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Research Article

POLICY OPTIMIZATION ON A MANUFACTURING COMPANY IN RAPID GROWTH: A CASE STUDY

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ABSTRACT

Decision making and policy development is an important process for organizations, since the consequences of given decisions were identified among the major risk factors for organizations' future. This study aims to prove the importance of using combined decision making methods for a successful and strong decision making for managers. We integrate the multi-criteria decision making methods into a strengths, weaknesses, opportunities and threats (SWOT) analysis framework to show the applicability of the proposed method in a ceramic manufacturing firm in Kayseri, Turkey. Multi-criteria decision making processes were applied for taking quick action for future policies. SWOT analysis is used to optimize potential policies. Then, multi-criteria decision making methods: Analytical Hierarchy Process (AHP), The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and Grey Relational Analysis (GRA) are used in order to determine the importance of each potential policy. Determining the importance of the policies also gives the best solution for each method. This study shows the potential policies ranked by different multi-criteria decision-making methods for simplifying the decision-making process.
Keywords: Decision optimization, SWOT analysis, policy management.

1. INTRODUCTION

Decision making has always been a tough process for organizations. The decision making process is one of the most complex mechanisms of human thinking, as various factors and courses of action intervene in it, with different results (Lizarraga, Baquedano & Cardelle-Elawar, 2007). Particularly in situations that the possible effects of decision making process are major, making decision is crucial. For centuries, people and corporations study on method development in order to obtain more effective decision making process and make the most appropriate decisions. In a decision making process, all the factors that take decision makers to the result are investigated well. Some of the time the decision is emerged clearly, while the decision is still not very clear at other times. Intense decisions have been made in recent years, taking into account uncertain factors. Nowadays, uncertain factors are clearly formulated and attempted to be solved. In this study, a combined method including AHP, TOPSIS and grey relational analysis is developed for a better decision making process of policy selection via SWOT analysis. The results obtained from all these methods are analyzed and ranked for choosing the best policy according to SWOT.

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These multi-criteria decision making methods and results of strategic analysis were used for future plans of a company operating in the ceramic industry in Turkey.

Ceramic industry is among the three most active industries in Turkey with its trading volume, rapid growth and challenging competition. There are many new companies that are about to enter this sector. The company recently opened its second factory and wants to make more unbiased decisions here. Company that bet on this work is a business that is placed in the top rank in the Turkish market and is a candidate to become the best company. It needs assistance for decision making due to industry's challenging situation. The main purpose is being sure that the possible policies derived from SWOT analysis suits well for the organization's future plans.

Main contributions of the paper are the development of an evaluation model from SWOT and strategic planning and the application of GRA for an effective policy selection. In literature, there are many studies which use AHP, TOPSIS and GRA. In ceramic sector there is no study so far in literature that combines these methods for the policy selection problem, in Turkey. This paper has originality not only for its evaluation methodology, but also for its use in a real case study in Turkey.

2. LITERATURE REVIEW

Strategic management includes decisions and action plans that determine long term activities of organizations (Houben, Lenie & Vanhoof, 1999). In decision making process, the most creative work is choosing important factors for decision making (Uçar & Doğru, 2005). SWOT analysis helps define information needed and make possible decisions (Balamuralikrishna & Dugger, 1995). SWOT analysis is actually a basic list; it does not have any specific knowledge in it (Pickton & Wright, 1998). Essentially, SWOT is a tool that categorizes external factors as opportunities and threats; internal factors as strengths and weaknesses (Chang & Huang, 2006). Potential policies are determined by considering internal and external factors. Analysis of these factors will help decision makers to evaluate alternate results from different angles. This helps decision makers to get to the end quickly and easily, and the likelihood of making mistakes is reduced. Process of SWOT analysis contains reasonable symbolic transactions, complexity, judgment and uncertainty. SWOT analysis does not contain so many numerical transactions. Thus, it constitutes a convenient environment for classic data processing methods (Houben, Lenie & Vanhoof, 1999). Decision making used for obtaining much of information, come up to a mathematical science these days (Figuera, Greco & Ehrgott, 2005). If we make our decisions intuitively, we tend to think every information is useful and more amount of information is better (Saaty, 2008). However, this is not true. According to Saaty, there are so many examples that show too much information is as bad as little information. In many industrial engineering applications, the final decision depends on improvement of many alternative criteria. These criteria can be expressed as using various scales or convenient data can be too hard to digitalize, thus this problem turns into a tough problem (Triantaphyllou & Mann, 1995). Analytical hierarchy process (AHP) is an effective approach for solving these kind of decision making problems. It enables evaluation by considering many criteria together, and provides giving values to qualitative criteria by quantitative measurement.

