

A Strategic Model for Consolidating BSC Measures Based on the Desirability Function: A Case Study of a Website Company

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Abstract: *Following the idea of “what you measure is what you get,” this paper discusses the necessity to improve managing and planning firms’ service based on performance evaluation. The Balanced Scorecard (BSC) has been used as a tool for suggesting measures that can evaluate performance of a company by considering both financial and non-financial perspectives. The current BSC technology does not provide techniques to formally define, verify, implement, consolidate and analyze the performance measures. Therefore, we developed a model for deriving and analyzing the BSC score. This model provides a normalization process to reflect characteristics of the BSC performance measure and a computation process to derive the total score. The model proposed in this paper would provide executives with the single total score as well as the corresponding information model for interpreting the information provided. The model developed here consists of the following three phases: collection phase, calculation phase and decision making phase. The suggested model is illustrated through a case study in each phase. The results of the case study proved usefulness of our model.*

1. Introduction

In today’s strong competitive environments, availability of the right information at the right time based on performance evaluation has become critical [2]. Therefore, It is essential to improve managing and planning firms’ service based on performance evaluation [1], because “what you measure is what you get” [14].

No single measure about finance can provide a clear performance target or focus attention on the critical areas of the business [14]. So, the balanced scorecard (BSC) presents managers with four different perspectives from which to choose measures. It complements traditional financial indicators with measures of performance for customers, internal processes, and learning and growth activities [16]. Therefore it enables companies to track financial results while simultaneously monitoring progress in building the capabilities and acquiring the intangible assets they would need for future growth [17] [25] [26].

The continuous process centered on the BSC combines the four processes; clarifying & translation the vision & strategy, communication & linking, planning & target setting, strategic feedback & learning [15]. To implement the part of strategic

feedback and learning in the four processes to form a cycle, it is essential to derive the total score that helps a company to know its strategic achievement level [1]. By comparing the total score at different time stamps, we can identify the core problems of the company. Furthermore, if we analyze the differences of the normalized value between divisions in a company based on the BSC measure, we can know the efficiency and effectiveness of each division.

However, the units of the BSC performance measure differ depending on a certain perspective. For example, the unit of the BSC performance measure related to cost or benefit in the financial perspective is in dollars, while the unit related to customer satisfaction in the customer perspective is in the form of a rating, since customer satisfaction is evaluated through a survey. Likewise, other units differ from one perspective to another since those perspectives have different characteristics. This discrepancy in the units causes problems when calculating the total score.

Even though any performance measures above the minimum value would be acceptable, management might find the values considerably above the minimum value highly desirable. On the other hand, having the value of the performance measures considerably above the minimum value are not of critical importance.

Managers consider that all performance measures are important at the same level. In fact, some of the measures critically influence the strategic accomplishment, while the other measures do not have a direct effect. So, considering the characteristics of performance measures for consolidating the normalized value is needed.

However, in the existing BSC evaluation model, authors suggested a relative satisfaction level of BSC perspectives [18] as well as consolidating methodology without considering normalization methods that would reflect the characteristics of the BSC performance measures [1]. Therefore, we will develop the methodology for deriving the BSC total score the results of which will provide a normalization process to reflect the characteristics of the BSC performance measure and a computation process to derive the total score. The availability of the total score could, in turn, lead to the establishment of standard sets of consolidated measures and to the institutionalization of internal-external benchmarking practices. Furthermore, organization can establish strategy and find the critical part to achieve their strategy based on the normalized value and the total score.

This paper is organized as follows. First, section 2 of the paper covers the existing BSC evaluating model and the consolidating model for computing the total score. The model for deriving the BSC total score is developed in section 3. The suggested model is illustrated through a case study in sections 4, 5, 6. Finally, we conclude our study with emerging issues in the area of deriving the total score.

2. Literature Review

In almost research related with the BSC, the BSC was viewed as an instrument for translating an abstract vision and strategy into specific measures and goals [10] [18] [20] [21] [23]. Sohn et al., [30] explored the relationship between corporate strategies, environmental forces, and the weighting of the BSC performance measure.

Geisler [9] presented an integrated cost-performance model to consolidate cost and

performance assessment of research and development evaluation (R&D). To suggest the overall index, each indicator was measured by a small set of measures using the same unit. However, the model was too over-simplified to adequately reflect the multi-dimensional nature of the performance. Thus, the type of model does not meet the analytical requirements of management when various viewpoints must be taken into account simultaneously, since the BSC performance measure has different unit. Buglione and Abran [4] proposed the Quality factor + Economic, Social, and Technical dimensions (QUEST) nD model to obtain a richer multidimensional, combined view of performance measurement. Abran and Buglione [1] used a software performance measurement model, the QUEST nD for consolidating value of the BSC performance measure. Based on the QUEST model, the single perspective value and the overall BSC value were developed. However, the combination of the upper threshold, the lower threshold and the real value solely does not reflect the characteristics of each BSC performance measure in the normalization process. An objective of BSC performance measures classified into three types: a larger-the-better (LTB)-type objective, a smaller-the-better (STB)-type objective and the nominal-the-best (NTB) type [13]. And, despite the same value if the measures, the normalized value can be different according to the manager decision. The main intention of the methodology proposed in the following sections is to overcome these deficits.

