STRATEGIC GROUP ANALYSIS BY USING SELF ORGANIZING MAPS

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The aim of strategic group analysis is to find out if clusters of firms that have a similar strategic position exist within an industry or not. Findings of strategic group analysis may further be used to investigate the performance implications of strategic group membership. Using a theoretical conceptual framework applicable for the construction industry and self organizing maps (SOM), the objective of this research is to identify possible strategic groups within the Turkish construction industry. SOM is an unsupervised neural network computational mapping technique that forms an ordered non-linear projection of high dimensional input data items to a low dimensional grid. In this research, by considering the U-matrix and Daveis-Bouldin index, the number of the strategic groups is determined as three. There exist significant performance differences between these three clusters. Major mobility barriers between the first and second strategic groups are determined as the strategic planning style and experience. For the second and third strategic groups, financial resources and managerial capability are found to be the most important mobility barriers. All of the firms in the strategic group that have the highest performance utilize a quality differentiation strategy. Findings of the strategic group analysis can be used by professionals to understand current strategic position of a firm within the competitive environment and formulate strategies to shift to a better performing cluster. Results are country specific and can not be generalized. However, comparative studies can be conducted by using the strategic dimensions and analysis method proposed within this paper.

Keywords: competitive advantage, self organizing maps, strategy.

INTRODUCTION

All companies should have a clear strategic perspective to achieve competitive advantage. The selected strategies should be in accordance with the objectives, competencies and competitive rules prevailing in the market. The need for a strategic perspective for construction companies has long been stressed by many researchers (Warszawski 1996; Dikmen and Birgonul 2003). It is clear that a number of companies that compete in the same industry may have similar resources/ competencies and develop similar strategic perspectives. The question is whether these companies show similar performance or not. In the forthcoming parts of this paper, the theoretical background of strategic group analysis will be discussed as well as its performance implications.

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STRATEGIC GROUPS

The strategic group concept was first introduced by Hunt (1972) for explaining the performance difference between firms which follow different strategies. According to Porter (1980), strategic group is a group of firms in an industry following the same or similar strategy along a set of strategic dimensions. Dimensions include strategic decision variables that best distinguish the business strategies and competitive positions of firms within an industry such as scope and mode of competition. According to Porter, strategic groups are persistent structural features of industries that are bounded by mobility barriers. Drawing from economic and cognitive theories, researchers have argued that there may be differences between the performances of firms that belong to different strategic groups. The traditional view of strategic groups draws from industrial organization economics and proposes that firms within strategic groups collude to isolate themselves from firms outside their group (Caves and Porter 1977). Due to this collusive action, a favourable competitive environment exists in a strategic group leading to a similar performance among them.

STRATEGIC GROUPS AND PERFORMANCE

Investigation of the link between strategic groups and performance has been a very popular research theme. However, whether there exists a direct relationship between the strategic group membership and performance is still questionable. There are various empirical studies carried out in different sectors to investigate this issue. In some of these studies, strong relationship has been established, whereas some studies demonstrate no clear relationship. The inconsistency of results may be attributed to different factors. Strategic group analysis requires choosing or developing a conceptual framework in which the strategic dimensions are defined. Yet, there is no consensus on these dimensions. Caves and Porter (1977) tried to explain strategic group formation, and suggested that due to differences in risk posture or random differences in skills and quality of assets, firms tend to utilize different strategies, and this creates mobility barriers and different strategic groups. Since late 1980s, there has been a surge of interest in the role of resources and capabilities of a firm as the basis for strategy and primary determinants of profitability, which is considered under "the resource-based view". Rather than the "generic" sources of competitive advantage, resource-based view concentrates upon the resources and capabilities that underlie these advantages. Accordingly, resources and capabilities are proposed to be considered during strategic grouping. On the other hand, Cool and Schendel (1987) argue that mobility barriers alone are insufficient to explain profitability; firm-level characteristics and market factors should also be considered. In their work, strategic resources are considered as well as scope for strategic grouping. Industry specific variables are also proposed to be used as strategic dimensions. Relevant strategic dimensions may also change with respect to the characteristics of each industry. As the strategic dimensions are industry specific, the direct comparison of results from different industries may not be possible. Similarly, as different performance indicators are used, research results about impact of strategic grouping on performance may not be directly comparable. Using perceptions of industry professionals to identify the structure of the industry and competitive positions of firms is an alternative way. The study of strategic groups from a cognitive perspective has gained prominence during the past years (Hodgkinson 1997). According to this cognitive view, the cognitive classification schemes developed in the mind of the decision makers to simplify the market for being able to evaluate the differences between his or her business and

