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An Application of Analytic Hierarchy Process (AHP) in a Real World Problem of Store Location Selection

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Abstract

In today's competitive business environment, opening a new business store has a strong influence on both financial and corporational appearance. For this reason, it can be clearly stated that a location selection problem presents a very complex structure which includes several matters such as, profitability, cost cutting, boosting durability and efficiency, etc. In order to reach their goals regarding above mentioned issues, companies have to select their locations by considering relevant criteria and using convenient methods. Therefore it can be said that this issue has to be handled within all its aspects. In this study a new store location selection problem of Carglass Turkey is handled. As this problem includes both tangible and intangible criteria, analytic hierarchy process (AHP) was accepted as the main methodology. During the solution process a strict cooperation was ensured with the Carglass Turkey's administration. Obtained results were presented to the management as a report and its feasibility was confirmed accordingly.

JEL Classification Numbers: C440, M1, L810
Keywords: Analytic hierarchy process (AHP), pairwise comparison, real world problem, location selection, multi-criteria decision making

1 Introduction

In general terms, a location selection problem points out the determination of a specified area for deployment of a facility. In accordance with the nature of the market conditions, choice of a particular location displays a direct impact on companies' competitiveness and performance therefore it can be stated that this is a strategically important decision problem. In this context, administrative ability to solve this critical problem within all its aspects will

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provide stability in above mentioned vying environment [1] yet an accurate choice of location mainly ensures the availability of sufficient products whenever and wherever needed [2]. A good location also appeals customers thereby boosts sales numbers in today's highly competitive business market [3]. As a crucial decision, probable mistakes in this period may cause overspends, high transportation costs, loss of skilled labor and future profits which may possibly harm administrative issues [4]. Therefore it can be clearly stated that a proper alternative should fulfill companies' goals. In order to do that, these needs must be determined completely and objectively. In addition to this, decision maker(s) must determine the criteria that affect the selection by considering a long period of time. Such as almost every real world problems, location selection problems present a complex structure that includes both tangible and intangible factors. Therefore various multi-criteria decision methods has been used in the literature such as analytic hierarchy process, analytic network process, TOPSIS, ELECTRE, PROMETHEE including integrated approaches [5], [6], [7], [8], [9], [10], [11], [12]. In this study a real world problem of an auto glass company; Carglass Turkey's location selection problem is handled. As this was a multi-criteria decision problem which includes both tangible and intangible factors, AHP was used to acquire a solution.

This study consists of four sections: In the first section a brief review of location selection problems is presented. In Section 2, AHP method and its applications are explained. In the following section, the location selection problem of Carglass Turkey with its AHP model, the steps of the analysis and its results were given. The evaluation of the results constitutes the last section.

2 AHP And its Applications

AHP, a multi-criteria decision method, was developed by Saaty in 1976 [13]. Because of its well-known advantages, this method has been used successfully in various fields. As previously mentioned, this method counts both tangible and intangible factors in and this attribute fits to the subjectivity feature of real-world problems [14]. Also the hierarchical structure that includes more than one time periods, decision makers and criteria can be stated as another advantage. Yet this kind of hierarchical modelling facilitates the involvement of decision-maker(s) to the solution process and enables reassessments of judgments when necessary [15]. Thereby a mutual agreement can also be provided among decision-makers prior to their final decision.

Even there seems to be differences in various studies, it can be stated that AHP method has four general steps. Firstly the alternatives, main and sub-criteria -if there is any- must be determined. In the next step the decision problem is modelled hierarchically by considering previously selected criteria [16]. The decision-makers' judgments are collected through pairwise comparisons in the third step. In this step, the importance rankings of alternatives and criteria will be determined by analyzing these data which are obtained from these comparisons. Hence comparisons must be performed among these criteria and alternatives. In this process, Saaty's scale of relative importance, which has a range of values from 1 to 9, will be used. This scale is given in Table 1 below;

Table 1: Fundamental scale used in AHP [13]

