A Performance Evaluation of Introducing Balanced Scorecard to High-tech Related Industries in Taiwan

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Abstract

Balanced Scorecard (BSC) has become the most desirable performance evaluation tool for industries in Taiwan; however, difficulty or bad performance of system introduction has occurred due to an incomplete understanding of the implementation approaches and correct objectives of the BSC system, causing the risk of cost loss. Two domestic high-tech companies in the high-tech related industry were served as the object of study in this research. The contents of four perspectives of the BSC were converted to twenty key performance evaluation indicators in terms of modern business administration as the variables in the research.

Based on the DMAIC model, the importance and satisfaction of BSC implementation factors in high-tech related industry are defined first. The performance indices of satisfaction and importance of implementing BSC are standardized by fuzzy methods for evaluation and a performance matrix with the target line and upper and lower performance control lines are established. Management can analyze the performance level and compare the performance indices and matrixes of two companies after introducing BSC according to the coordinates of satisfaction and importance of implementation factors in the matrixes. These two-dimension matrices will then be converted to one-dimension coordinates for cross performance matrices of four quadrants. Next, performance improvement strategies will be devised in accordance with the aspects of the theory of constraints. After carrying out improvement strategies, the cross performance matrix will be constructed to verify the effect and ascertain the factors of bad performance. In this way, improvement strategies can be re-devised and the most appropriate distribution of resources will be made to sustain the optimum state of ability and cost during the process of introducing the BSC system.

Requirements for a short period of time and low cost to evaluate the performance of BSC introduction can be met via this simple and convenient evaluation model presented in this research. Resources will be invested to enhance satisfaction for the implementation factors of high importance and low satisfaction. Likewise, resources will be adjusted to reduce the cost of system introduction for the implementation factors of low importance and high satisfaction. As a result, the time efficiency of introducing the BSC system will be promoted effectively.

Keywords

Balanced Scorecard (BSC), Fuzzy theory, Performance matrix, Theory of constraints (TOC)

Introduction

It has been fifteen years since Robert Kaplan and David Norton presented Balanced Scorecard (BSC) in 1992. Harvard Business Review rated it as one of the most influential management tools for business strategies for the past 75 years. According to the statistics of Fortune magazine in 2002, more than half of the top 1,000 companies around the globe employed BSC. The BSC system integrates the missions and strategies of an organization to form an all-round structure for performance measurement. Four balanced perspectives of financial, customer, internal business processes, and learning and growth are the foundation of performance management and development for businesses t o think over. This tool not only designs and reviews business strategies through four major perspectives of financial, customer, internal business processes and learning and growth, but also defines the strategic objectives, action plans and measures. Businesses may integrate internal departments via the strategic structure established by BSC to create overall performance of the organizations. Furthermore, BSC provides a tool for systematic measurement and management so that each internal department and the strategies of the organization can be integrated closely for the focused effect. The ultimate BSC does not intend to measure performance only; on the contrary, it motivates each department to participate in changes through reformations and offers systematic management methods for complete implementation.

Currently, not many domestic businesses have successfully introduced this system, which is mainly due to lack of an efficient measurement and improvement model. As a result, one simple evaluation model is proposed in this research for the management to devise strategies for improvement. Performance indices of introducing BSC will be evaluated and improvement strategies will be established via the DMAIC (Define, Measure, Analyze, Improve and Control) model and the flow chart is shown in Fig. 1 as follows:

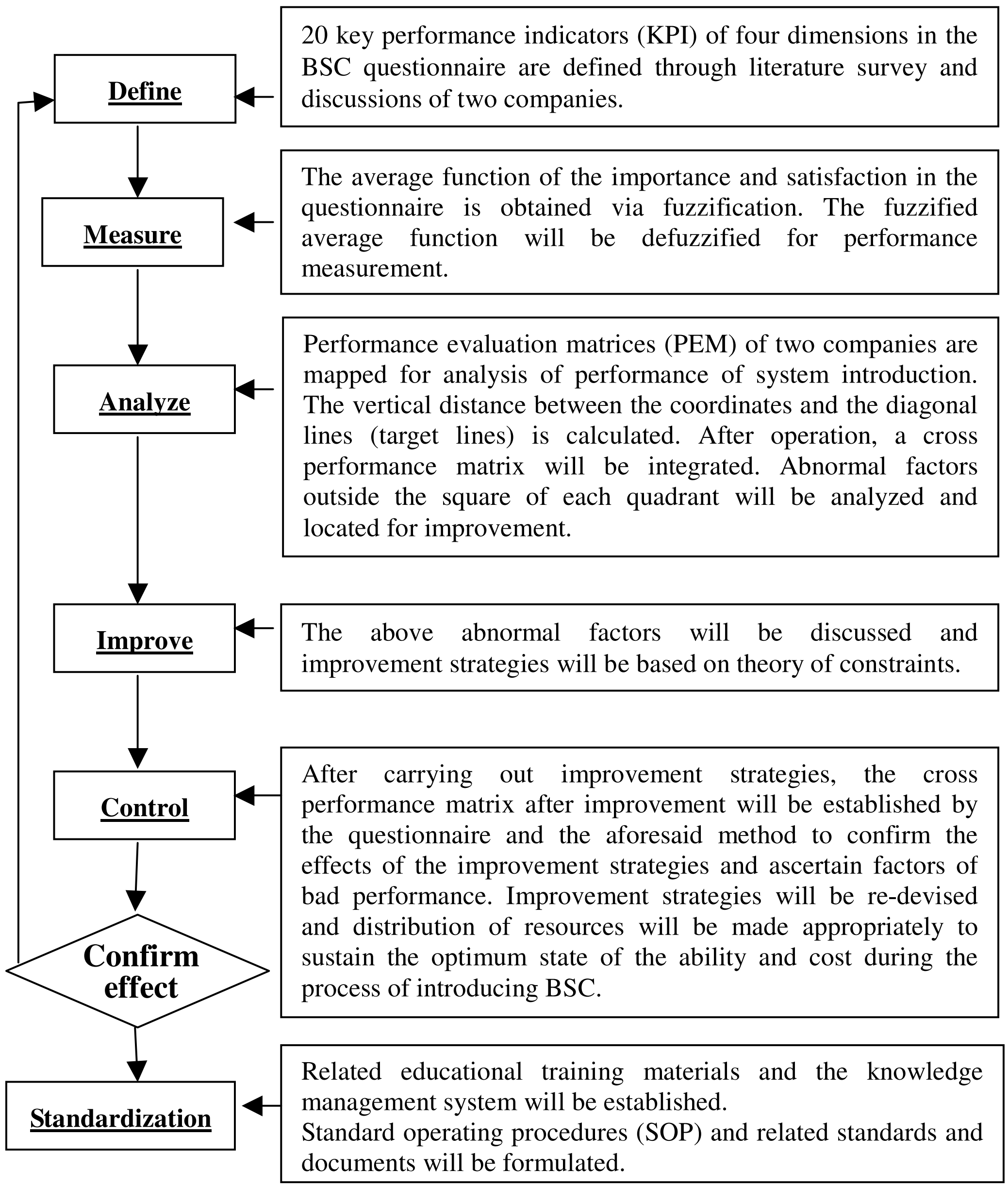

Fig. 1 Flow Chart of DMAIC

Define and Measure

Definition of questionnaire and measurement of validity

According to the core indices of the four perspectives of BSC proposed by Kaplan and Norton (2000) and discussions of two companies, 20 key performance evaluation indicators for the BSC questionnaire are concluded. There are 5 key performance indicators (KPI) for each perspective and a survey on the importance and satisfaction of each KPI is conducted. For importance of introduction, 5 points mean extremely important, 4 points for important, 3 for medium important, 2 for unimportant and 1 for very unimportant. For satisfaction of introduction, 5 points refer to very satisfied, 4 for satisfied, 3 for medium satisfied, 2 for dissatisfied and 1 for very dissatisfied.

A number of 100 surveys were issued, including 50 for company A and 50 for company B. Twenty eight questionnaires from the company A were returned and 4 were invalid, causing 24 valid questionnaires; whereas, the company B recalled 23 questionnaires and 2 of them were invalid resulting in 21 valid questionnaires. Consequently, 45 (24+21) valid questionnaires were collected representing a feedback percentage of 45%. In principle, a greater Cronbach's α means higher reliability of a questionnaire and the overall reliability coefficient was 0.8325. Nunnally (1978) considered a reliability coefficient greater than 0.7 indicated a minimum acceptable reliability. Thus, the reliability of the results from the questionnaires is highly stable and consistent.

Definition of fuzzification and defuzzification

Fuzzy Mathematical Programming. Taking limited resources, human, and financial resources into consideration, businesses always focus on the factors of high importance and low performance for improvement. Triangular fuzzy numbers are selected in this research so that the maximum grade of membership is the membership function $\mu_{\tilde{M}}(x)$ of triangular as $\tilde{M} = (c, a, b)$.

Linguistic variable. Linguistic variable proposed by Zadeh (1975) is the linguistic value of fuzzy numbers $\tilde{M}$. When 0 > a, the triangular fuzzy number can be expressed natural languages. According to Dubois and Prade (1978), a linguistic variable can be approximated by fuzzy numbers. For example; linguistic terms (very important, important, medium important, unimportant, and very unimportant) can be used to express the perceptions of an evaluator towards a certain object to be evaluated. Linguistic variables can convey these subjective judgments suitably and are usually used for handling indefinite or uncertain information. Those five linguistic weights are applied and converted to triangular fuzzy numbers with their membership functions limited to [0, 1] which is in compliance with the conversion scale of Chen et al. (1992) listed in Table 1.

Table 1 Fuzzified Linguistic Functions

Importance	Fuzzified Linguistic Variable
Very Important	(0.7 , 1 , 1)
Important	(0.5, 0.75, 1)
Medium Important	(0.3, 0.5, 0.7)
Unimportant	(0, 0.25, 0.5)
Very Unimportant	(0 , 0 , 0.3)

The basic algorithm of fuzzified linguistic variables is defined as

$\tilde{m} \oplus \tilde{n} = (m_1 + n_1, m_2 + n_2, m_3 + n_3)$ and $\tilde{m} \otimes \tilde{n} = (m_1 * n_1, m_2 * n_2, m_3 * n_3)$, where $\tilde{m} = (m_1, m_2, m_3)$ and $\tilde{n} = (n_1, n_2, n_3)$ are Triangular fuzzy numbers. Chen and Tsai (2001) developed a new approach to shorten the procedures and time required. Their approach prevented an increase in the target weight only and not in accomplishment in the weighted method. Suppose there are m decision makers. When the importance of cost factors are evaluated, the average fuzzy importance can be defined as equation (1):

$$\tilde{F}_j = \left(\frac{1}{m}\right) \otimes (\tilde{W}_{j1} \oplus \tilde{W}_{j2} \oplus \tilde{W}_{j3} \ldots \oplus \tilde{W}_{jn}) . \qquad (1)$$

Method for defuzzification. The importance of linguistic functions is fuzzified by fuzzy mathematical programming and converted t o weights by defuzzification. In short, defuzzification is a method for transforming linguistic variables or fuzzy numbers into specific values. Delgado et al. (1998) indicated it was inappropriate to use a single conversion equation for defuzzification because the calculation was simplified too much and effective verification could not be conducted. As a result, the most commonly used distance measurement method developed by Chen (2000) through the relative distance equation was adopted in this research and explained in equation (2):

$$M_i(\tilde{F}_j) = \frac{d_i^-}{d_i^- + d_i^*} \text{ , } i = 1, 2, 3, \ldots, n, \qquad (2)$$

wherein $0 \le M_i \le 1$. The best fuzzy performance is defined as $\tilde{F}_j^* = (1,1,1)$ and the worst fuzzy performance is defined as $\tilde{F}_j^- = (0,0,0)$, then we have

$$d_i^- = \sqrt{\frac{1}{3}(F_1^2 + F_2^2 + F_3^2)} \text{ and } d_i^* = \sqrt{\frac{1}{3}\left[(1 - F_1)^2 + (1 - F_2)^2 + (1 - F_3^2)\right]} .$$

Fuzzification of questionnaire and measurement of defuzzification

Step 1: Fuzzification

Five linguistic weighted terms were applied in this study. According to the conversion scale of Chen et al. (1992), the results of the questionnaire survey were converted to triangular fuzzy numbers of their membership functions limited to [0, 1]. Next, equation (1) was used for the average fuzzified result of respective questionnaire. For example, we define F_1 is the average function of fuzzified importance in item No. 1.According to equation (1), F_1 is conducted as (0.660, 0.906, 0.975). The other items are calculated in accordance with equation (1) as well which are listed in table 2.