competitors may be used for strategic grouping (Tang and Thomas 1992). Strategic group analysis has got its benefits and shortcomings. Key question is whether strategic group analysis provides any information that cannot be gained from the study of industries and individual firms. In order to answer this question, more research is needed to investigate behaviour of strategic groups and possible group-level impacts on performance.

STRATEGIC GROUP ANALYSIS IN THE CONSTRUCTION INDUSTRY

Kale and Arditi (2002) argue that research on competitive positioning in the construction industry appears to be unbalanced in favour of anecdotal or descriptive approaches. Only a few construction management researchers have conducted empirical research studies in this area and explored performance implications (Akintoye and Skitmore 1991; El-Mashaleh *et al.* 2006). In their study, Kale and Arditi (2002) used one of the most influential generic typologies, Porter's (1980) generic competitive positioning typology to classify US firms. Four clusters have been identified, and statistically significant performance differences have been found between the clusters. It is found out that construction companies that outperform their rivals adopt a hybrid mode, rather than a single mode of competition. However no statistically significant finding was found about impact of scope on performance.

THE CONCEPTUAL FRAMEWORK

Within the context of this paper; a conceptual framework based on the study of Price and Newson (2003) is used for the strategic group analysis. Price and Newson (2003) mentioned three dimensions of strategy that can be recognized in every real-life strategic problem situation; strategy content, strategy process and strategy context.

Strategy content
The scope and mode of competition are the products of a strategy formulation process. An organization distinguishes itself by differentiating its offerings in some way. Basically there are two generic strategies: price differentiation (cost leadership as defined by Porter) and quality differentiation. Companies that utilize price differentiation strategy charge a lower price for their service/product and it seems as if this is the only way to survive in a market like construction industry where usually the lowest cost bidder is awarded the contract. The level of competitive advantage gained from a particular mode of competition depends on priorities of clients, how they define project success and the level of sensitivity of the project success criteria to different factors. In this research, they are grouped into two categories: price and non-price factors. Quality differentiation strategy does not mean that cost issues are not considered, however reducing cost is not the primary objective. Companies should make strategic choices about the markets they serve and types of projects they undertake, which is about drawing the boundaries of an organization. Companies may have a diversification strategy or a focus strategy which determines their competitive scope. In this research, two dimensions are identified to group the companies with respect to their competitive scope: market-level and project-level diversification. Project-level diversification has two dimensions: type of project and type of client.

Strategy process
During the strategic group analysis, "realized strategies" of firms are evaluated to identify possible similarities or differences between firms operating in the same market. A realized strategy has two components: deliberate strategy (plans realized) and emergent strategy (patterns developed in the absence of intentions) (Mintzberg 1987). In this research, two strategic variables have been defined: systematic strategic planning and centralization of decision making.

Strategy context
The resource-based view asserts the critical role of resources and capabilities of a firm as the basis for strategy and primary determinants of profitability. Under the title of strategy context, tangible (human resources and financial resources) and intangible resources (experience and relations) of companies are considered as well as the capabilities (managerial and technical capabilities). Finally, based on strategy context, content and process, 14 variables are defined.