AHP is a method created by Thomas L. Saaty in 1970s. The chosen alternatives are grouped, these alternatives are ranked individually and they are also ranked by groups. After calculation of rankings, best alternative is chosen. It can be integrated with other techniques. It does not only consider qualitative and quantitative factors, but also techniques like mathematical programming for considering real life resource constraints (Ho, 2008).

TOPSIS, developed by Hwang and Yoon in 1981, is used to obtain ranking scores and rank the alternatives accordingly (Sen & Yang, 1998). It is widely used in multi-criteria decision making tools due to its simplicity and programmable nature. It is a technique for ranking and selection of a number of externally determined alternatives through distance measures (Tsaur, 2011). TOPSIS met hod orders preferences by similarity to ideal solution that maximizes the benefit criteria/attributes and minimizes the cost criteria/attributes, whereas the negative ideal solution maximizes the cost criteria/attributes and minimizes the benefit criteria/attributes. The best alternative is the one which is closest to the ideal solution and farthest from the negative ideal solution (Tsaur, 2011). Decision makers consider benefits and costs together using TOPSIS method. Choosing the best alternative depends on distance to the ideal solution. It suggests mathematical solution to the decision making process which simplifies the process.

GRA was first invented by Julong Deng in 1982. Using less data and giving importance to the relations between them is among the most important advantages of this analysis method. Even in case of lack knowledge, grey relational analysis is a very useful method in determining qualitative and quantitative relations (Tseng, 2010). Initially, all alternatives are translated into a comparability sequence. According to these sequences, a reference sequence which is an ideal target sequence is defined. The grey relational coefficient between all comparability sequences and the reference sequence is calculated, and then the grey relational grade between the reference sequence and each comparability sequence are calculated. The best choices are determined after these comparisons.

While making SWOT analysis, recently decision makers prefer to combine it with other multi-criteria decision making methods recently. Decision makers able to reach certain results faster than normal SWOT by combining it with multi-criteria decision making methods. There are many studies using multi-criteria decision making methods with SWOT in literature, they inspired us while making this study.

Szuleckaa and Zalazara (2017) examined why this is the case, and why until today investment in forest plantations in Paraguay is constrained despite visible wood shortages. Tavana et al. (2016) proposed a new hybrid model to implement an IF-AHP and SWOT to identify and evaluate the criteria of a reverse logistics outsourcing decision. Shahba et al. (2017) aimed to identify SWOT, and strategies for waste management in iron mines and provide a quantitative basis to analytically determine the ranking of the factors in SWOT analysis via AHP and TOPSIS. Shakerian et al. (2016) used the combination of the SWOT analysis and Fuzzy TOPSIS analysis for identifying the organizational environment and ranking the available organizational strategies. Aich and Ghosh (2016) used SWOT to identify the method of selection of right technology for processing and disposal of municipal solid waste; which may eventually promote a sustainable waste management system. Kaczmarek (2016) introduced a SWOT application to maintenance system diagnosis. In terms of policy selection, Duan and Liao (2013) determined the optimal replenishment policies of capacitated supply chains (SC) operating under two different control strategies (decentralized vs. centralized) and various demands. Polotski et al. (2017) addressed the optimal scheduling for hybrid manufacturing–remanufacturing systems with setups. Zhang et al. (2015) presented a freight transport optimization model that simultaneously incorporates multimodal infrastructure, hub-based service network structures, and the various design objectives of multiple actors. Polotski et al. (2016), presented a numerical study based on the solution of Hamilton-Jacobi-Bellman equations that complements analytic results and allows to validate the proposed sub-optimal policies. Wurm and Bestle (2016) developed an approach for transmission calibration. Comparison with a deterministically found design shows improved performance and validates the eligibility of the proposed design strategy. Mayerle et al. (2016) proposed a quantitative model for determining long-term productive capacity in competitive oligopolistic markets. Mynttinen et al. (2015) studied a modified smoothing strategy and an extended penalization approach to approximate the non-smooth dynamic optimization problem by a smooth one are presented.

