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Selection of technology acquisition mode using the analytic network process

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ABSTRACT

Selecting the appropriate acquisition mode for a required technology, is one of the critical strategic decisions in formulating a technology strategy. Although a number of factors were found to be influential in the choice of technology acquisition mode, it still remains a void in the literature how to make a strategic decision, based on a huge set of those factors with the help of a systematic approach. This study deals with the selection of technology acquisition mode as a multiple criteria decision making (MCDM) problem. The proposed solution to the problem in this study, is the analytic network process (ANP) approach. Since the ANP is a MCDM method that can accommodate interdependency among decision attributes, it is capable of providing priorities of alternatives with consideration of interrelationships among strategic factors. The 21 influential factors identified from the empirical studies are included as sub-criteria in the ANP model, and they are grouped into five criteria: capability, strategy, technology, market, and environment. The final decision can be made based on the resulting priorities of the alternative acquisition modes. The proposed approach is expected to effectively aid decision making on which mode is adopted for acquisition of required technologies. A case of a software company is presented for the illustration of the proposed approach.

1. Introduction

Effective formulation and implementation of technology strategy has been considered as a major driver for competitive advantage of a firm. Although much debate is still going on about how to define the scope of technology strategy, from quite specifically focusing on technology development, to very broad knowledge-based definitions [1], what the literature has in common is that technology strategy can be viewed as a process composed of a series of steps requiring strategic decisions and actions, such as acquisition-management-exploitation [1,2]. One of the critical strategic decisions in formulating technology strategy is how to acquire the required technology. Technology acquisition concerns whether to acquire technologies through internal development, cooperating with other firms of institutions, or buying the technology [3]. A variety of technology acquisition strategies (or modes) available and the complexity of modern business environments have led the decision to be intractably difficult.

Several empirical studies have been conducted to identify key determinants affecting the choice of technology acquisition mode [4–7]. However, there is a missing link between influential factors and final decisions. Although a number of factors were found to be influential in selecting the acquisition mode, it still remains a void in the literature how to make a strategic decision based on a huge set of influential factors with the help of a systematic and quantitative approach. Various approaches, based on mathematical programming, statistical analysis, or multiple criteria decision making (MCDM) methods have been proposed to aid decisions both prior to and posterior to selection of technology acquisition mode: selection

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of technologies to be acquired among identified alternatives, such as technology selection [8], R&D project selection [9], and decisions under the selected acquisition mode such as technology supplier selection [10], go/no-go decision of R&D projects [11]. However, very few systematic approaches have been proposed to selection of technology acquisition strategy, while there is a growing need of employing sophisticated mathematical modelling for such strategy selection problems.

This study deals with the selection of technology acquisition mode as a MCDM problem. In MCDM, decision makers evaluate several alternatives using multiple conflicting criteria. The decision environment of selecting technology acquisition strategy constitutes a typical form of the MCDM: selecting the appropriate option among several technology acquisition modes as alternatives by considering various influential factors as criteria. Among a variety of MCDM methods, the analytic network process (ANP) is employed in the proposed approach. The ANP is a generalisation of the analytic hierarchy process (AHP), which is one of the most widely used MCDM methods [12]. Since the ANP allows for more complex interrelationships among elements, by replacing a hierarchy in the AHP with a network, it is capable of providing priorities of alternatives that capture interrelationships among strategic factors [13]. In particular, the ANP has been proved to be useful for strategy selection problems, since strategic elements that need to be considered in decision making have interdependency to each other at most cases. The example of using the ANP for strategy selection includes business strategy [14], e-business strategy [15], knowledge management strategy [16], and national military strategy [17]. This study also employs the ANP for selection of technology acquisition strategy.

The remainder of this paper is organized as follows. Section 2 reviews the underlying methodology of the proposed approach, the ANP. The proposed approach is explained in Section 3 and illustrated with a case study in Section 4. The paper ends with conclusions in Section 5.

2. Analytic network process

The ANP is a generalisation of the AHP [12]. The AHP, also developed by Saaty [18], is one of the most widely used MCDM methods. The AHP decomposes a problem into several levels making, up a hierarchy in which each decision element is considered to be independent. The ANP extends the AHP to problems with dependence and feedback. The ANP allows for more complex interrelationships among decision elements by replacing the hierarchy in the AHP with a network [19].

Due to such advantage, recent years have seen a huge increase in the use of the ANP for various MCDM problems [20]. In addition, the ANP has been applied to decision making with the existing frameworks such as quality function deployment (QFD) [21] and balanced scorecard (BSC) [22]. Various attempts have also been made to integrate the ANP with another theory or technique such as fuzzy set theory [23,24] and mathematical programming [25,26].

The process of the ANP is comprised of the following four major steps [12,19,27]:

(i) Step 1 (model construction): A problem is decomposed into a network in which nodes corresponds to components. The elements in a component can interact with some or all of the elements of another component. Also, relationships among elements in the same component can exist. These relationships are represented by arcs with directions.

(ii) Step 2 (pairwise comparisons and local priority vectors): The elements are compared pairwisely with respect to their impacts on other elements. The way of conducting pairwise comparisons and obtaining priority vectors is the same as in the AHP. The relative importance values are determined on a scale of 1–9, where a score of 1 indicates equal importance between the two elements and 9 represents the extreme importance of one element compared with the other one. A reciprocal value is assigned to the inverse comparison; that is, $a_{ji} = 1/a_{ij}$ where a_{ij} denotes the importance of the ith element compared with the jth element. Also, $a_{ii} = 1$ is preserved in the pairwise comparison matrix. Then, the eigenvector method is employed to obtain the local priority vectors for each pairwise comparison matrix. To test consistency of a pairwise comparison, a consistency ratio (CR) can be introduced with consistency index (CI) and random index (RI). If the CR is less than 0.1, the pairwise comparison is considered acceptable. For detailed information on how to calculate CR, see the text by Saaty [18].

(iii) Step 3 (supermatrix formation and transformation): The local priority vectors are entered into the appropriate columns of a supermatrix, which is a partitioned matrix where each segment represents a relationship between two components. The supermatrix of a system of N components is denoted as the following:

$$\mathbf{W} = \begin{array}{cc} & \begin{array}{ccccc} C_1 & \cdots & C_k & \cdots & C_N \\ e_{11}\cdots e_{1n_1} & \cdots & e_{k1}\cdots e_{kn_k} & \cdots & e_{N1}\cdots e_{Nn_N} \end{array} \\ \begin{array}{cc} C_1 & \begin{array}{c} e_{11} \\ \vdots \\ e_{1n_1} \end{array} \\ \vdots & \vdots \\ C_k & \begin{array}{c} e_{k1} \\ \vdots \\ e_{kn_k} \end{array} \\ \vdots & \vdots \\ C_N & \begin{array}{c} e_{N1} \\ \vdots \\ e_{Nn_N} \end{array} \end{array} & \begin{pmatrix} \mathbf{W}_{11} & \cdots & \mathbf{W}_{1k} & \cdots & \mathbf{W}_{1N} \\ \vdots & & \vdots & \ddots & \vdots \\ \mathbf{W}_{k1} & \cdots & \mathbf{W}_{kk} & \cdots & \mathbf{W}_{kN} \\ \vdots & & \vdots & \ddots & \vdots \\ \mathbf{W}_{N1} & \cdots & \mathbf{W}_{Nk} & \cdots & \mathbf{W}_{NN} \end{pmatrix} \end{array} \quad (1)$$