JOURNAL OF CURRENT RESEARCH IN SCIENCE
ISSN 2322-5009
CODEN (USA): JCRSDJ
Available at www.jcrs010.com

JCRS
4 (3), 2016: 186-193

Assessment of Organizational Performance in Aluminium Conductor Production Factory Using Balanced Scorecard

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K E Y W O R D S: Aluminium conductor production factory ,BSC, Fuzzy AHP.

ABSTRACT : Balanced Scorecard (BSC) 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. This technique helps that organization to reach its goals by focusing on the organization strategies and making logical and true relations with all the organizational aspects (financial, customer, internal processes, learning and growth). In this research, a method of decision making along with BSC has been used. In order to use experts' ideas, Fuzzy AHP method has been used. In this research, a aluminium conductor production factory in Iran has been studied. In this research, BSC and Fuzzy AHP methods has been used to improve organizational performance in aluminium conductor production factory. Finally, total performance score will be calculated by multiplying the global weights and scale values of performance indicators and then by summing the resulting performance levels.

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 (Eren, 2002; Dinçer, 2004; Ülgen and 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 and Norton, 1996a). However, it is discussed that BSC approach has some deficiencies on a methodological basis (Abran and Buglione, 2003; Leung et al, 2006; Lee et al, 2008; Yüksel and Dağdeviren, 2010). 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 and 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 (Sohn et al, 2003; Ravi et al, 2005; Leung et al, 2006; Yüksel and Dağdeviren, 2007; Lee et al, 2008).

In this research, a aluminium conductor production factory in Iran has been studied. The candidate of more suitable and best conductor, for the determinrd transmission line, depends on numerous factors such as the term of power for transmission, the price of conductor, rate of structure, mechonical robust, electrical resistance and other features which are related to the conductor, among these features are: strain stress, thermal properties, reactance and capacitor. In addition of these cases, the geoghraphical terms, and environment, government acts along with othe millieu conditions all are effective on conductors candidate. In this research, BSC method has been used to improve organizational performance in aluminium conductor production factory.

Research Methodology

Balanced Scorecard (BSC)

The Balanced Scorecard (BSC) is a rather recent development in managerial accounting (Ittner and Larcker, 2001). Kaplan and Norton (1992) introduced the BSC as a performance measurement and reward system that helps link operational performance measures to the implementation and monitoring of strategy. The BSC typically consists of four sets of measures: financial, customer, internal processes, and learning and growth. Though the BSC is a compelling innovation because it incorporates strategy, process, and managers to provide an integrated system of planning and control (Atkinson et al, 1997), there is really very little credible academic evidence that it delivers enhanced performance, even on its own value-terms (see Nørreklit, 2000). Researchers have examined various explicitly cognitive biases found in the use of the BSC. Lipe and Salterio (2000) identified a common measures bias in the BSC where superiors ignore unique performance measures in favor of measures common to subordinates being evaluated. Subsequent studies have examined approaches to mitigate the common measures bias such as the use of strategically linked performance measures and strategy maps (Banker et al, 2004; Humphreys and Trotman, 2011), knowledge and training (Dilla and Steinbart, 2005), assurance and process accountability (Libby et al, 2004), and disaggregation of the assessment process (Roberts et al, 2004). Other biases examined when the BSC is used for performance evaluation include a 'selective attention to strategy effectiveness' bias (Wong-On-Wing et al, 2007), likeability bias (Kaplan et al, 2008), bias from BSC information organization (Cardinaels and van Veen-Dirks, 2010; Lipe and Salterio, 2002), and evaluator ambiguity intolerance (Liedtka et al, 2008). Cognitive biases have also been considered in the use of the BSC for strategy development and evaluation. Tayler (2010) examines the influence of motivated reasoning on projects evaluated under the BSC (Upton and Arrington, 2012).

Fuzzy AHP (FAHP) Method

A fuzzy comprehensive evaluation method (FCEM) is a quantitative scientific evaluation method, proposed by Zadeh (Gao and Hailu, 2012; Feng et al, 2014). FCEM has been widely used for multi-criteria decision making (Dağdeviren et al, 2009; Güngör et al, 2009; Lee et al, 2008). Human judgment based factors always entails subjectivity and ambiguity, and in this situation, methodology of AHP is not a suitable selection (Chan et al, 2008; Bhatti et al, 2010). To manage the issues, it is proposed to use the fuzzy set theory with the AHP method (Hu et al, 2009; Jakhar and Barua, 2013; Mangla et al, 2015). Fuzzy AHP has been successfully applied in diverse applications. Many authors have developed many variations of fuzzy AHP for evaluating fuzziness of decision making problems (Csutora and Buckley, 2001; Lee et al, 2005; Saaty and Tran, 2007; Vahidnia et al, 2009; Lee, 2009). The earliest work in fuzzy AHP appeared in van Laarhoven and Pedrycz (1983), which compared fuzzy ratios described by triangular membership functions. Da-Yong Chang (1992, 1996) introduces a new approach for handling fuzzy AHP, with the use of triangular fuzzy numbers for pairwise comparison scale of fuzzy AHP, and the use of the extent analysis method for the synthetic extent values of the pairwise comparisons. The steps of Chang's extent analysis can be given as in the following (Chang, 1992, 1996):
Step 1: The value of fuzzy synthetic extent with respect to the i-th object is defined as