3. APPLICATION

In this study, SWOT analysis is used for a factory operating in ceramic industry to obtain effective future policies. For the factory management itself, it is hard to decide future policies clearly. This is because of lack of experience, it needs guidance for analyzing all the processes right and determining approximate future policies. In the study, after SWOT factors and possible policies are determined; multi-criteria decision making methods including AHP, TOPSIS and Grey Relational Analysis are applied. We used AHP to obtain the initial weights and decision matrix for TOPSIS and Grey Relational Analysis. The most eligible policies are selected according to results derived from multi-criteria decision making methods used. The needed guidance for the factory is provided, thus the factory is able to select more effective policies for its future.

3.1. SWOT

SWOT factors strengths, weaknesses, threats and opportunities are determined for ceramic factory together, with the managers of the factory. Strengths and weaknesses are internal, whereas opportunities and threats are external factors. By determining them, factory's present situation is considered carefully. After SWOT factors are determined possible policies are identified. Determined strengths, weaknesses, opportunities and threats are listed below.

Strengths:
1. Making quick decisions
2. Think tanks with leadership ability
3. Resolving problems rapidly
4. Having qualified products
5. Young and dynamic staff
6. Flexible and strong production capacity
7. Fulfillment of various customer demands
8. Giving importance to customer complaints
9. Strong and idealistic management
10. Giving importance to domestic and international fairs

Weaknesses:
1. Lack of Research and Development department
2. Using success factor without benchmarking
3. Insufficient domestic marketing network
4. Lack of marketing system using internet and online sale
5. Communication problems between staff and management board
6. Importing investment good resulting from dependence to abroad in production technology
7. Missing of defective products by quality control department
8. Insufficient physical space
9. Low growth rate for institutionalization
10. Lack of experience on buying raw materials

Opportunities:
1. Plenty of closed ceramic factories
2. Promotion laws for industry
3. Economic restoration in Middle East area
4. Resurgence of construction industry
5. Global trade environment in ceramic industry
6. Turkey's ceramic industry ranking as 2nd best place in Europe
7. Development of construction industry due to rapid growth in economies of whole world and border countries
8. Easier integration for Europe standards in production and quality resulting from technological developments
9. Being close to Anatolian market in Turkey
10. Ability to buy cheap convenient raw materials resulting from economic recession

Threats:
1. High energy costs in Turkey
2. Factory's distance to other factories in industry and raw material source
3. Economic recession
4. International rival threat in domestic market
5. Increasing rate of rivals producing with low cost in industry and increasing demand to them by customers
6. Lack of stability in construction industry of Turkey
7. Low budget used for Research and Development studies in Turkey
8. Increasing customer expectations
9. Increasing rate of contraction in market
10. Using weak technology compared to international factories

Possible policies are identified after SWOT factors are determined. Policies below are the most convenient ones after consideration of all factors.

Possible Policies:

1. Setting an effective Research and Development structure for independency of production technology
2. Setting an online sale system in order to empower marketing network
3. Improvement of quality control department
4. Setting an advanced performance evaluation system for more effective evaluations
5. Creating a platform for staff to communicate and send their suggestions and offers to management board
6. Selecting method of production with lower costs and more qualified
7. Using management power for effective communication to staff and setting an effective communication network

3.2. AHP

In AHP method, comparison matrices are generated between groups and components of each group, and thus weights for each matrix are calculated as in Gürbüz (2017). Resulting from calculations made in AHP method, possible strategies' average weights are calculated. According to results given below the most important possible policy is policy one with its weight calculated as 0.0051; and the least important possible policy is policy four as its weight as 0.0009 (Gürbüz, 2017).