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
2	Weak	--
3	Moderate Importance	Experince and judgment slightly favour one activity over other
4	Moderate Plus	--
5	Strong Importance	Experince and judgment strongly favour one activity over other
6	Strong Plus	--
7	Very strong	An activity is favoured very strongly over another
8	Very, very strong	--
9	Extreme Importance	The evidence favouring one activity over another is of highest possible order of affirmation

As it can be seen through Table 1, the rankings in comparisons must be as follows; 1 for equal importance, 3 for moderate, 5 for strong, 7 for very strong importance. If one element of the comparison is extremely important than the other, 9 points must be given. Other choices can be used if the decision-maker feels hesitant between two values. Through these comparisons, pairwise comparison matrices are acquired.

This is followed by calculating the inconsistency ratios for each matrices. These ratios enable to determine possible misevaluations in the comparisons. In general, 0.10 is the upper limit for this ratio but according to some scholars, this ratio is acceptable up to 0.20 [17], [18]. If the consistencies are ensured in all matrices, the process will move on. If not, pairwise comparisons must be repeated for inconsistent ones until a ratio within the limit is provided. Determining relative importance levels in accordance with the judgments can be defined as the following step [19]. The synthesis of this outcome and selection of the best alternative provides the solution in the last step.

AHP has been used in many research areas including selection of the best alternative, planning, resource selection, conflict resolution, optimization etc. There are several researches that focus on a review of AHP applications such as Boer et al. (2001)[20], Vaidya and Kumar, (2006)[21], Bruno et al. (2011)[22], Subramanian and Ramanathan (2012)[23]. Table 2 includes some of these researches in different fields which include AHP and integrated AHP approaches to real world problems;

Table 2: AHP-based applications to real world problems

Industries	Authors and References
Manufacturing	Yurimoto and Masui (1995)[24], Melachrinoudis and Min (1999)[25], Bitici et al. (2001)[26], Tahriri et al. (2008)[27], Verma and Paeteriya (2013)[28]
Marketing	Yang and Lee (1997)[29], Erbıyık et al. (2012)[11]
Logistics	Alberto (2000)[30], Buyukozan et al. (2008)[31]
Engineering	Ramanathan and Ganesh (1995)[32], Partovi (2006)[33], Chan and Kumar (2007)[34], Yu and Tsai (2008)[35], Wu et al. (2009)[36],
Commercial Tools	Cebi and Zeren (2008)[37], Schoenherr et al. (2008)[38], Çınar (2010)[10]

In accordance with Table 2, it can be clearly stated that there are various studies in which AHP is used to solve real-world problems. From this studies, Hegde & Tadikamalla (1990)[39], Yang & Lee (1997)[29], Alberto (2000)[30], Kinra & Kotzab (2008)[40], Cebi & Zeren (2008) [37], Çınar (2010)[10], Erbıyık et al. (2012)[11] handled location selection problems by using AHP and integrated AHP methods. In this study, a real world location selection problem of Carglass Turkey is handled.

3 An Application Of Analytic Hierarchy Process (AHP) In Store Location Selection

Carglass Turkey is an auto glass company which serves more than 110.000 customers every year in 12 branches and 198 franchises. The company is owned by Belron Inc. which operates in 28 countries and serves 8 million clients and has other brands such as, Carglass Europe, O'Brien Australia and Safelite USA.

After deciding opening a new store, Carglass Turkey executives faced a location selection problem recently. As a strategically important decision, there were both tangible and intangible criteria that should be counted in. Therefore in order to solve this problem, AHP method was accepted as the methodology. In the first step alternatives, main and sub-criteria was determined. During these steps, a strict collaboration was carried out with a team consists of Carglass executives. After several interviews, three location alternatives were determined and these were renamed as L1, L2 and L3 because of company's confidentiality policy.

In accordance with the varying advantages of these locations, more than 40 criteria was presented and five of them; *sectoral factors*, *environmental factors*, *investment cost*, *labor potential*, *regional potential* were chosen as the main criteria.