Step 2: Defuzzification

Defuzzification is conducted by the distance measurement method derived from equation 2 of relative distance. M_i is obtained after defuzzification of F_i. For example, we define M_1 is the performance values after Defuzzification in item No.1, and the results of M_1 is 0.808. The other items are calculated in accordance with equation (2) as well listed in table 3.

After defuzzification, fuzzy performance of importance of the company A is redefined as P_I and that of satisfaction as P_S, whereas, fuzzy performance of importance of the company B is redefined as P_I' and that of satisfaction as P_S'.

Table 2 Fuzzified Average Functions

Perspective	Item	Description	Average Fuzzified Function of Importance, F_i (company A)	Average Fuzzified Function of Satisfaction, F_i (company A)	Average Fuzzified Function of Importanc, F_i (company B)	Average Fuzzified Function of Satisfaction, F_i (company B)
Financial Perspective	1	Contribution of new product and service to operating income	(0.660, 0.906, 0.975)	(0.632 , 0.767, 0.884)	(0.705, 0.937, 0.993)	(0.623 , 0.857, 0.958)
	2	Reduction of purchasing cost	(0.682, 0.930, 0.986)	(0.573 , 0.724, 0.856)	(0.696, 0.925, 0.984)	(0.689, 0.881, 0.967)
	3	Saving of operating expenses	(0.686, 0.924, 0.991)	(0.532 , 0.697, 0.823)	(0.732, 0.943, 0.996)	(0.657, 0.874, 0.961)
	4	Turnover growth rate	(0.692, 0.927, 0.993)	(0.553 , 0.711, 0.831)	(0.728, 0.939, 0.994)	(0.723, 0.927, 0.982)
	5	Product cost difference & control analysis	(0.711, 0.932, 0.995)	(0.518 , 0.721, 0.843)	(0.709, 0.940, 0.993)	(0.701, 0.903, 0.964)
Customer Perspective	6	Time of handling customer complaint	(0.297, 0.467, 0.678)	(0.687 , 0.917, 0.978)	(0.237, 0.426, 0.631)	(0.283, 0.493, 0.701)
	7	Customer satisfaction with product price	(0.268, 0.473, 0.665)	(0.217 , 0.389, 0.578)	(0.253, 0.447, 0.647)	(0.307, 0.523, 0.736)
	8	Frequency of customer complaint	(0.231, 0.427, 0.593)	(0.741 , 0.942, 0.987)	(0.246, 0.434, 0.628)	(0.297, 0.503, 0.725)
	9	Retention of regular customers	(0.257, 0.448, 0.621)	(0.237 , 0.416, 0.612)	(0.308, 0.517, 0.685)	(0.321, 0.513, 0.738)
	10	Increase in new customers	(0.226, 0.417, 0.587)	(0.324 , 0.527, 0.731)	(0.281, 0.473, 0.652)	(0.246, 0.451, 0.676)
Internal Business Process Perspective	11	Inventory management	(0.457, 0.632, 0.817)	(0.534 , 0.718, 0.873)	(0.473, 0.689, 0.895)	(0.125, 0.273, 0.438)
	12	Various yield rate analyses	(0.472, 0.658, 0.834)	(0.412 , 0.607, 0.816)	(0.489, 0.703, 0.912)	(0.367, 0.583, 0.791)
	13	Workflow standardization	(0.527, 0.713, 0.901)	(0.128 , 0.314, 0.501)	(0.526, 0.738, 0.934)	(0.138, 0.296, 0.453)
	14	Analysis of product defect rate	(0.449, 0.648, 0.826)	(0.107 , 0.253, 0.416)	(0.456, 0.661, 0.857)	(0.384, 0.597, 0.776)
	15	Numbers of successful mass production projects & patents	(0.518, 0.613, 0.837)	(0.604 , 0.767, 0.892)	(0.466, 0.678, 0.861)	(0.432, 0.642, 0.795)
Learning and Growth Perspective	16	Group performance rewards	(0.237, 0.448, 0.627)	(0.327 , 0.513, 0.679)	(0.213, 0.426, 0.643)	(0.238, 0.407, 0.562)
	17	Employee educational training	(0.213, 0.421, 0.594)	(0.302 , 0.483, 0.651)	(0.203, 0.417, 0.625)	(0.253, 0.423, 0.588)
	18	Employee productivity	(0.256, 0.462, 0.647)	(0.237 , 0.42, 0.594)	(0.258, 0.469, 0.554)	(0.327, 0.543, 0.762)
	19	Employee suggestions & frequency of adoption	(0.248, 0.419, 0.583)	(0.423 , 0.693, 0.821)	(0.232, 0.457, 0.661)	(0.318, 0.531, 0.753)
	20	Employee ability of using information facilities	(0.262, 0.473, 0.675)	(0.203 , 0.415, 0.623)	(0.246, 0.441, 0.638)	(0.344, 0.563, 0.784)

