignorable. As seen in the comparison matrix in Table 6, the ranking is: Corum, Karabuk, Amasya and Bayburt.

Table 7. Weights of the subcriteria of environment criterion with respect to alternatives.

Environment / Alternatives	Climate	Raw material	Legal framework	Fire hazard	W
Amasya	0,232	0,262	0,295	0,272	0,279
Corum	0,138	0,118	0,166	0,139	0,148
Karabuk	0,546	0,565	0,471	0,533	0,508
Bayburt	0,084	0,055	0,069	0,056	0,064
W	0,072	0,275	0,498	0,155	

As indicated by the weights of provinces with respect to criteria in Table 7., Karabuk Province outweighs other candidate provinces.

Finally, the weights found by conducted calculations were multiplied by the weights of the alternatives. In other terms, the criterion-based value of each alternative in the site alternatives matrix in the last calculations, is multiplied with that criterion's weight value, and sum of the rows is obtained accordingly. As a result of calculations, the site alternatives were found to gain weight among themselves. The new site for the factory will be determined upon ranking with AHP.

Table 8. Decision matrix.

Criteria / Alternatives	Economy	Production	Market Share	Environment	W
Amasya	0,154	0,236	0,185	0,279	0,191
Corum	0,256	0,237	0,439	0,148	0,250
Karabuk	0,444	0,453	0,290	0,508	0,445
Bayburt	0,145	0,074	0,087	0,064	0,114
W	0,548	0,303	0,047	0,102	

As indicated by the values of Relative Importance Vectors, the values of economy, production and environment criteria affect the decision for establishment site of the factory and facility. It can be inferred from Table 8. that, economy, production and environment criteria are effective in Karabuk Province. However marketing criterion seems to be effective in Corum Province. In the light of the information that the best site for factory and facility will be the cheapest place in terms of economy criterion, the most abundant one in terms of production, the closest one in terms of marketing and the most environment-friendly one in terms of environment; establishment of the facility in and near Karabuk Province is found to be a sound decision.

4. RESULTS AND SUGGESTIONS

Selection of the site for factory establishment holds great importance for all branches of the industry. A wrong decision for establishment site is likely to result in additional costs for the enterprises, even interruptions in their operations. Since the selection of establishment site is a multicriteria decision making problem, making the right decision on this holds vital importance for companies.

In the application, inconsistency ratios for all criteria and alternatives were found to be under 0,1. Therefore the results are in agreement with the predictions of the decision makers. Judgements were found to be consistent and their results were accepted. According to the general results, the paired comparison matrix, applied for all criteria, was found to be sufficiently consistent for AHP method. The overall results indicate that Karabuk Province has the highest importance weight with 0,445 in all criteria except marketing. Other alternatives are ranked as follows: Corum 0,250, Amasya 0,191 and Bayburt 0,114. Corum Province holds the first place in market share criterion with the weight importance of 0,439. The most important criterion among the criteria is economy with 0,548 importance weight. The ranking was found to be different in the sensitivity analysis due to the changes in market share criterion, and Corum Province took the first place in the ranking. The economy factor is also one of the most effective criteria in factory site selection decisions in the literature. On the other hand, information on the use of Expert Choice 11.5 software and information as to how this software will provide the users with ease of use and practicability during the solution of decision problems with AHP method, is provided through practice.

In recent years, there is a rapid growth in the furniture sector, a sub branch of forest products industry, in our country. With the present study, the entrepreneurs investing in this sector are provided with a sample model through application of AHP, one of the multi-criteria decision making methods, in site selection for establishments. Application of AHP method in such and similar cases will be useful for the decision makers in making the right decisions. Solution of various problems that we encounter in almost all stages of a facility's establishment such as selection of production method, hardware, material and even the personnel, by use of multicriteria decision making problems, will contribute to both the development of the sector, and efficient use the country's resources.

REFERENCES

- Ada,E. Kazancıoğlu Y., Özkan G. 2005. The Plant Location Problem By An Expanded Linear Programming Model, The 7 th Balkan Conference On Operation Research, Romanya, 11 s.
- Adıgüzel, E. 2007. Bir Üretim Sisteminin Performansının Anlık Olarak Ölçülmesi ve Değerlendirilmesi, Erciyes Üniversitesi, Fen Bilimleri Enstitüsü, Endüstri Mühendisliği Anabilim Dalı, Yüksek Lisans Tezi, 98 s.
- Alp, S., Gündoğdu, C. E. 2012. Kuruluş Yeri Seçiminde Analitik Hiyerarşi Prosesi ve Bulanık Analitik Hiyerarşi Prosesi Uygulaması, Dokuz Eylül Üniversitesi, Sosyal Bilimler Enstitüsü Dergisi, 14(1), 07-25.
- Aydın, Ö. 2009. Bulanık AHP İle Ankara İçin Hastane Yer Seçimi, Dokuz Eylül Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi, 24(2),87-104.