SELF ORGANIZING MAPS (SOM)

In this research; SOM developed by Kohonen between the years 1979 and 1982 has been used for the determination of strategic groups. SOM is an unsupervised neural network computational mapping technique that forms ordered non-linear projection of high dimensional input data items to a low, often one or two dimensional grid. SOM can be used as a cluster tool, since it converts the nonlinear statistical relationships between high dimensional data into simple geometric relationships of their image points on a low-dimensional display (Kohonen 2001).The SOM algorithm has attracted great deal of interest among researchers and practitioners in a wide variety of fields. Kaski *et al.* (1998) have conducted a bibliographical research concerning the applications of SOM. They found out 3343 scientific papers published in between the years 1981-1997. Oja *et al.* (2003) extended the survey for the years 1998-2001, and they have added 2092 more publications to this bibliography. Although, SOM is considered as a popular tool, its application in business and administration sectors is rather low. SOM has been used for the determination of strategic groups in two studies only; firstly Serrano-Cinca (1998) tried to determine the strategic groups of Spanish saving banks by using the published financial data and Curry *et al.* (2001) used SOM for determining the strategic groups in the UK hotel industry.

SOM consists of a set of neurons usually arranged in a two-dimensional structure, in such a way that there exist neighbourhood relations among the neurons, which dictates the topology, or structure. The network of SOM usually consists of two layers of neurons; an input layer and output layer. Although, the neurons on the input layer are fully connected to the neurons on the output layer, the neurons on each layer have no connection to the neurons in their layers regardless of their relative position. Neurons on the output layer are arranged in an either rectangular or hexagonal lattice. Each neuron is represented by n-dimensional weight vectors. The algorithm of SOM is initialized by assigning values to weight vectors of each output neuron, either linearly or randomly. Training process of SOM starts by representing a data point randomly in the network. The distances between this data point and the weight vectors of all neurons are computed by using distance measures, usually Euclidean distance. By comparing these distances, the nearest Kohonen neuron, identified as "winning" neuron, is determined. The weights of the winning neuron are adjusted in order to approach to the current data point. The weights of neighbouring neurons are also

updated, so that the order of the input space can be satisfied (Curry *et al.* 2001). This provides topology preservation property of the SOM. The process is repeated until all data points are assigned to an output neuron.

SOM is selected for clustering since it has got some advantages over traditional clustering methods. Major strength of SOM can be attributed to its visualization capability. SOM is considered as an effective method as it may deal with high dimensional data. Traditional statistical cluster analysis methods rely on strict assumptions of certain statistical distribution functions, but there is no need for making such assumptions for SOM. Also, the number of clusters is not required before the analysis, unlike the K-means clustering method.

RESEARCH METHOD

The target population is selected as the members of the Turkish Contractors Association (TCA) which is an independent and non-profit professional organization that represents the leading construction companies in Turkey. The business volume of its members encompasses nearly 70% of all domestic and 90% of all international contracting work done so far by the Turkish construction companies. The strategic group analysis carried out in this research covers only the medium-big contracting firms in Turkey. Small and local firms are excluded from the analysis.

A questionnaire form is designed and submitted to 136 members of TCA. In the questionnaire, each representative of the company is requested to give relevant information about 14 strategic variables. The yearly turnover and age of the company are also questioned. Subjective reporting approach is used for performance assessment rather than collecting financial data. Subjective performance measures are utilized in examining relative performance within an industry. Each respondent evaluated his/her company's performance considering the previous 3 year period in terms of profitability, workload and other company objectives. All subjective ratings are assigned using the 1-to-5 Likert scale. The total number of returned questionnaires is 83 and the return rate is 0.61.

APPLICATION OF SOM

The tool used for SOM analysis is the SOM toolbox designed for Matlab. The clustering results of a SOM can vary highly depending on the initial setting of parameters such as map size, shape of the output neurons, training algorithm, shape of the map, the decrease speed of neighbourhood and learning rate. The optimal map size is determined by the software automatically as 12x4. The neighbourhood radius determines to what extent the surrounding neurons are modified according to the input data (Lansiluoto 2004). The neighbourhood width function is initiated first with a large value, equal to half of the size of the network itself as suggested by Kohonen (2001), for minimizing the effect of the initial random weights assigned to nodes. According to this, the neighbourhood radius is determined as the half of the size of the network and decreased to unity with time according to different neighbourhood functions. All neighbourhood functions are tested for training, but they did not show any effect on the performance of analysis. The learning rate influences how the neighbour nodes of the winning node are adjusted after each training step (Lansiluoto 2004) and the purpose of the usage of learning rate is the convergence of the algorithm (Wang 2001). For large maps, the selection of an optimal learning rate may be crucial (Kohonen 2001). In this analysis, since the provided map size is small, the

