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Using the fuzzy analytic network process (ANP) for Balanced Scorecard (BSC): A case study for a manufacturing firm

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ABSTRACT

Balanced Scorecard (BSC), which is used as a strategic evaluation tool, is a method of determining business performance using lagging and leading indicators on the basis of vision and strategies. The method suggests that business performance should be evaluated not only by using financial indicators but also simultaneously considering non-financial indicators. It has been revealed in the review of relevant literature that despite the satisfying levels achieved in conceptual and theoretical dimension of Balanced Scorecard, the method has some deficiencies in terms of implementation on a quantitative basis and that there remain some problems to be resolved. Subject of this study covered the measurement and evaluation dimension of BSC. In the scope of the study, BSC approach was integrated with fuzzy ANP technique so as to determine the performance level of a business on the basis of its vision and strategies. Proposed model has shown that performance indicators with different structures included in BSC approach can be consolidated with the help of fuzzy ANP technique.

1. Introduction

There are many strategic control techniques and methods aimed at evaluating – from a strategic management perspective – the results of the activities carried out by a business (Dinçer, 2004; Eren, 2002; Ülgen & Mirze, 2004). One of the methods enabling periodical and systematic system controls is the Balanced Scorecard (BSC) system developed by Kaplan and Norton (1992, 1996a). Balanced Scorecard enables expression of the vision and strategies of a business in terms of performance indicators and thus ensures establishment of the framework required for strategic measurement and management system. While underlying that traditional financial indicators are important, BSC suggests that financial indicators prove to be insufficient in explaining the business performance when they only contain the information related with the incidents that have taken place in the past. In the light of this thought, Kaplan and Norton (1996b) proposed BSC system that enables integration of the measurements regarding the past business performance with the measurements regarding the elements that will bring future performances.

Kaplan and Norton (1996a) presented four perspectives that need to be balanced in performance measurement: financial, customer, internal business process and learning and development perspectives. On the basis of this approach proposed by BSC, not only financial lagging indicators but also leading indicators such as customer, internal business process and learning and development perspectives are taken into consideration in strategic management process. Therefore, BSC acts as a strategic management system rather than an operational system that gives tactics only (Kaplan & Norton, 1996a). However, it is discussed that BSC approach has some deficiencies on a methodological basis (Abran & Buglione, 2003; Lee, Chen, & Chang, 2008; Leung, Lam, & Cao, 2006). These deficiencies are in the method to be used in consolidating BSC perspectives or the performance indicators which act as different measurement units under each BSC perspective; the method to be adopted in determining the contribution to be made by each perspective on the performance (Abran & Buglione, 2003; Lee et al., 2008); the relative weights or importance of the performance indicators under each perspective and; the method to be used in calculating the business performance with a holistic quantitative approach (Leung et al., 2006). There are some studies, though limited in number, that focused on such discussions related with the methodological aspect of BSC and tried to suggest possible answers for these discussions with the help of multi-criteria decision-making techniques (Lee et al., 2008; Leung et al., 2006; Ravi, Shankar, & Tiwari, 2005; Sohn, You, Lee, & Lee, 2003).

Sohn et al. (2003) carried out a field study on 219 Korean businesses from different sectors and examined the relation between company strategies, environmental forces and BSC performance indicators. In the scope of the study; reactor, defender, analyzer and prospector business strategies (which are classified by Miles

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& Snow (1978)) and the environmental forces such as dynamism and hostility and heterogeneity were evaluated in terms of their effects on the weights of BSC indicators. Analytic Hierarchy Process (AHP) technique was applied to calculate the weights of 20 performance indicators belonging to four main perspectives of BSC. Ravi et al. (2005), on the other hand, examined the reverse logistics problem of computers by using analytic network process (ANP) technique and BSC approach. In the concerned study, a holistic model enabling selection of alternatives in reverse logistics operations was proposed. Explaining the reason why BSC prevails over other approaches as that BSC has an integrated structure enabling evaluation of the business performance on the basis of both financial and non-financial indicators, Lee et al. (2008) pointed out that conventional BSC fails to consolidate various performance indicators. They suggested fuzzy Analytic Hierarchy Process technique (a multiple-criteria evaluation technique) as a solution for this problem. They used fuzzy numbers in their study since many evaluation problems are fuzzy and vague by their nature and BAHP can eliminate such fuzziness and vagueness. The scope of their study was limited with the evaluation of the performances shown by information technology departments of Taiwan production industry. In the model proposed with BAHP technique, weights of the 14 performance indicators under the four main perspectives of BSC were calculated. Despite the high number of studies carried out on BSC framework, Leung et al. (2006) underlined in their study the lack of studies on how to correctly implement the BSC framework. In the light of this observation, they suggested a model aimed at facilitating the implementation of AHP technique, ANP technique (which is the successor of AHP) and BSC. In the proposed model, the relationships among BSC perspectives and the weights of each perspective were determined. An example was given in the study, which was related with rewarding manager performance.