$$\tilde{S}_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1}, i = 1,2,....,n \quad (1)$$

to obtain $\sum_{j=1}^{m} M_{gi}^{j}$, perform the fuzzy addition operation of m extent analysis values for a particular matrix such that

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right) \quad (2)$$

and to obtain $\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1}$, perform the fuzzy addition operation of $M_{gi}^{j} (j = 1,2, \dots, m)$ values such that

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i \right) \quad (3)$$

and then compute the inverse of the vector in Eq. (4) such that

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i} \right) \quad (4)$$

Step 2: The degree of possibility of $[M_2 = (l_2, m_2, u_2)] \geq [M_1 = (l_1, m_1, u_1)]$, is defined as

$$V(M_2 \geq M_1) = sup_{y \geq x}\left[min\left(\mu_{M_1}(x), \mu_{M_2}(y)\right)\right] \qquad (5)$$

and can be equivalently expressed as follows:

$$V(M_2 \geq M_1) = \mu_{M_2}(d) \qquad (6)$$

$$\mu_{M_2}(d) = \begin{cases} 1, & if\ m_2 \geq m_1 \\ 0, & if\ l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & otherwise \end{cases} \qquad (7)$$

where d is the ordinate of the highest intersection point D between μ_{M_2} and μ_{M_1}.
To compare M_1 and M_2, we need both the values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$.
Step 3: The degree possibility for a convex fuzzy number to be greater than k convex fuzzy numbers $M_i (i = 1,2, \ldots, k)$ can be defined by:

$$V(M \geq M_1, M_2, \ldots, M_k) = \min V(M \geq M_i), \qquad i = 1,2,3, \ldots, k \qquad (8)$$

Assume that

$$d'(A_i) = \min V(S_i \geq S_k) \qquad (9)$$
$$W' = \left(d'(A_1), d'(A_2), \ldots, d'(A_n)\right)^T \qquad (10)$$

where $A_i (i = 1,2, \ldots, n)$ are n elements.
Step 4: Via normalization, the normalized weight vectors are:

$$W = \left(d(A_1), d(A_2), \ldots, d(A_n)\right)^T \qquad (11)$$

where "W" is a nonfuzzy number.

Finding
This research has been done according to the following steps (Yüksel and Dağdeviren, 2010):
Step 1: A vision was determined by the expert team established at the beginning of the implementation and the business vision was expressed as "Becoming a preferred market brand".
Step 2: Strategies required for the achievement of the business vision were determined. At the end of this step, the following strategies were decided to be pursued:
Strategy 1 (S1): The development of research projects and more attention to research and groundworks.
S2: Diversifying the facilities, activities and packing services in order to satisfy customers.
S3: To improve after-sales service quality by widening service network.
Step 3: BSC perspectives and performance indicators were defined (table 1).

Table 1. BSC perspectives and performance indicators

BSC perspectives	Performance indicators
Financial	Cash flow (F1)
	Total assets (F2)
	Debts (F3)
Customer	Market share (C1)
	Response rate (C2)
	Sales volume (C3)
Internal business process	Percentage of waste (I1)
	Check times of inventory (I2)
	Research and development costs (I3)
Learning and growth	Staff productivity (L1)
	Per capita educational investment (L2)
	Motivation (L3)

Step 4: local weights of the strategies, BSC perspectives and performance indicators are calculated. Pairwise comparison matrices are formed by the expert team by using the scale given in table 2. Pairwise comparison matrices are analyzed by the Chang's extent analysis method and local weights are determined. The local weights for the strategies are calculated in a similar fashion to the fuzzy evaluation matrices, as shown under table 3.

Table 2. Scale of pairwise comparison (Chang's method)

Definition	Degree of importance
Equally important	(1, 1, 1)
Weakly important	(2/3, 1, 3/2)
Moderately important	(3/2, 2, 5/2)
Strongly important	(5/2, 3, 7/2)
Absolutely important	(7/2, 4, 9/2)

Table 3. Local weights and pairwise comparison matrix of strategies

Strategy	S1	S2	S3	Weights
S1	(1, 1, 1)	(2/3, 1, 3/2)	(2/3, 1, 3/2)	0.324
S2	(2/3, 1, 3/2)	(1, 1, 1)	(3/2, 2, 5/2)	0.451
S3	(2/3, 1, 3/2)	(2/5, 1/2, 2/3)	(1, 1, 1)	0.225

After the determination of the strategic priorities, BSC perspective weights were defined on the basis of these strategies. Pairwise comparison matrices developed for this purpose are presented in tables 4-6 together with the calculated weights.