P1	P2	P3	P4	P5	P6	P7
0.0051	0.0045	0.0043	0.0009	0.0014	0.0049	0.0038

3.3. TOPSIS

In TOPSIS method, all factor's normalization matrices are derived from AHP calculations. According to formulas in (1) and (2) positive and negative ideal solutions are calculated. Equation 1 shows the positive ideal solution (the maximum value), equation 2 shows negative ideal solution (Opricovic & Tzeng, 2004).

$$A^+ = \{ v_1^+, v_2^+, \dots, v_m^+\} = \{(\max_i v_{ij} | j \in \Omega_b), (\min_i v_{ij} | j \in \Omega_c)\} \quad (1)$$

$$A^- = \{ v_1^-, v_2^-, \dots, v_m^-\} = \{(\min_i v_{ij} | j \in \Omega_b), (\max_i v_{ij} | j \in \Omega_c)\} \quad (2)$$

The distance to positive and negative ideal solutions of each alternative is calculated using the formulas (3) and (4) (Opricovic & Tzeng, 2004):

$$D_i^+ = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^+)^2}\ , i = 1,2, \dots, n. \quad (3)$$

$$D_i^- = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^-)^2}\ , i = 1,2, \dots, n. \quad (4)$$

Distance from positive and negative solutions are measured for all SWOT objects in each normalization decision matrices. There is an example shown in Table 1 below.

Table 1. Distance from positive and negative ideal solutions for strengths group objects

SWOT factors	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
P1	0,0015	0.0010	0.0026	0.0123	0.0004	0.0017	0.0072	0.0118	0.0011	0.0087
P2	0.0010	0.0003	0.0033	0.0062	0.0006	0.0028	0.0049	0.0171	0.0002	0.0075
P3	0.0006	0.0001	0.0015	0.0107	0.0005	0.0022	0.0044	0.0072	0.0016	0.0038
P4	0.0005	0.0009	0.0020	0.0031	0.0002	0.0010	0.0007	0.0030	0.0003	0.0011
P5	0.0015	0.0010	0.0021	0.0016	0.0002	0.0008	0.0007	0.0021	0.0004	0.0006
P6	0.0008	0.0006	0.0013	0.0142	0.0011	0.0053	0.0058	0.0091	0.0003	0.0087
P7	0.0025	0.0013	0.0040	0.0028	0.0016	0.0075	0.0008	0.0049	0.0011	0.0030
	0.0084	0.0052	0.0168	0.0509	0.0044	0.0213	0.0245	0.0553	0.0051	0.0334
A+ (positive ideal)	0.0025	0.0013	0.0040	0.0142	0.0016	0.0075	0.0072	0.0171	0.0016	0.0087
A- (negative ideal)	0.0005	0.0001	0.0013	0.0016	0.0002	0.0008	0.0007	0.0021	0.0002	0.0006

After positive ideal solution (A+) and negative ideal solution (A-) are calculated, each SWOT group object's difference from positive ideal and negative ideal solution are found. For finding results, both ideal solutions are subtracted from each value. For finding distance from positive ideal solution and distance from negative ideal solution the extracted square roots of all factors and objects are multiplied for each possible policy. There are seven positive and seven negative distance values similar to possible policy number. The results are given in Table 2.

Table 2. Positive and seven negative distance values similar to possible policy

Distance from negative ideal solution		Distance from positive ideal solution	
S1-	0.055886722	S1+	0.048229462
S2-	0.041790932	S2+	0.049014157
S3-	0.042876062	S3+	0.043239504
S4-	0.004854722	S4+	0.079148211
S5-	0.011260124	S5+	0.072720435
S6-	0.055633218	S6+	0.039521993
S7-	0.040332158	S7+	0.049719244

Relative distance of each alternative to the ideal is calculated using (S- / (S+ + S-)). Results are given in Table 3.

Table 3. Relative distance of each alternative

Relative distance of each alternative to the ideal	
C1+	0.53677
C2+	0.46023
C3+	0.49789
C4+	0.05779
C5+	0.13408
C6+	**0.58466**
C7+	0.44788

According to the relative distance of each alternative to the ideal values, the most important policy is the sixth one.