Table 3 Performance Values after Defuzzification

Perspective	Item	Description	Fuzzy Performance of Importance, M_i (company A)	Fuzzy Performance of Satisfaction, M_i (company B)	Fuzzy Performance of Importance, M_i (company A)	Fuzzy Performance of Satisfaction, M_i (company B)
Financial Perspective	1	Contribution of new product and service to operating income	0.808	0.747	0.836	0.779
	2	Reduction of purchasing cost	0.823	0.704	0.829	0.815
	3	Saving of operating expenses	0.825	0.673	0.85	0.798
	4	Turnover growth rate	0.828	0.687	0.865	0.842
	5	Product cost difference & control analysis	0.837	0.679	0.838	0.825
Customer Perspective	6	Time of handling customer complaint	0.482	0.823	0.438	0.493
	7	Customer satisfaction with product price	0.472	0.403	0.454	0.52
	8	Frequency of customer complaint	0.424	0.839	0.442	0.507
	9	Retention of regular customers	0.447	0.429	0.503	0.521
	10	Increase in new customers	0.417	0.525	0.471	0.462
Internal Business Process Perspective	11	Inventory management	0.624	0.691	0.664	0.295
	12	Various yield rate analyses	0.641	0.6	0.677	0.572
	13	Workflow standardization	0.692	0.332	0.705	0.31
	14	Analysis of product defect rate	0.628	0.277	0.641	0.577
	15	Numbers of successful mass production projects & patents	0.645	0.737	0.651	0.612
Learning and Growth Perspective	16	Group performance rewards	0.443	0.506	0.435	0.409
	17	Employee educational training	0.418	0.48	0.424	0.427
	18	Employee productivity	0.459	0.424	0.431	0.539
	19	Employee suggestions & frequency of adoption	0.423	0.63	0.456	0.53
	20	Employee ability of using information facilities	0.473	0.423	0.447	0.556

Analysis

Analysis of performance matrix

The performance evaluation model proposed by Lin et al. (2005) will be referred to in this research and a questionnaire survey designed by scales will be conducted for an understanding of performance related to introduction of the BSC system. In the performance matrix presented by Lin et al. (2005), coordinates falling within or close to the appropriate performance zone are not useful in performance diagnosis or objective judgment of implementation factors to be improved for businesses. As a result, this performance matrix was modified and the Shewhart control chart and the ideas of Taguchi method were integrated to set up a control boundary model with upper and lower control lines.

Taguchi et al. (2003) considered that the quality traits of products should be close to the target values as much as possible since a farther target value meant greater loss. That is to say, a greater performance difference stands for higher cost loss and vice versa, as shown in figure 2.

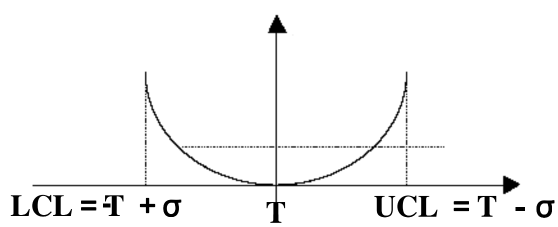

Fig. 2 Taguchi Quality Loss Curve
Data source: Taguchi et al. (2003)

Next, the performance control line was defined via the Shewhart control chart and the performance center line was set to be 0. According to Hung et al. (2003), a target value of $0 \pm 1\sigma$ was used to specify the Upper Control Line (UCL) and the Lower Control Line (LCL). Based on heuristics, 99.73% of them fell ± 3 times of standard deviation, which meant a failure rate of about 0.27%. Whereas, 95.44% of them landed within the standard deviation by ±2 times with a failure rate of 4.56%. There was about 68.26% falling within ±1 time of standard deviation, which indicated a failure rate of about 31.74%. If ±3 and ±2 times of standard deviations were applied in this study, unqualified question items would not be able to locate since there were 20 question items in this questionnaire and the failure rate was extremely low. Thus, according to the 80/20 rule (80% of the problems concentrated on 20% of items to be implemented), the standard deviation by ±1 time was used to establish the UCL and the LCL expressed as follows:

Upper Control Line UCL = $T + \sigma = \sigma$

Target of Center Line $T = 0$

Lower Control Line LCL = $T - \sigma = -\sigma$.

It is known from Fig. 3 that the total area of the square is 1 x 1 =1. If the target value of the diagonal center line is T =0, the performance matrix can be divided into two triangles with an area of 0.5 respectively. After mapping UCL and LCL, three areas will be formed and defined as an increase in resources, maintenance of status quo, and decrease in resources for differentiation.

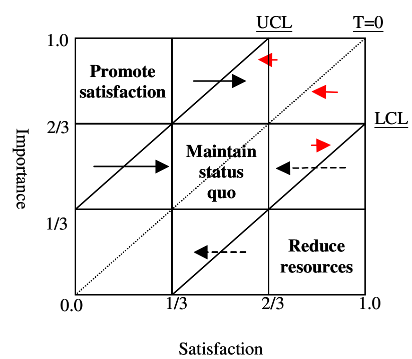

Fig. 3 Appropriate Performance Zone
Data source: Model of Lin et al (2005) modified

According to Taguchi et al. (2003), when the performance of abnormal coordinates outside UCL means satisfaction is significantly lower than importance. This implies that the insufficient performance and the performance index need to move towards the performance control boundary for improvement. Consequently, resources to be invested need to increase in order to enhance satisfaction. On the contrary, when the performance value of abnormal coordinates outside LCL means satisfaction is much higher than importance. It implies excess performance. Such performance indices should move toward the performance control boundary and resources to be invested need to decrease to prevent waste.

Population mean, μ_p, and population standard deviation, σ_p, are used to obtain the UCL and the LCL. Consequently, μ_P and σ_p can be derived via equations (3) and (4):

$$\mu_p = \frac{\sum_{i=1,j=1}^{n}(y_j - x_i)^2}{n} \tag{3}$$

$$\sigma_p = \sqrt{\frac{\sum_{i=1,j=1}^{n}(y_j - x_i)^4}{n} - \mu_\rho^{\,2}}\ . \tag{4}$$

According to the UCL and LCL defined above, equations (5) and (6) represent the UCL and LCL respectively, and target of center line, T, is set to be 0. The coordinates of UCL and LCL can be calculated through equations (5) and (6). They are:

$$\text{Upper Control Line, UCL} = \sqrt{\frac{\sum_{i=1,j=1}^{n}(y_j - x_i)^4}{n} - \mu_\rho^{\,2}}\ . \tag{5}$$

Target of Center Line, T = 0.

$$\text{Lower Control Line, } \mathrm{LCL} = -\sqrt{\frac{\sum_{i=1, j=1}^{n} (y_j - x_i)^4}{n} - \mu_\rho^{\ 2}} \ . \tag{6}$$

The coordinates and indices corresponding to performance matrices of the company A and the company B (control boundary of 1σ) are listed in tables 4 and 5.