Table 4. Local weights and pairwise comparison matrix of BSC perspectives with respect to S1

Perspectives	F	C	I	L	Weights
F	(1, 1, 1)	(2/3, 1, 3/2)	(7/2, 4, 9/2)	(2/7, 1/3, 2/5)	0.381
C	(2/3, 1, 3/2)	(1, 1, 1)	(2/5, 1/2, 2/3)	(2/3, 1, 3/2)	0.099
I	(2/9, 1/4, 2/7)	(3/2, 2, 5/2)	(1, 1, 1)	(2/5, 1/2, 2/3)	0.082
L	(5/2, 3, 7/2)	(2/3, 1, 3/2)	(3/2, 2, 5/2)	(1, 1, 1)	0.438

Table 5. Local weights and pairwise comparison matrix of BSC perspectives with respect to S2

Perspectives	F	C	I	L	Weights
F	(1, 1, 1)	(2/5, 1/2, 2/3)	(5/2, 3, 7/2)	(2/3, 1, 3/2)	0.307
C	(3/2, 2, 5/2)	(1, 1, 1)	(2/3, 1, 3/2)	(2/5, 1/2, 2/3)	0.236
I	(2/7, 1/3, 2/5)	(2/3, 1, 3/2)	(1, 1, 1)	(3/2, 2, 5/2)	0.221
L	(2/3, 1, 3/2)	(3/2, 2, 5/2)	(2/5, 1/2, 2/3)	(1, 1, 1)	0.236

Table 6. Local weights and pairwise comparison matrix of BSC perspectives with respect to S3

Perspectives	F	C	I	L	Weights
F	(1, 1, 1)	(2/7, 1/3, 2/5)	(3/2, 2, 5/2)	(2/7, 1/3, 2/5)	0.084
C	(5/2, 3, 7/2)	(1, 1, 1)	(3/2, 2, 5/2)	(2/3, 1, 3/2)	0.496
I	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)	(1, 1, 1)	(2/3, 1, 3/2)	0.012
L	(5/2, 3, 7/2)	(2/3, 1, 3/2)	(2/3, 1, 3/2)	(1, 1, 1)	0.408

Global weights of BSC perspectives were calculated as follows, by multiplying the weights listed in tables 4-6 with the strategy weights:

$$W_{BSC} = \begin{bmatrix} F \\ C \\ I \\ L \end{bmatrix} = \begin{bmatrix} 0.230 \\ 0.291 \\ 0.268 \\ 0.211 \end{bmatrix}$$

In the last phase of this step, local weights of the performance indicators were determined by using the pairwise comparison matrices listed in tables 7-10. The local weights calculated for performance indicators are given in the last column of tables 7-10.

Table 7. Local weights of financial

F	F1	F2	F3	Weights
F1	(1, 1, 1)	(3/2, 2, 5/2)	(3/2, 2, 5/2)	0.708
F2	(2/5, 1/2, 2/3)	(1, 1, 1)	(2/3, 1, 3/2)	0.146
F3	(2/5, 1/2, 2/3)	(2/3, 1, 3/2)	(1, 1, 1)	0.146

Table 8. Local weights of customer

C	C1	C2	C3	Weights
C1	(1, 1, 1)	(3/2, 2, 5/2)	(2/3, 1, 3/2)	0.434
C2	(2/5, 1/2, 2/3)	(1, 1, 1)	(3/2, 2, 5/2)	0.363
C3	(2/3, 1, 3/2)	(2/5, 1/2, 2/3)	(1, 1, 1)	0.203

Table 9. Local weights of internal business process

I	I1	I2	I3	Weights
I1	(1, 1, 1)	(1, 1, 1)	(3/2, 2, 5/2)	0.542
I2	(1, 1, 1)	(1, 1, 1)	(2/3, 1, 3/2)	0.285
I3	(2/5, 1/2, 2/3)	(2/3, 1, 3/2)	(1, 1, 1)	0.173

Table 10. Local weights of learning and growth

L	L1	L2	L3	Weights
L1	(1, 1, 1)	(3/2, 2, 5/2)	(3/2, 2, 5/2)	0.708
L2	(2/5, 1/2, 2/3)	(1, 1, 1)	(2/3, 1, 3/2)	0.146
L3	(2/5, 1/2, 2/3)	(2/3, 1, 3/2)	(1, 1, 1)	0.146