Various sub-criteria were defined for the first two and the last main criteria and these were listed below:

- Sectoral factors: Nearness to warehouse (NW), nearness to market (NM), regional commercial activity (RCA), customer potential (CP), subjective factors (SF), availability of competitors (AC), availability of Carglass franchises (ACF), regional autoglass sales (RAS) and performance of franchises (PF)
- Environmental factors: Transportation, climate, urbanization rate, land size and security
- Regional potential: Number of cars in the region (NC), regional rate of automobile insurance rate (RAI)

Following the determination of these criteria, hierarchical model was set up and is shown in Figure 1.

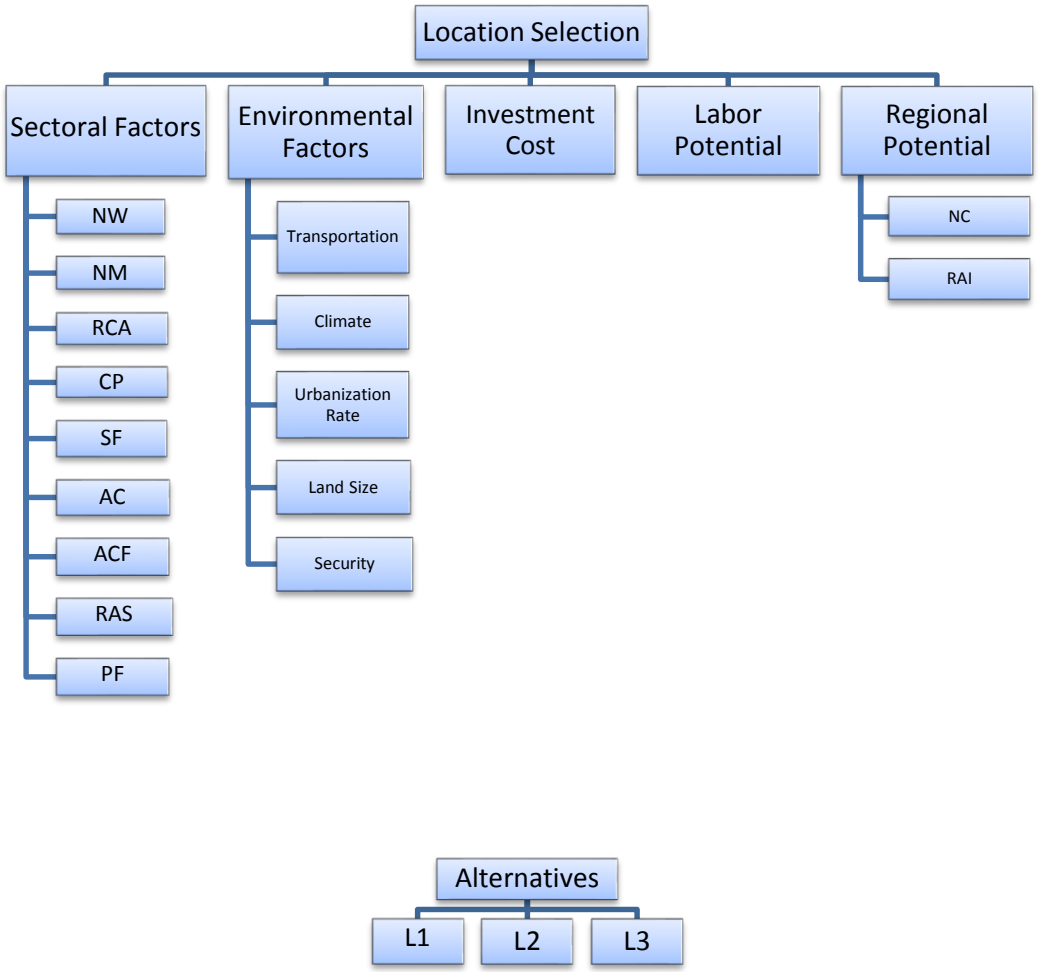

Figure 1: Hierarchical model of Carglass Turkey's selection of the best location problem

After modelling the decision problem as shown above, data were collected from the decision maker by pairwise comparisons. The scale shown in Table 1 is used and thereby pairwise comparison matrices were obtained. An example of these matrices that includes evaluation of the executives was shown in Table 3.