In the light of the studies carried out within the scope of BSC theoretical framework and the multiple-criteria evaluation techniques specified above; the main issue of our study was to enable determination of the business performance with a holistic approach and on the basis of the vision and strategies of the business and the perspectives and performance indicators of BSC.

There are fundamental methodological and contextual differences between our study and the other studies in the literature. In the other studies in the literature (Lee et al., 2008; Sohn et al., 2003); BSC perspectives and the weights of performance indicators were studied with AHP method according to orthogonality theory and with ANP method according to dependency theory (Leung et al., 2006; Ravi et al., 2005). In AHP and ANP studies except for the study of Sohn et al. (2003), only the weights of BSC perspectives and performance indicators were calculated (Lee et al., 2008; Leung et al., 2006; Ravi et al., 2005). In these studies, no relationship was established between BSC perspectives and performance indicators with the vision and strategies of the business on an analytical basis neither were the performance determined on the basis of such a relationship. Only the study carried out by Sohn et al. (2003) examined the effects of the strategies classified by Miles and Snow (1978) and of the environmental forces on performance indicators. The scope of the study of Sohn et al. (2003), on the other hand, did not cover evaluation of the business performance on the basis of the vision and strategies of the business. However, theoretical basis of BSC requires determination of performance indicators by taking into consideration the vision and strategies of the business (Kaplan & Norton, 1996b) as the vision has a leading function in the selection of business strategies and in the determination of business goals and objectives (Dinçer, 2004). The main contribution of our study has been the attempt to eliminate this deficiency in the related literature. This study proposed a systematic approach related with the evaluation of overall business performance on the basis of strategy-related BSC perspective and performance indicators. Thus, as suggested in the theoretical basis of BSC (Kaplan & Norton, 1992, 1996a, 1996b), early warning function that is related with the extent to which the business strategies are applied can be determined in terms of performance.

In this study, AHP and ANP were used in developing analytical structure of BSC model, which are multiple-criteria decision-making methods. AHP is a multiple-criteria decision-making method developed by Saaty (1980). AHP is a method enabling evaluation of both qualitative and quantitative variables in evaluation problems together. ANP was also developed by Saaty (1996) to eliminate the deficiencies of AHP and to increase the functionality of the latter. The main reason behind the use of AHP and ANP in this study is that fundamental hypothesis and characteristics of these methods are in line with BSC structure. Fuzzy numbers were used since fuzzy set theory (Zadeh, 1965) is generally found to be better-suited to real life than the binary logic system. Binary logic – in other words classical logic, is based on certainty theory. However, real life is quite uncertain by its nature. The results obtained by evaluating a situation or a system related particularly with human factor and human thought from a certain and absolute perspective prove inadequate in reflecting the reality (Şen, 2001, 2003).

2. Methods

2.1. Fuzzy sets and fuzzy number

Zadeh (1965) introduced the fuzzy set theory to deal with the uncertainty due to imprecision and vagueness. A major contribution of fuzzy set theory is its capability of representing vague data. The theory also allows mathematical operators and programming apply to the fuzzy domain. A fuzzy set is a class of objects with a continuum of grades of membership. Such a set is characterized by a membership (characteristic) function, which assigns to each object a grade of membership ranging between zero and one (Kahraman, Ruan, & Doğan, 2003).

A tilde '~' will be placed above a symbol if the symbol represents a fuzzy set. A triangular fuzzy number (TFN), $\tilde{M}$ is shown in Fig. 1. A TFN is denoted simply as $(l/m,m/u)$ or (l,m,u). The parameters l, m and u, respectively, denote the smallest possible value, the most promising value and the largest possible value that describe a fuzzy event.

Each TFN has linear representations on its left and right side such that its membership function can be defined as

$$\mu(x/\tilde{M}) = \begin{cases} 0, & x < l, \\ (x-l)/(m-l), & l \leqslant x \leqslant m, \\ (u-x)/(u-m), & m \leqslant x \leqslant u, \\ 0, & x > u. \end{cases} \quad (1)$$

A fuzzy number can always be given by its corresponding left and right representation of each degree of membership:

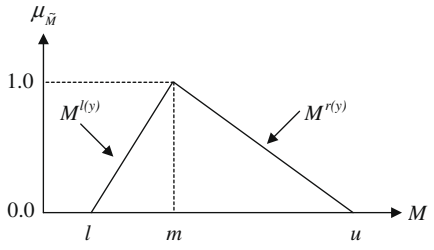

Fig. 1. A triangular fuzzy number, $\tilde{M}$.