determination of the learning rate is left to the software. The alternatives of remaining three parameters; shape of lattice, shape of the map and training algorithm, are changed at a time for determining the optimal solution. The quality of the results is evaluated according to three measures; quantization error, topographic error and average distortion measure, offered by the toolbox. As it can be seen in Table 1, the optimal solution is provided by using hexagonal shaped lattice, sheet shaped map and batch training algorithm.

Table 1: Quality measures of SOM

Shape of Lattice	Shape of the Map	Training Algorithm	Quantization Error	Topographic Error	Average Distortion Measure
Hexagonal	Sheet	Batch	1.558	0.012	16.852
Rectangular	Sheet	Batch	1.565	0.012	16.869
Hexagonal	Cylinder	Batch	1.629	0.000	25.344
Rectangular	Cylinder	Batch	1.661	0.024	24.800
Hexagonal	Toroid	Batch	1.643	0.012	26.039
Rectangular	Toroid	Batch	1.666	0.048	25.082
Hexagonal	Sheet	Sequential	1.659	0.000	16.684
Rectangular	Sheet	Sequential	1.646	0.012	15.808
Hexagonal	Cylinder	Sequential	1.727	0.000	25.512
Rectangular	Cylinder	Sequential	1.730	0.000	25.503
Hexagonal	Toroid	Sequential	1.747	0.071	27.751
Rectangular	Toroid	Sequential	1.727	0.000	25.030

The number of clusters in the SOM is usually decided by visual inspection of the map. The most widely used methods for visualizing the cluster structure of the SOM are distance matrix techniques, such as U-matrix. U-matrix developed by Ultsch and Siemon (1989) reflects distances between neighbouring map units. High values of the U-matrix indicate a cluster border; uniform areas of low values indicate clusters themselves. Another visualization method is to display the number of hits in each map unit. This visualization can also be used for clustering the SOM by using zero-hit units to indicate cluster borders. These two tools are used in the determination of the number of clusters. Figure 1 shows the median distance matrix and hit histogram. The median distance matrix can be described as the summary of the U-matrix. By examining these two figures, three clusters are identified as shown in Figure 1. The first cluster is determined by examining the hit histogram, where zero-hit units are observed at the top partition of the map. These zero-hit units separate the first two rows from the other neurons, which lead to the formation of the first cluster. Since it has been observed that, the neuron in the third row has the biggest height, this neuron is re-examined, and it is found out that this increase originated due to neighbouring neuron located at the bottom adjacent part. Due to this reason, this neuron is also considered as a part of the first cluster.
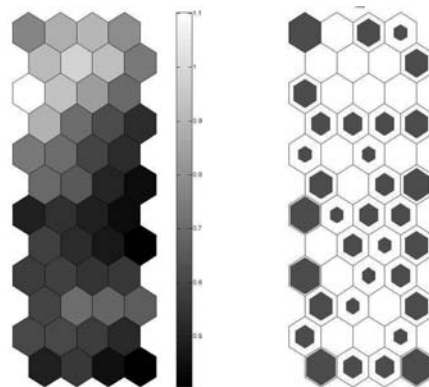
Figure 1: The median distance matrix and hit histogram

The zero-hit units can also be observed at the bottom portion of the map. Since, the extent of the boundary at the right hand side can not be determined clearly, the median distance matrix has to be examined, in order to decide the number of clusters. As the neurons located at the right portion of the third row from the bottom display lighter colours compared to its neighbouring neurons, it is decided that the border between the clusters should pass from this location.