Table 4 Coordinates & Indices Corresponding to Performance Matrix (control boundary of 1σ) of the Company A

Indices & Coordinates / Performance Matrix	UCL Coordinates (x,y)	LCL Coordinates (x,y)
Satisfaction V.S. Importance	[0 , 0.2276]	[0.2276 , 0]
	[0.7724 , 1]	[1 , 0.7724]

Table 5 Coordinates & Indices Corresponding to the Performance Matrix (control boundary of 1σ) of the Company B

Indices & Coordinates / Performance Matrix	UCL Coordinates (x,y)	LCL Coordinates (x,y)
Satisfaction V.S. Importance	[0 , 0.2074]	[0.2074 , 0]
	[0.7926 , 1]	[1 , 0.7926]

The UCL and LCL defined in tables 4 and 5 are mapped by Maple 9.5 and the values in table 3 are added into the performance matrices to locate BSC factors beyond the control boundary, as shown in figures 4 and 5. In figure 5, the Y-axis of the performance evaluation matrix (PEM) refers to the importance indicator, P_I, and the X-axis stands for the satisfaction indicator, P_S. The area between [0.0, 0.0] and [1.0, 1.0] refers to the target line as well as the most appropriate location of importance and satisfaction. The range on the right of the LCL means that satisfaction is higher than importance and resources have to be decreased to reduce cost. Whereas, the range on the left of the UCL means that satisfaction is lower than importance and resources need to be increased.

Likewise, the PEM in figure 5 will be classified in accordance with the same principle.

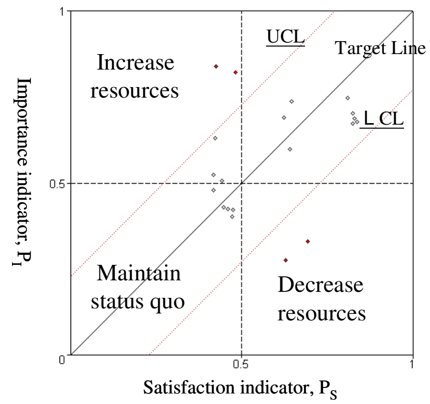

Fig.4 Performance Matrix of the Company A

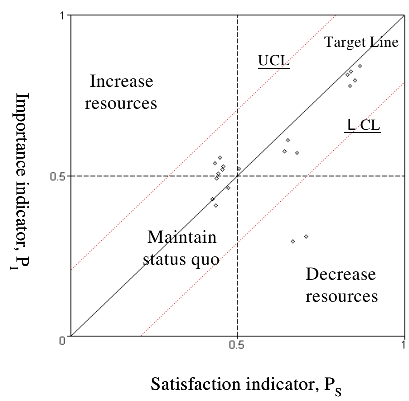

Fig.5 Performance Matrix of the Company B

Definition of cross performance matrix

Cost and appropriate performance need to be taken into consideration for system introduction. As a result, successful introduction of the BSC system not only has to maintain quality at a certain level, but also reduce the cost of introducing the system. Accordingly, strategies and the priority of various factors need to be adjusted by performance. Three strategies for the correlation between importance and satisfaction during the process of system introduction are devised in this research, which are an increase in resources to be invested to enhance ability, maintenance of status quo, and a decrease in resources to be invested to reduce cost. A cross performance matrix based on quadrants is established for a full understanding of the location of each factor and corresponding strategies as illustrated in figure 6 and explained in table 6.

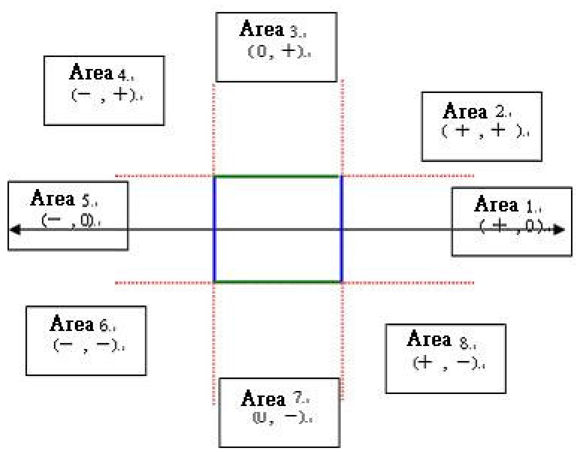

Fig. 6 Cross Performance Matrix

Table 6 Description of Cross Performance Matrix

Item	Description
Axis	X-axis for X and Y-axis for Y
Square	The line on the left of the square represents the LCL and that on the right stands for the UCL of the company A; whereas, the upper line refers to the UCL and the lower line stands for the LCL of the company B.
Area	8 areas are divided beyond the square control boundary. ”＋” means an increase in resources to be invested, “－” a decrease in invested resources to reduce cost and “0” an appropriate status without any disposition required.

If an abnormal point falls in area 1, it means that only the BSC factors of the company A are beyond the control boundary and these BSC factors require improvement and the company B stays the same. However, if an abnormal point falls in area 2, it implies that improvement is required for both companies. As a result, strategies of an increase or a decrease in resources to be invested or maintenance of status quo can be determined immediately by the coordinates of the BSC factors of both companies in the cross performance matrix.

Analysis of cross performance matrix

For establishment of a one-dimension performance matrix, the performance evaluation matrices of company A and company B need to be integrated to single performance indices. Furthermore, when the performance index of a certain factor is away from the target line, it indicates priority adjustment should be given to that performance index. Therefore, the distance between a performance coordinate and the target line is based for the evaluation here. If a performance coordinate falls on the upper left of the target line, it means that satisfaction is lower than importance due to insufficient resources invested and resources need to be increased. These performance indices requiring an increase in resources are represented by "＋". If a performance coordinate falls on lower right of the target line, it implies that satisfaction is higher than importance because of excess resources invested causing waste of cost. Consequently, resources need to be decreased for cost reduction. These performance indices requiring a decrease in resources are shown by "－". When the performance index is "0", it will fall within the target line, which means importance equals ability and with the most appropriate performance.

