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Operational Criteria Evaluation for Collaboration of Innovative SMEs

İrem Düzdar*‡, Gülgün Kayakutlu**, Bahar Sennaroğlu***

* Department of Industrial Engineering, Faculty of Engineering and Architecture, İstanbul Arel University, İstanbul, Turkey
**Department of Industrial Engineering, Faculty of Management, İstanbul Technical University, İstanbul, Turkey
*** Department of Industrial Engineering, Faculty of Engineering, Marmara University, İstanbul, Turkey

‡ Corresponding Author; Address: İstanbul Arel University, Tepekent, 34537 İstanbul, Türkiye Tel: +90 850 850 2735 e-mail: iremduzdar@gmail.com

Abstract- SMEs should organize alliances with universities or other research organizations, global business companies, and other SMEs. Each type of alliance has specific risk and success criteria to be studied. SMEs need to construct successful alliances in order to have sustainable business in a competitive environment. Pre-analysis of the path for successful alliances will lead to improvements in innovative power. This study attempts to perform qualitative analysis of the SME alliances in order to express the criteria supporting the success in innovation. In this empirical study, the survey results will be extracted by literature taxonomy to categorize criteria of innovation success. These results will be analyzed by the Analytic Hierarchy Process to prioritize the innovation criteria to help any SME or large business to reduce risks in future alliances. This study will allow structuring strategic decisions based on operational criteria.

Keywords- Analytic Hierarchy Process, Innovation, Taxonomy

1. Introduction

The Organization for Economic Co-operation and Development (OECD) has defined innovation as “the implementation of a new or significantly improved product or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations” (OECD, 2009). Competitive market conditions are forcing Small and Medium Sized Enterprises (SMEs) to cooperate for innovation, but the presence of risks in the case of defining the route for success is an undeniable fact for collaborating SMEs. The stated strategic decisions of alliances must be powered by the association rules directed at innovative synergy. Innovative collaboration can be defined as cooperative arrangements engaging companies, universities, and government agencies and laboratories in various combinations to pool resources in pursuit of a shared research and development (R&D) objective (Block and Keller, 2009).

Various items that have common features can be categorized or codified into groups or clusters by taxonomies (De Jong and Marsili, 2006). In other words the reviews can be categorized by taxonomies in the base of their principal specifications (Cooper, 1982). The literature taxonomy is used for innovation collaboration factors in SMEs. In this context it is observed that the operational, managerial, financial, and technological elements of innovation need to be kept going for a long time. It is observed that there are many operational factors that are focused on the value chain as primary process for innovation as the result of the literature analysis (Poggel and Schönwetter, 2010; Singh et al., 2008; Hughes and Wood, 2000).

In this study, effective factors described by taxonomy were determined by the group decision technique. The priorities of these operational factors are evaluated using the Analytic Hierarchy Process (AHP). Based on these priorities, SMEs can define new strategies to have a competitive advantage for collaborative innovation.

2. Methodology

The most common methods of Multi Attribute Decision Making (MADM) problems are the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), AHP, and outranking. The Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) is one of the widely used outranking techniques (Bozbura et al., 2007; Yoon and Hwang, 1995).

Feng et al. (2011) used an integrated method that includes AHP, a scoring method, and weighted geometric averaging method for the selection of collaborative innovation research teams (Feng, 2011). To evaluate the inclinations and choices of the stakeholders, a specific AHP model application is used by Álvarez et al. (2013) in a distinctive social infrastructure projects.

The theory of quantifiable and intangible criteria evaluation, AHP, serves as a very useful method for Multiple Criteria Decision Making (MCDM) problems, which deal with selections and prioritization. AHP can be used to solve problems stemming from investment to resource allocation and organization planning including politics, economics, social, marketing, and management areas (Saaty and Vargas, 1994).

Assuming that we are dealing with n criteria at a given hierarchy, the procedure creates an n×n pairwise comparison matrix, **A**. The pairwise comparison is done as the criterion in row i (i=1,2,…,n) is leveled relative to each of the criteria denoted by the n columns. Letting a_{ij} define the element (i,j) of the matrix **A**, AHP uses a discrete scale from 1 to 9 for pairwise comparisons (Figure 1). For consistency, a_{ij} = k automatically means that a_{ji} = 1/k. All the diagonal elements a_{ii} of the comparison matrix **A** equal 1.

Therefore, when n criteria are being compared, n(n−1)/2 pairwise comparisons are required to complete the matrix **A** (Saaty, 1980).

Likert-type or frequency scales use fixed answer formats and are prepared for rating attitudes or ideas. These ranked measures rate the levels of agreement/disagreement (McLeod, 2008).

1	equal importance
3	moderate importance of one over another
5	strong or essential importance
7	very strong or demonstrated importance
9	extreme importance
2,4,6,8	intermediate values
Use reciprocals for inverse comparisons	

Fig. 1. AHP pairwise comparison scale (McLeod, 2008).

Consistency proves that the decision maker is showing coherent judgment in specifying the pairwise comparison of the criteria or alternatives.