In order to verify the findings, the method developed by Vesanto and Alhoniemi (2000) has been applied to the data set. In this method, clustering is carried out using a two-level approach, where the data is first clustered using SOM, and then, the prototypes of SOM is clustered. In the first level, a large set of prototypes-much larger than the expected number of clusters- is formed by using SOM. In the second level, these prototypes are taken as inputs. The number of clusters is determined by using the Davies-Bouldin index, a function of the ratio of the sum of within-cluster scatter to between-cluster separation. After deciding the number of clusters, K-means cluster analysis is applied to the prototypes, and the borders of the clusters are determined.

By using Davies-Bouldin index graph, the number of clusters is determined as three, which are shown in Figure 2. The borders of the clusters as obtained by visual inspection and the borders obtained from this algorithm are approximately the same. The clusters, determined by using the two-level algorithm, are decided to be used in strategic group analysis. For determining existence of the performance difference between clusters, ANOVA has been performed. According to ANOVA results, statistically significant performance differences exist between the clusters.
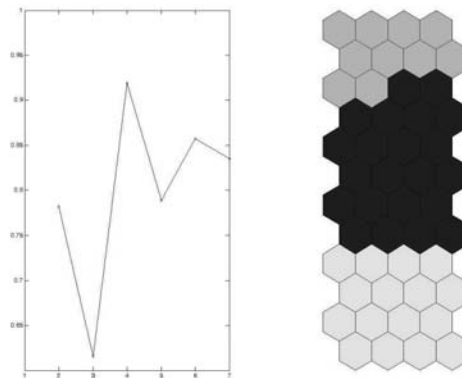

Figure 2: Davies-Bouldin index and borders of the clusters

DISCUSSION OF RESEARCH FINDINGS

The variables that show highest contribution to the separation of the clusters show a rapid change on the borders of the clusters. Upon examination of Figure 3, the mobility barriers between the first and second strategic groups are determined as the strategic planning style and experience. For the second and third strategic groups, financial resources and managerial capability are found to be the most important mobility barriers. In addition, experience is determined as an important variable that affects the separation of second and third clusters. The contributions of factors such as internationalization ratio, type of projects and clients are found to be insignificant, since there is no uniform colour distribution between the strategic groups. One can argue that strategy context is the major determinant of performance difference in

different strategic groups. According to those findings, three strategic groups exist within the Turkish construction industry.
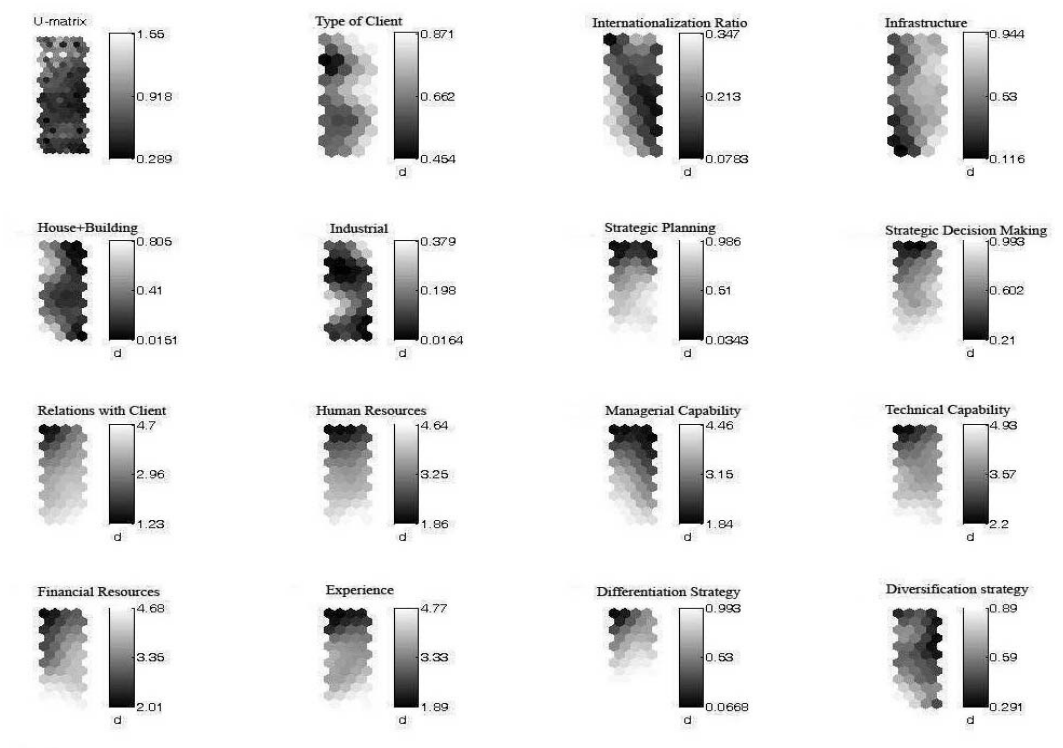
Figure 3: U- matrix and variables