3.4. GRA

Initially, the matrices derived from AHP calculations is used as the inputs for grey relational analysis. Then calculated values are used for getting normalized values of grey relational analysis. To find normalized values of GRA, formulas (5) and (6) are used (Tosun, 2006).

$$x_i^* = \frac{x_i(\mathrm{j}) - \min_j x_i(j)}{\max_j x_i(j) - \min_j x_i(j)} \tag{5}$$

$$x_i^* = \frac{\max_j x_i(j) - x_i(\mathrm{j})}{\max_j x_i(j) - \min_j x_i(j)} \tag{6}$$

Equation 7 should be used, if value of a factor is wanted to be high. If the high value is not favourable of a factor, Equation 8 should be used instead of Equation 7.

GRA absolute value table is created after normalized values are calculated. Absolute values for each field can be found by using Equation 7 (Tosun, 2006).

$$\Delta_{0i}(j) = |x_0^*(j) - x_i^*(j)| \tag{7}$$

GRA results depend on absolute value and normalized value tables calculated previously, from absolute values, Equation 8 could be helpful for finding final results (Tosun, 2006).

$$\varepsilon_{t1} = \frac{\Delta_{min} + \xi \Delta_{max}}{\Delta_{0i}(k) + \xi \Delta_{max}} \tag{8}$$

ξ Value is set to 0.5 for this study. Factor matrix is created after getting absolute values.

An example of a grey relational analysis calculated for strengths factors are shown in Table 4. Comparison matrix is calculated for strength factors in the Table 4. It is clear that the reference value is the largest value for each SWOT factor. And then a table of absolute values is created as shown in Table 5.

Table 4. Comparison matrix for strength factors

SWOT factors	S1	S2	S3	S6	S8	S9	S16	S24	S27	S38
Reference	0.0025	0.0013	0.0040	0.0142	0.0016	0.0075	0.0072	0.0171	0.0016	0.0087
P1	0.0015	0.0010	0.0026	0.0123	0.0004	0.0017	0.0072	0.0118	0.0011	0.0087
P2	0.0010	0.0003	0.0033	0.0062	0.0006	0.0028	0.0049	0.0171	0.0002	0.0075
P3	0.0006	0.0001	0.0015	0.0107	0.0005	0.0022	0.0044	0.0072	0.0016	0.0038
P4	0.0005	0.0009	0.0020	0.0031	0.0002	0.0010	0.0007	0.0030	0.0003	0.0011
P5	0.0015	0.0010	0.0021	0.0016	0.0002	0.0008	0.0007	0.0021	0.0004	0.0006
P6	0.0008	0.0006	0.0013	0.0142	0.0011	0.0053	0.0058	0.0091	0.0003	0.0087
P7	0.0025	0.0013	0.0040	0.0028	0.0016	0.0075	0.0008	0.0049	0.0011	0.0030
	0.0084	0.0052	0.0168	0.0509	0.0044	0.0213	0.0245	0.0553	0.0051	0.0334

Table 5. Absolute values for strength factors

SWOT factors	S1	S2	S3	S6	S8	S9	S16	S24	S27	S38
Reference	1	1	1	1	1	1	1	1	1	1
P1	0.4994	0.305	0.536	0.157	0.861	0.861	0	0.355	0.328	0.001
P2	0.751	0.818	0.274	0.636	0.705	0.705	0.364	0	1	0.148
P3	0.952	1	0.944	0.277	0.791	0.791	0.434	0.663	0	0.603
P4	1	0.378	0.747	0.883	0.972	0.972	1	0.940	0.955	0.944
P5	0.519	0.277	0.720	1	1	1	0.998	1	0.865	1
P6	0.841	0.562	1	0	0.327	0.327	0.218	0.534	0.977	0
P7	0	0	0	0.900	0	0	0.984	0.816	0.352	0.708

Then, values of the factor matrix are calculated. ξ Value is set as 0.5 in this calculation. An example of a factor matrix is shown in Table 6.

GRA results are calculated after getting values of factor matrix. For each SWOT factor (strength, weakness, opportunity and threat factors) an average value is calculated. Average value is calculated by using the calculated average factor values in AHP method. After average value calculated for each SWOT factor, average value of each possible policy is calculated. This value is the average of four SWOT factors for each possible policy. The results are shown in Table 7.