- Aydın, Ö., Öznehir, S., Akçalı, E. 2009. Ankara İçin Optimal Hastane Yeri Seçiminin Analitik Hiyerarşi Süreci İle Modellenmesi, Süleyman Demirel Üniversitesi, İktisadi ve İdari Bilimler Fakültesi Dergisi, 14(2), 69-86.
- Burdurlu, E. and Ejder, E. 2003. Location Choice For Furniture Industry Firms By Using Analytic Hierrarchi Process (AHP) Method, Gazi Ün.Fen Bil.Dergisi, 16(2),369-373.
- Chen, T. C. 2001. A Fuzzy Approach To Select The Location Of The Distribution Center, Fuzzy Set And Systems,118 (1),65-73.
- Dağdeviren, M. 2002. Analitik Hiyerarşi Projesi ile Yeni Bir Analitik İş Değerlendirme Tekniğinin Geliştirilmesi, Yüksek Lisans Tezi, Gazi Ü. Fen Bilimleri Enstitüsü, 47-63.
- Dağdeviren, M., Akay, D., Kurt, M. 2004. İş Değerlendirme Sürecinde Analitik Hiyerarşi Prosesi ve Uygulaması, Gazi Üniversitesi Mühendislik ve Mimarlık Fakültesi Dergisi, 19(2), 131–138.
- Eleren, A. 2006. Kuruluş Yeri Seçiminin Analitik Hiyerarşi Süreci Yöntemi İle Belirlenmesi; Deri Sektörü Örneği, İktisadi ve İdari Bilimler Dergisi, 20(2), 405-416.
- Erbıyık, H., Özcan S., Karaboğa K. 2012. Retail Store Location Selection Problem With Multiple Analytical Hierarchy Process of Decision Making an Application in Turkey, Procedia - Social and Behavioral Sciences, 8th International Strategic Management Conference, 58 (1), 1405–1414.
- Ho, W. 2008. Integrated Analytic Hierarchy Process and Its Applications-A Literatüre Review, European Journal of Operational Research, p.211-228.
- İmren E. 2011. Mobilya Endüstrisinde Analitik Hiyerarşi Prosesi Yöntemi İle Kuruluş Yeri Seçimi, BÜ Fen Bilimleri Enstitüsü, Orman Endüstri Mühendisliği Anabilim Dalı, Bartın, 85 s.
- Kişioğlu, S. 2004. Kuruluş Yeri Seçiminin Boyutsal Analiz Yöntemi İle Belirlenmesi; Giyim Sektörü Örneği, Mühendis ve Makina, s.530.
- Kuo., R. J., Chı, S.C. and Kao, S. S. 2002. A Decision Support System For Selecting Convenience Store Location Through İntegration Of Fuzzy Ahp And Artifical Neural Network ,Computers In Industry, p. 199-214.
- Ömürbek, N., Üstündag, Seda., Helvacioglu, Ö. C. 2013. Kuruluş Yeri Seçiminde Analitik Hiyerarşi Süreci (AHP) Kullanımı: Isparta Bölgesi'nde Bir Uygulama, Çanakkale Onsekiz Mart Üniversitesi, Yönetim Bilimleri Dergisi, 11(21), 101-116.
- Saaty T. L. 1990. How to make a decision: The Analytic Hierarchy Process, European Journal of Operational Research, 48(1), 9-26.
- Samarakoon, H. M. D. R. H., Srhestha, S. M., Fujiwara, O. 2001. A mixed Integer Linear Programming model for transmission expansion planning with generation location selection, Electrical Power and Energy Systems, Vol. 23, 285-293.
- Sauıan, M. S. 2006. Strategizing Business Location Using Analytic Hierarchy Process, MCDM, Congress, China.
- Trıantaphyllou, E. 1995. Using the Analytic Hierarchy Process for Decision Making in Engineering Applications: Some Challenges, Inter'l Journal of Industrial Engineering: Applications and Practice, 2(1), 35–44.
- Yang, J. and Lee, H. 1997. An AHP Decision Model for Facility Location Selection, Facilities, 15 (9), 241-254.