Strategic Group 1: In this group, there exist 16 companies which have performance ratings in the range of 1-to-2 (on a scale of 1-5); only one company showing third level performance. This group comprises of comparatively small firms that mostly utilize a price differentiation and focus strategy. The basic difference from the other groups is that majority of firms in this group do not have a systematic and democratic strategy process. Also, they have weaknesses in terms of all sources of competitive advantage. They are especially weak in terms of client relations and experience.

Strategic Group 2: This group comprises of 35 companies. All of the strategy context variables have values in the range of 3-to-4, showing that their competitiveness is higher in all dimensions when compared with the firms in Strategic Group 1. Also, the percentage of firms having systematic strategic planning and democratic decision-making process is significantly higher. It may be argued that although majority of the firms in this group have non-price differentiation strategy, the level of resources and competencies that should backup this strategy are not very high. The performance of firms in this group is moderate and significantly higher than the performances in Strategic Group 1. The companies placed at the right side of the map (Figure 1) outperform the other companies in that group. The reason of this performance difference may originate from strong financial resources and democratic decision-making process.

Strategic Group 3: The number of firms in this group is 32. Majority of the firms in this group have a systematic strategic planning process and strategies are formulated in a democratic decision making environment. When compared to other clusters, the level of experience and client relations is significantly higher. The values of other

strategic variables regarding the strategy context, which are financial resources, technical capability, human resources and managerial capability are also very high. All of the firms in this group utilize a non-price strategy, meaning that they differentiate themselves from others in terms of quality, innovation etc. Similarly, majority of the firms are diversified into sectors unrelated to construction. The performance ratings are in the range of 4-to-5 where, only one company showing average performance (3 out of 5) places itself on the border of second and third strategic groups. This high performance may result from the exceptional level of resources and capabilities which give them the opportunity to differentiate their services from others.

CONCLUSIONS

In the light of the above given research findings; it can be concluded that types of projects conducted by a construction company, types of clients served and the level of internationalization can hardly explain the differences between the performances of firms. However, strategy development process and strategic choice may contribute to performance differences. Strategic groups are mainly determined by the level of resources and competencies. Results demonstrate that experience constitutes the major mobility barrier between different groups. This is an expected result because in many projects, amount of similar works completed is a prequalification criterion.

All of the companies in the high performance group (Strategic Group 3) are found to utilize a non-price differentiation strategy. Diversification also contributes to performance difference between the firms in different groups. Majority of the firms that belong to the highest performance group are diversified into sectors other than construction. However, amount of works in the domestic and international markets do not create a major performance difference between the firms categorized under different strategic groups. Moreover, contribution of scope of works in terms of projects and clients is not statistically significant.

Research findings may be used to propose certain strategies for the Turkish contractors. For example, a systematic and democratic strategy formulation process is found to make a significant contribution to the separation of clusters, thus, the performance levels. Similarly, firms may aim to increase their financial resources and managerial capability to promote a better performing group. The results of this study are specific for Turkish construction industry, thus can not be generalized. However, the conceptual framework and SOM used in this study may further be applied to other countries to investigate the existence of strategic groups and possible performance differences between them.

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