The vertical distance between the coordinates and the diagonal center line (target line) of these two performance matrices should be calculated first and expressed in equations (7) and (8) respectively.

$$d_{SI} = \sqrt{\left(S_i - \tfrac{S_i+I_i}{2}\right)^2 + \left(I_i - \tfrac{S_i+I_i}{2}\right)^2} = \frac{\sqrt{(I_i - S_i)^2}}{\sqrt{2}} = \frac{|I_i - S_i|}{\sqrt{2}} . \tag{7}$$

$$d_{S'I'} = \sqrt{\left(S'_i - \tfrac{S'_i+I_i}{2}\right)^2 + \left(I_i - \tfrac{S'_i+I_i}{2}\right)^2} = \frac{\sqrt{(I_i - S'_i)^2}}{\sqrt{2}} = \frac{|I_i - S'_i|}{\sqrt{2}} . \tag{8}$$

Next, make $x = (I_i - S_i)$, $y = (\mathrm{I}'_i - S'_I)$ and substitute them in equations (7) and (8). Obviously, $|x| = |y| = \sqrt{2}d_{SI} = \sqrt{2}d_{S'I'}$ and $-1 \leq x, y \leq 1$ are within -1 and 1 as listed in table 7.

Table 7 Distance Performance Indices between *x* & *y* for Importance and Satisfaction of All Factors

BSC Implementation Factor	*x*	*y*
1. Contribution of new product and service to operating income	0.061	0.057
2. Reduction of purchasing cost	0.118	0.014
3. Saving of operating expenses	0.152	0.052
4. Turnover growth rate	0.141	0.023
5. Product cost difference & control analysis	0.158	0.014
6. Time of handling customer complaint	**-0.341**	**-0.055**
7. Customer satisfaction with product price	0.068	-0.066
8. Frequency of customer complaint	**-0.415**	**-0.066**
9. Retention of regular customers	0.018	-0.018
10. Increase in new customers	-0.107	0.009
11. Inventory management	**-0.067**	**0.369**
12. Various yield rate analyses	0.041	0.105
13. Workflow standardization	**0.360**	**0.394**
14. Analysis of product defect rate	**0.351**	**0.064**
15. Numbers of successful mass production projects & patents	-0.092	0.038
16. Group performance rewards	-0.063	0.026
17. Employee educational training	-0.063	-0.003
18. Employee productivity	0.036	-0.108
19. Employee suggestions & frequency of adoption	-0.208	-0.075
20. Employee ability of using information facilities	0.050	-0.109

The "*x*" value in table 7 refers to the importance-satisfaction performance index of each BSC factor in the company A. If "＋" shows up, it means that resources invested are insufficient and need to be increased to enhance satisfaction. If "－" appears, it indicates that excess satisfaction and resources need to be decreased to reduce cost. If "0" is shown, it represents a suitable state within the control boundary and no disposition is required. The "*y*" value in the above table refers to the importance-satisfaction performance index of each BSC factor in the company B and the interpretations of symbols "＋", "－", and "0" are the same as above. Next, *x* will be served as the *x*-coordinate and *y* as the *y*-coordinate of the cross performance matrix. The square area and 4 quadrants will be established in accordance with the UCL and LCL diagonals in Fig. 4 and 5. Three symbols of "＋", "－", and "0" represent suggestions for strategies in each quadrant. "＋" means inadequate satisfaction and resources need to be invested; "－" refers to excess satisfaction and resources to be invested need to be decreased to reduce cost and "0" indicates a proper status not beyond the control boundary and no disposition is required. The cross performance matrix established in this research follows the rule bellow and is shown in figure 7.

1. Transverse axis with a cross arrow is the X-axis and vertical axis is the Y-axis
2. X-axis is for factor evaluation of increase or decrease in resources for the company A
3. Y-axis is for factor evaluation of increase or decrease in resources for the company B.

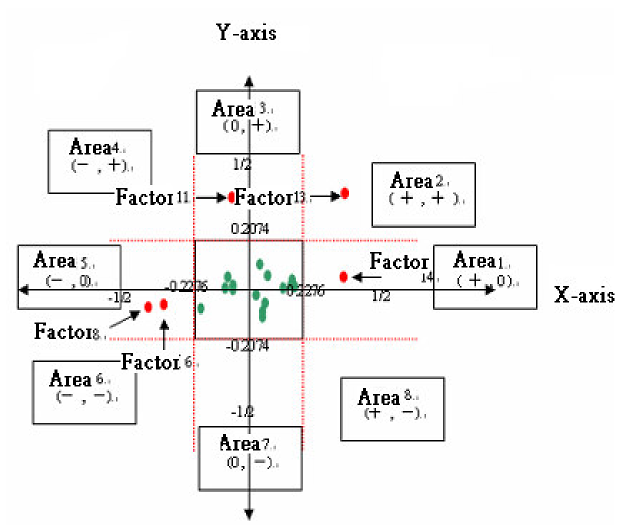

Fig. 7 Cross Performance Matrix

It can be found in figure 7 that there are five factors outside the control boundary, which are factors 6, 8, 11, 13 and 14. The descriptions of all five factors are listed in table 8.

Table 8 Area Distribution and Abnormal Factors		
Factor No.	Abnormal Factor	Cause
14	Analysis of product defect rate	x is beyond the control boundary and y falls within the control boundary. Company A needs to increase resources to be invested after evaluation.
13	Workflow standardization	x and y are outside of the control boundary. Company A and company B need to increase resources to be invested following the evaluation.
11	Inventory management	x is within the control boundary and y is beyond the control boundary. Company B needs to increase resources to be invested after evaluation.
6	Time of handling customer complaint	Company A needs to decrease resources to be invested after evaluation.
8	Frequency of customer complaint	Company A needs to decrease resources to be invested after evaluation.