Step 5: In this step, dependence among BSC perspectives were determined. Interdependent weights of the BSC perspectives are calculated and the dependencies among the perspectives are considered. Dependence among the perspectives is determined by analyzing the impact of each perspective on every other perspective using pairwise comparisons. Using the computed relative importance weights, the dependence matrix of the perspectives is formed. Interdependent weights of the perspectives are computed by multiplying the dependence matrix of the perspectives we obtained with the local weights of perspectives provided in step 4. The interdependent weights of the perspectives are calculated as follows:

$$W_{BSC} = \begin{bmatrix} F \\ C \\ I \\ L \end{bmatrix} = \begin{bmatrix} 0.361 \\ 0.222 \\ 0.217 \\ 0.200 \end{bmatrix}$$

Step 6: Using interdependent weights of the perspectives (step 5) and local weights performance indicators, global weights for the indicators are calculated in this step. Global indicators weights are computed by multiplying local weight of the indicators with the interdependent weight of the perspective to which it belongs. Computed values are shown in table 11.

Table 11. Computed global weights of performance indicators

BSC perspectives	Interdependent weights	Performance indicators	Weights	Global weights
F	0.361	F1	0.708	0.256
		F2	0.146	0.053
		F3	0.146	0.053
C	0.222	C1	0.434	0.096
		C2	0.363	0.081
		C3	0.203	0.045
I	0.217	I1	0.542	0.118
		I2	0.285	0.062
		I3	0.173	0.037
L	0.200	L1	0.708	0.142
		L2	0.146	0.029
		L3	0.146	0.029

Steps 7: In this stage, performance of the organization is determined by using the global weight values of performance indicators table 11 and the linguistic measurement scale (table 12). The calculations are shown in table 13. Measure the performance indicators. Linguistic variables proposed by Cheng et al (1999) are used in this step. The memberships functions of these linguistic variables are shown on figure 1 and the average value related with these variables are shown table 12 (Yüksel and Dağdeviren, 2010).

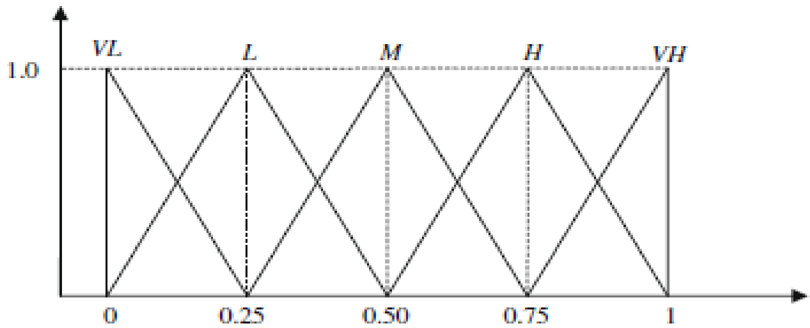

Figure 1. Membership functions of linguistic values for performance indicator rating

Table 12. Linguistic values and mean of fuzzy numbers

Linguistic values	The mean of fuzzy numbers
Very high (VH)	1
High (H)	0.75
Medium (M)	0.5
Low (L)	0.25
Very low (VL)	0

Table 13. Performance measured by using the proposed BSC–FAHP model

Performance indicators	Global weights (gw)	Linguistic evaluations	Scale value (sv)	Performance gw×sv
F1	0.256	H	0.75	0.192
F2	0.053	H	0.75	0.040
F3	0.053	H	0.75	0.040
C1	0.096	M	0.5	0.048
C2	0.081	L	0.25	0.020
C3	0.045	H	0.75	0.034
I1	0.118	M	0.5	0.059
I2	0.062	L	0.25	0.015
I3	0.037	L	0.25	0.009
L1	0.142	M	0.5	0.071
L2	0.029	M	0.5	0.014
L3	0.029	L	0.25	0.007

Total performance score was calculated by multiplying the global weights and scale values of performance indicators and then by summing the resulting performance levels.

Conclusions

Nowadays what is considered about most of the organizations is the assessment of organizational performance. One of the tools to do it is Balanced Scorecard (BSC). This technique helps that organization to reach its goals by focusing on the organization strategies and making logical and true relations with all the organizational aspects (financial, customer, internal processes, learning and growth). In this research, a method of decision making along with BSC has been used. In order to use experts' ideas, Fuzzy AHP method has been used. In this research, a aluminium conductor production factory in Iran has been studied. Total performance score was calculated by multiplying the global weights and scale values of performance indicators and then by summing the resulting performance levels.

The model proposed in the scope of this study was related with aluminium conductor production factory; however, it can also be adapted to different businesses. Modifications may be required on the proposed system due to two reasons: firstly, the components constituting the analytical structure of the proposed model – namely, strategies, BSC perspectives and performance indicators – may vary depending on the business vision. Secondly, relationships or dependencies among BSC perspectives or performance indicators may also vary. Modifications and adaptations to be made due to these two reasons will enable the use of this model in other enterprises.

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