Table 3: Pairwise comparison matrix of the main criteria

	Sectoral Factors	**Environmental Factors**	**Investment Cost**	**Labor Potential**	**Regional Potential**
Sectoral Factors	1	8	5	5	1/5
Environmental Factors	1/8	1	1/4	1/4	1/8
Investment Cost	1/5	4	1	1	1/6
Labor Potential	1/5	4	1	1	1/6
Regional Potential	5	8	6	6	1

According to this matrix, sectoral factors has a very strong importance compared to the environmental factors and strong importance over investment cost and labor potential. Regional potential appears to be the most important factor among all main criteria. After obtaining all matrices the inconsistency ratios were checked out and all ratios were between 0 and 0.09. As these results were below 0.10 it can be clearly stated that all the matrices were also consistent. In the analysis step of AHP, the calculation of relative weights for all alternatives and criteria leads to the solution of the problem. In order to achieve this result Expert Choice 11 was used and relative weights of the criteria were given below in Table 4.

Table 4: Relative weights of main and sub-criteria

Criteria	**Relative Weights**
Sectoral Factors	0.257
- Nearness to warehouse	0.175
- Nearness to market	0.208
- Regional commercial activity	0.097
- Customer potential	0.262
- Subjective factors	0.21
- Availability of competitors	0.057
- Availability of Carglass franchises	0.041
- Regional autoglass sales	0.081
- Performance of franchises	0.058
Environmental Factors	0.032
- Transportation	0.052
- Climate	0.519
- Urbanization rate	0.204
- Land size	0.143
- Security	0.083
Investment Cost	0.078
Labor Potential	0.078
Regional Potential	0.555
- Number of cars in the region	0.833
- Regional automobile insurance rate	0.167

According to the Table 4, *regional potential* criteria is the most important criteria in Carglass Turkey's location selection problem. This is followed by *sectoral factors*, *investment cost*, *labor potential* and *environmental factors*. In addition to this, the most important sub-criteria is the *number of cars in the region*. Prior to the selection of the location, these results ad their validity were approved by the team. Therefore the importance values of the main criteria was calculated and is given below in Table 5

Table 5: Importance values and the ranking of alternatives

Alternatives	**Importance Values**	**Ranking**
L1	0.617	1
L2	0.292	2
L3	0.091	3

As it can be seen in Table 5, the best location for Carglass Turkey's new store is *L1*. The implementation of this result is the last step this process. Thus a report that included all obtained results and their interpretations were presented to Carglass Turkey's administration and its feasibility was approved accordingly.

4 Discussion and Conclusions

Location selection is a very critical decision for the companies in nowadays vying environment. The right decision will bring about many advantages to the companies irrespective of their business line. In a location selection problem each criteria's effect may differ and also these effects may contravene with each other. Therefore these problems present a complex structure that consists of tangible and intangible factors and thereby it can be said that AHP is a convenient method in order to solve these kinds of problems. In this study Carglass Turkey's location selection problem is handled. Firstly the alternatives, main and sub-criteria were defined. The problem was modelled as it was shown in Figure 1 and pairwise comparison matrices were obtained accordingly. The inconsistency ratios were calculated and after ensuring consistency for all matrices the relative weights were acquired. In Table 3, the numbers points out that the *regional potential* is the most important main criteria among others. Similarly the *number of cars in the region* which is a sub-criteria of regional potential has the highest relative importance. Consequently the importance levels of alternatives were calculated and in accordance with Table 5, *L1* region was selected as the best location for this problem. These outcomes were presented as a report to the Carglass Turkey administration and considered as feasible by the company.
As this study was performed in one particular business line, the criteria were specified in accordance with the auto glass sector, therefore this situation can be seen as a limitation in this study. But the hierarchical model which was established for this problem may provide an insight regarding location selection problems. Also as an example of a feasible solution to a real-world location selection problem, this study may guide companies and researchers whom may work on a similar problem in the future.

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