Mathematically, a comparison matrix A is consistent if $a_{ij}\, a_{jk} = a_{ik}$, for all i,j, and k. This property implies that all the columns (and rows) of A to be linearly dependent. The columns of any 2×2 comparison matrix are dependent, and hence a 2×2 matrix is always consistent.

Given that human thinking is the basis for generating these matrices, some degree of inconsistency is expected and should be tolerated, provided that it is not unreasonable. To measure the consistency to see whether or not it is reasonable, the consistency ratio (CR) is used. Given **w** is the column vector of the relative weights w_i, $i=1,2,\ldots,n$, **A** is said to be consistent if, and only if,

$$\mathbf{A}\mathbf{w} = n\mathbf{w} \tag{1}$$

For the case where **A** is inconsistent, the relative weight, w_i, is approximated by the average of the n elements of row i in the normalized matrix N.

Letting $\bar{\mathbf{w}}$ be the computed estimate, it can be shown that the closer n_{max} to n, the more consistent the comparison matrix **A**.

$$\mathbf{A}\bar{\mathbf{w}} = n_{\max}\bar{\mathbf{w}} \quad , n_{\max} \geq n \tag{2}$$

The value of n_{max} is computed from $\mathbf{A}\bar{\mathbf{w}} = n_{\max}\bar{\mathbf{w}}$ by observing that the i^{th} equation is (Taha, 2003)

$$\sum_{j=1}^{n} a_{ij}\bar{w}_j = n_{\max}\bar{w}_i \qquad , i = 1, 2, \ldots, n \tag{3}$$

$$\sum_{i=1}^{n}\left(\sum_{j=1}^{n} a_{ij}\bar{w}_j\right) = n_{\max}\sum_{i=1}^{n}\bar{w}_i = n_{\max} \qquad \text{given } \sum_{i=1}^{n}\bar{w}_i = 1 \tag{4}$$

This means that the value of n_{max} can be determined by first computing the column vector $\mathbf{A}\bar{\mathbf{w}}$ and then summing its elements (Taha, 2003).

CI : Consistency index of A

RI : Random consistency index of A

CR : Consistency ratio of A

$$CI = \frac{n_{\max} - n}{n - 1} \tag{5}$$

$$RI = \frac{1.98(n-2)}{n} \tag{6}$$

$$CR = \frac{CI}{RI} \tag{7}$$

If CR is less than or equal to 0.1, then the level of inconsistency is acceptable. Otherwise, the inconsistency in **A** is high and the decision maker is advised to revise the elements a_{ij} of A to realize a more consistent matrix (Saaty, 1980).

3. Application and Results

The criteria derived from the literature review, that affect innovation on the basis of the operation is classified by knowledge. The 'Operational' group covers Operational Management, Processes Style, Production & Manufacturing Style, Service Style, Outsourcing Experience, Demand & Supply Management, Inventory Management, Quality Management, Design Operations and, Sales Management. Design Operations, Demand & Supply Management, and Production & Manufacturing Style are frequent in operational criteria (Table 1).

Table 1. Operational criteria frequency

Operational criteria	**Number of frequency**
Operational Management	**3**
Processes Style	**3**
Production & Manufacturing Style	**7**
Service Style	**4**
Outsourcing Experience	**3**
Demand & Supply Management	**7**
Inventory Management	**1**
Quality Management	**3**
Design Operations	**8**
Sales Management	**1**
Total	**40**

The factors shown in Table 1 were evaluated by five experts with AHP pairwise comparison scale. The geometric mean technique was applied to these evaluations for the group decision. The geometric mean is "the nth root product of n numbers" and can be calculated by using the following formula:

$$G = \sqrt[n]{x_1 \, x_2 \ldots x_n} \tag{8}$$

AHP technique was used to determine the relative importance of operational criteria. It was observed that inconsistency was at an acceptable level. The priorities of operational criteria according to their weights are seen in Table 2.

Table 2. Weights for operational criteria

Criterion	**Priority**
Design Operations	0.161
Demand & Supply Management	0.155
Exportation	0.112
Inventory Management	0.095
Operational Management	0.075
Marketing Activities	0.073
Working Conditions	0.068
Employment Rate	0.062
Production & Manufacturing Style	0.048
Number of Executives	0.040
Quality Management	0.030
Outsourcing Experience	0.029
Service Style	0.024
Sales Management	0.021

4. Conclusion

Design Operations and Demand & Supply Management are critical for the operational criteria. Therefore, achieving high performance in these two sub-criteria will bring competitive advantage to SMEs for innovation collaboration. These two influencers are the most important factors to distinguish the SMEs for innovation collaboration. The SMEs that have less experience in exportation because of their economies of scale will prefer to collaborate with the successful alliances in exportation for innovation. Among the other operational criteria, marketing activities have intermediate importance and sales management has minimum importance.

It must be emphasized that the criteria related to human resources have intermediate importance. This may be recognized as one of the priorities of collaborators for innovation.

As a further study, the operational criteria derived from the literature taxonomy can be compared with the other grouped criteria generated in the same manner.

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