Project Improvement and Control

Resources to be invested need to increase in factor 14 for Company A and resources also need to increase in factor 11 for Company B. Both companies need to increase resources for improvement in factor 13, which clearly implies that the abnormal point of both companies concentrates on the internal process perspective. The theory of constraints will be applied to three issues: What will it be when it is changed? What will be changed? How to change? These three consecutive improvement steps will be based on the decisions of internal process improvement. The strategies of improving factor 14 in company A are listed as follows:

1. Current Reality Tree: Main problems of status quo will be located. The steps are:

(1) Describe the reality of bad effects resulting from current implementation via intuition and experience in logical thinking, and clarify the most influential adverse factors, which are also the core problems of the system to be improved first.

2. Future Reality Tree: The future reality tree shows the ideal to be achieved; i.e., to accomplish the desirable objective by transforming bad effects into positive effects. The steps are:

(1) Problems are manifested through the aforesaid current reality tree and the extent, direction, and any possible improvement projects for future growth are searched via the relation between cause and effect.

(2) All improvement projects, advantages, and future ideal objectives are collected and interconnected for establishment of the future reality tree.

3. Transition Tree: The main purpose of transition tree is to establish principles for implementation and action plans in compliance with intermediate targets. The steps are:

(1) Obstacles of intermediate targets encountered will be overcome and action plans are devised in accordance with intermediate targets.

(2) Intermediate targets, improvement projects, and implementation principles will be connected by cause and effect.

The processes of improving factor 14 in company A are shown in figures 8, 9, and 10.

