



Operational Criteria Evaluation for Collaboration of Innovative SMEs

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Abstract

SMEs have to organize alliances with universities or other research organizations, global business companies as well as 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 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 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

Introduction

OECD has defined the innovation notion 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” [1]. The competitive market conditions are forcing Small and Medium Sized Enterprises (SMEs) to cooperate for innovation, but the presence of the 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 to the innovative synergy. The 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 share research and development (R&D) objective” [2].

Various items which have common features can be categorized or codified into groups or clusters by taxonomies [3]. In other words the reviews can be categorized by taxonomies in the base of their principal specifications [4]. 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, which are focused in value chain as primary process for innovation as the result of the literature analysis [5]-[6]-[7].

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

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Methodology

The most common methods of Multi Attribute Decision Making (MADM) problems are the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Analytic Hierarchy Process (AHP) and outranking. The PROMETHEE (Preference Ranking Organization METHod for Enrichment Evaluations) is one of the widely used outranking techniques [8]-[9].

Feng et al. (2011) used an integrated method that includes AHP, scoring method and weighted geometric averaging method for selection of collaborative innovation research teams [10]. 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 [11].

The theory of quantifiable and intangible criteria evaluation, AHP, serves as a very useful method for MCDM problems, which are dealing with the selections and prioritization. The AHP can be used to solve the problems dealing from investment to resource allocation and organization planning including politics, economics, social, marketing, and management areas [12].

Assuming that we are dealing with n criteria at a given hierarchy, the procedure create an $n \times n$ pairwise comparison matrix, $\mathbf{A}$. The pairwise comparison is done as the criterion in row i ($i=1,2,\dots,n$) is leveled relative to each of the criteria denoted by the n columns. Letting a_{ij} define the element (i,j) of the matrix $\mathbf{A}$, 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 $\mathbf{A}$ equal 1. Therefore, when n criteria are being compared, $n(n-1)/2$ pairwise comparisons are required to fill in the matrix $\mathbf{A}$ [13].

Likert-type or frequency scales uses fixed answer formats and are prepared for rating attitudes or ideas. These ranked measures rate the levels of agreement/disagreement [14].

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	

Figure 1. AHP pairwise comparison scale [13]

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

Mathematically, a comparison matrix $\mathbf{A}$ 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 $\mathbf{A}$ 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 $\mathbf{w}$ is the column vector of the relative weights w_i , $i=1,2,\dots,n$, $\mathbf{A}$ is said to be consistent if, and only if,

$$\mathbf{A}\mathbf{w} = n\mathbf{w} \quad (1)$$

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

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



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 [15]

$$\sum_{j=1}^n a_{ij} \bar{w}_j = n_{\max} \bar{w}_i, \quad i = 1, 2, \dots, n \quad (3)$$

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

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 [15].

CI : Consistency index of $\mathbf{A}$

RI : Random consistency index of $\mathbf{A}$

CR : Consistency ratio of $\mathbf{A}$

$$CI = \frac{n_{\max} - n}{n - 1} \quad (5)$$

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

$$CR = \frac{CI}{RI} \quad (7)$$

If CR is less than or equal to 0.1, then the level of inconsistency is acceptable. Otherwise, the inconsistency in $\mathbf{A}$ is high and the decision maker is advised to revise the elements a_{ij} of $\mathbf{A}$ to realize a more consistent matrix [13].

Application and Results

The criteria derived from the literature review, that affect the 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 5 experts with AHP pairwise comparison scale. The geometric mean technique was applied to these evaluations for the group decision. The geometric mean is “the n^{th} root product of n numbers” and can be calculated by using the following formula:

$$G = \sqrt[n]{x_1 x_2 \dots x_n} \quad (8)$$

AHP technique was used for determining 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

Conclusion

Design Operations and Demand & Supply Management have maximum importance 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 may be seen as the most important factors to distinguish the SMEs for innovation collaboration. The SMEs, which 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, the 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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