Table 6. Factor matrix for strength factors

SWOT factors	S1	S2	S3	S6	S8	S9	S16	S24	S27	S38
Reference	1	1	1	1	1	1	1	1	1	1
P1	0.500	0.620	0.482	0.760	0.367	0.367	1	0.584	0.603	0.997
P2	0.399	0.379	0.645	0.440	0.414	0.414	0.578	1	0.333	0.770
P3	0.344	0.333	0.346	0.642	0.387	0.387	0.535	0.429	1	0.453
P4	0.333	0.568	0.400	0.361	0.339	0.339	0.333	0.347	0.343	0.346
P5	0.490	0.643	0.409	0.333	0.333	0.333	0.333	0.333	0.366	0.333
P6	0.372	0.470	0.333	1	0.604	0.604	0.696	0.483	0.338	1
P7	1	1	1	0.356	1	1	0.336	0.379	0.586	0.413

Table 7. Grey relational analysis results

SWOT factors	S	W	O	T	Average
P1	0.052	0.051	0.056	0.053	0.053
P2	0.045	4.234	0.057	0.044	1.095
P3	0.040	4.856	0.042	0.045	1.246
P4	0.031	3.814	0.028	0.081	0.988
P5	0.032	4.190	0.029	0.074	1.081
P6	0.049	4.233	0.046	0.029	1.089
P7	0.059	4.645	0.037	0.048	1.197

3.5. Results and Discussion

In this study, first the possible policies resulting from consideration of all SWOT factors is determined carefully. After that AHP, TOPSIS and GRA are used for ranking of these possible policies. All the results were compared to select more effective policies. Results derived from four multi-criteria decision making methods are compared to each other. Decision-making process gets easier with this comparison and decision maker could select the most convenient policies and make decision more effectively.

According to results getting from AHP, the first, sixth and the second possible policies are the most desirable policies. Results from TOPSIS, show that the sixth, the first and the third possible policies are more preferable. Grey relational analysis (GRA) results give the third, seventh and second strategies as the most desirable possible strategies. From the overall results given in Table 8, we can say that third, sixth and first policies are more important for the company. GRA is a useful and efficient method for decision makers without analyzing the relationship between discrete data sets in many complex multi-purpose problems. One of its main objectives is to reveal the "Gray Relationship" between the elements of the observation data. Also GRA is an alternative interdisciplinary method of fuzzy logic (Wu, 2002). Despite some variations in the results; the first policy has not been chosen as the best policy for the last rank according to the results of GRA. The sixth policy is the first according to TOPSIS. However, due to the advantages of the GRA, it was decided that instead of the sixth policy, the third policy, which ranked first in the GRA should be applied.

Table 8. Results of the study

Policy ranking according to AHP method	1, 6, 2, 3, 7, 5, 4
Policy ranking according to TOPSIS method	6, 1, 3, 2, 7, 5, 4
Policy ranking according to GRA method	3, 7, 2, 6, 5, 4, 1

4. CONCLUSION

In this study, SWOT analysis data of a factory operating in ceramic industry is used for determining strategies and helping organization to survive in sector. At first, possible strategies are determined as alternatives to use while processing multi-criteria decision making methods. As for the multi-criteria decision making methods; AHP, TOPSIS and GRA methods are considered.

Calculated results are compared to each other for making better decisions. This comparison is the basis of the combined method.

Through using multi-criteria decision making methods, strategies derived from SWOT analysis are transformed into a numerical form and are given weights. Strategies are evaluated using these multi-criteria decision making methods and ranked. While making decisions about strategies, AHP, TOPSIS and grey relational analysis methods play an important part. A combined method using all these methods was never used before, especially in a ceramic industry. Comparison between different methods provides various points of view to decision makers. Thus, more efficient decision making process could be handled. It simplifies reaching the factory's future goals. Decision making process gets more objective due to using various methods and comparing them together. In future studies different multi-criteria decision making techniques can be combined with SWOT analysis to compare the results.

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