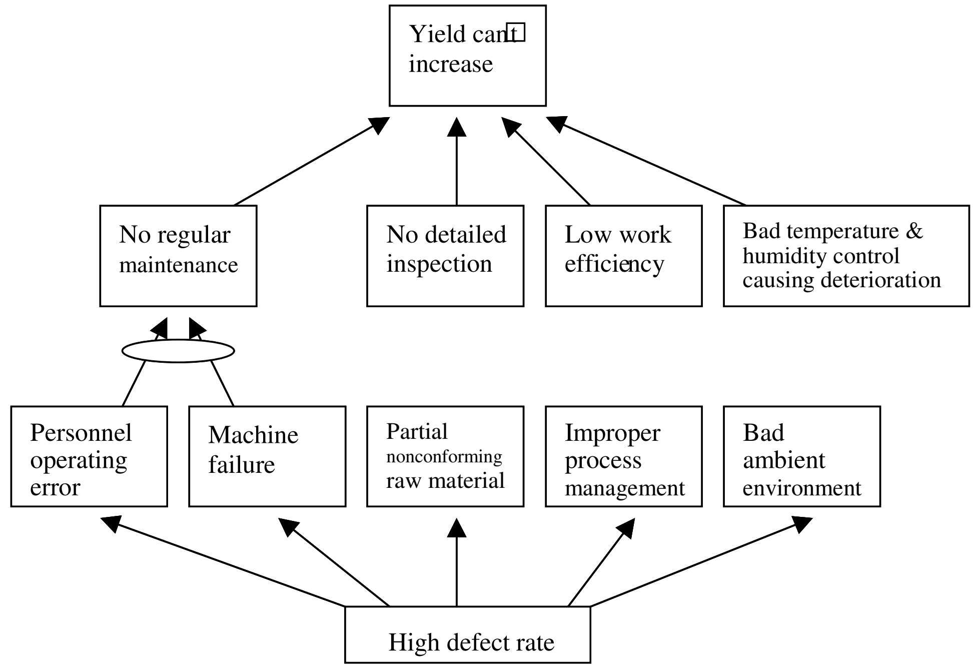

Fig. 8 Current Reality Tree of the Factor 14 in the Company A

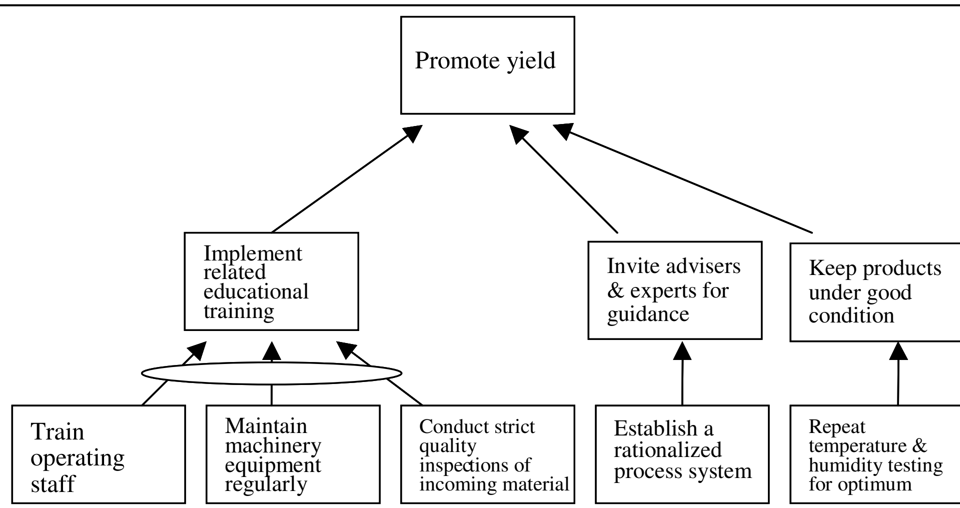

Fig. 9 Future Reality Tree of the Factor 14 in the Company A

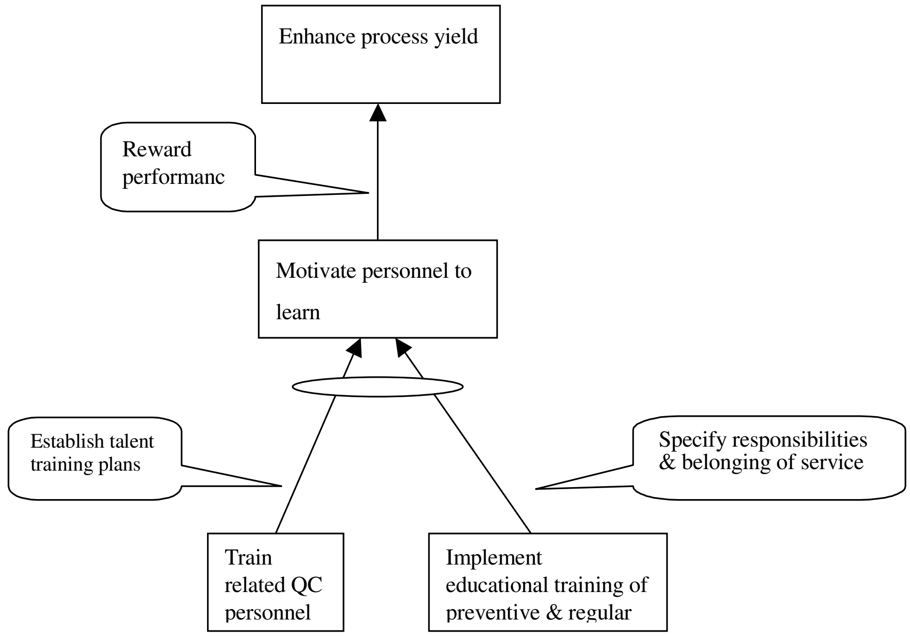

Fig. 10 Transition Tree of the Factor 14 in the Company A

Improvement strategies for factor 14 in company A are proposed according to the theory of constraint and integrated with factor 13 listed in table 9.

Table 9 Improvement strategies for factor 14 & 13

Factor No.	Factor	Problem	Solution	Back-up Measure
14	Analysis of product defect rate	Locate the problem with 4M1W.	Carry out related educational training and invite advisers and experts for guidance.	Specify responsibilities and belonging of service personnel and reward performance.
13	Workflow standardization	Process reengineering not implemented	Analyze business process and apply the concepts and methods of business process reengineering for organizational and workflow reengineering.	Establish a project team with members of executive supervisors. Communicate with executive supervisors often to get their trust and support.

After carrying out the aforesaid improvement strategies, the cross performance matrix will be set up in compliance with the questionnaire and the methods mentioned earlier to confirm the effects of these improvement strategies and ascertain the related factors of bad effects. In this way, improvement strategies can be re-devised and the most suitable distribution of resources can be made for the optimum state of ability and cost during the process of introducing the BSC system. The cross performance matrix after improving factors 13 and 14 of company A is shown in figure 11. From figure 11, we can see the change of performance indices of factor 13 and 14 between the improvement before and after (just from the circle point transfer to the star point).

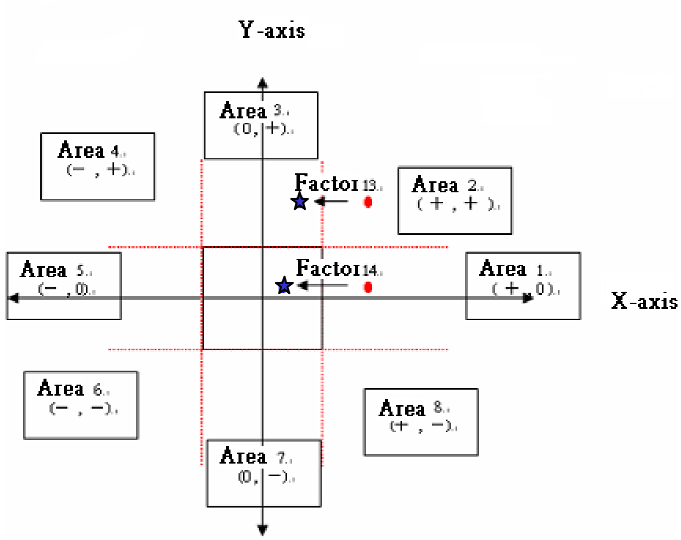

Fig. 11 Cross Performance Matrix following Improvement

The effects are quite significant after improvement. Points that are used to be outside of the square area are moved into the control boundary. The theory of constraint developed a thinking process of logical tree concerning these three improvement procedures by specific logical reasoning and analysis of every link, event and causal relationships among various limited adverse factors in the system.

Conclusion

The Harvard Business Review rated Balanced Scorecard as one of the most influential management tools for business strategies in the past 75 years. This tool not only designs and reviews business strategies through four major perspectives of financial, customer, internal business processes, and learning and growth, but also defines strategic objectives, action plans, and measure indices. Businesses may build the strategic structure and integrate internal departments via BSC to create the overall performance of the organizations. Furthermore, BSC provides a tool for systematic measurement and management so that each internal department and strategies of the organization can be integrated closely for the focused effect. The ultimate BSC does not intend to measure performance merely; on the contrary, it motivates each department to participate in changes through reformations and offers systematic management methods for complete implementation.

Perspectives of management performance are evaluated and compared by the balanced scorecard in this research. The management can measure the performance level and compare the performance indices and matrixes of themselves and the benchmarking companies according to the areas formed by the coordinates of satisfaction and importance and the target line in the performance matrixes. These two matrices of two-dimension coordinates are converted to a cross performance matrix of one-dimension coordinates with four quadrants. Improvement will be based on the theory of constraints and strategies for system performance improvement will be devised. Improvement decisions will be made in compliance with the process of the theory of constraints and problems will be located continuously for improvement to enhance the competitiveness of introducing BSC. Upon carrying out improvement strategies, a cross performance matrix following improvement will be constructed to verify the effects of these improvement strategies and find out the related factors of bad effects. As a result, improvement measures can be re-devised and the most suitable distribution of resources can be made for the optimum state of ability and cost during the process of introducing the BSC system.

The management may define and measure the factors rapidly and efficiently through the definitions, measures, analysis, improvement, and control model provided in this research when introducing the BSC system. Next, they may locate the critical and to be improved factors (inadequate and excess resources) for improvement and control in accordance with the performance indices of importance and satisfaction. In this way, the BSC system will be introduced under the requirements of economy and effectiveness and business competitiveness will be promoted. Improvement decisions will be made via the theory of constraints to locate problems for continuous improvement and enhancement of competitiveness of BSC introduction.

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