3. Proposed model

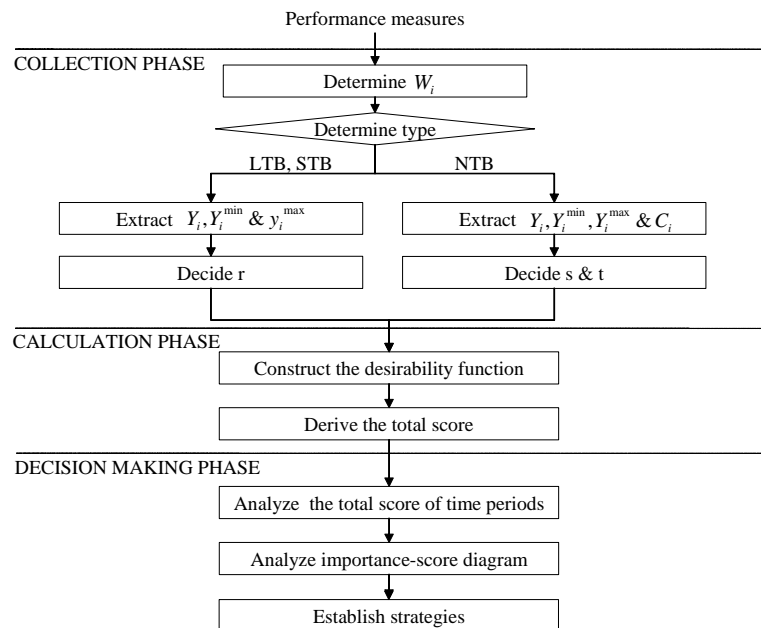


Figure 1. The model for deriving the BSC total score

We developed a model for acquiring the normalized value to reflect the characteristics

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of each performance measure and for deriving the total score, based on the desirability function. The model developed here consists of the following three phases: collection phase, calculation phase & decision making phase.

The model for deriving the BSC total score is a process that assesses the effectiveness of a company. As [Figure 1] shows, the first phase in this process is to investigate the value related to performance measure. Once this process is completed, the next step is to survey how much each measure influence strategic objectives. Based on the relative weight and the real value of the performance measure, the next phase is to calculate the desirability value by the use of the desirability function. The geometric mean of the desirability value becomes the total score. In the last phase, compared to different total scores of each time period or to the total score of another company, the total score demonstrates the level of effectiveness of a company. Furthermore, this model can show the core parts of a company to where a certain strategy is necessary to be applied using the importance-score diagram. Based on this information, a company can establish the strategy to gain competitive advantage.

4. Collection phase

The company (further denoted as company M) is an entertainment portal that provides multimedia e-cards, music videos, advertising, flash games and animation. As a preliminary study, we interviewed the president of company M in order to collect background information about the company. Data collection was undertaken from October 2000 to December 2001, through interviews, internal questionnaires, and Web log analysis. Time related data, such as revenue, sales, cost, and site traffic, were collected during 1 year. The measures were used according to the specific mission and goals of company M. Among the six perspectives, some metrics of customer perceived value and the Web site interface was evaluated by a questionnaire. A ten-point scale response format, which ranged from 1 (highly dissatisfied) to 10 (highly satisfied), was provided. The questionnaire was sent to 250 randomly selected customers of company M and 52 responses were returned.

4.1. Determine w_i

The relative weights for the performance measure can be calculated using the Analytic Hierarchy Process (AHP) [27]. The AHP method directs how to determine the priority of a set of alternatives and relative importance of attributes in a multiple criteria decision making problem. . The AHP has been recommended as a useful decision-making approach [8].

In our study, we used the AHP since the BSC performance measures have hierarchic structure. Following the AHP procedure, first, six questions are asked for pair-wise comparing of the BSC perspectives (Business value, operation excellence, customer value, management and maintenance, web site interface, learning and innovation). Next, questions are asked to compare pairwise performance measures under each perspective [27]. It is essential to check the consistency ratio (CR) since the CR is larger than 0.1 is normally considered to be unacceptable [28]. The relative weights

and the CR for each BSC performance measure were then calculated using Expert Choice, developed by Expert Choice, Inc. (2000).

We surveyed 40 employees and experts to acquire the relative weight of each performance measure. Because the CR was larger than 0.1 for 12 points of the survey data, these 12 observations were not considered when calculating the relative weights. The average w_i is produced based on Equation 1.

$$w_i = \frac{\sum_{j=1}^{22} r_j}{22} \dots (1)$$

r_j : The relative weight of j-th respondent

4.2. Determine type

Harrington [11] first proposed a simple form of the desirability function. Derringer and Derringer [6] extended Harrington's approach by suggesting a more systematic transformation scheme. To use the desirability function for normalizing performance measures based on their characteristics, the types of the performance measures should be determined according to the objective type.

For an objective to be maximized, which is called a larger-the better (LTB)-type objective, the desirability function is defined by Equation 2. A smaller-the better (STB)-type objective can be easily transformed based on Equation 3. Another type of objective is called the nominal-the-best (NTB) type. Unlike an LTB or STB-type, the best value of an NTB type objective exist in the middle of its range. The desirability function for an NTB-type objective can be defined by Equation 4 [13]. We determined a type of the performance measure in accordance with their objective type: LTB, STB and NTB.

4.3. Extract $y_i, y_i^{\min}, y_i^{\max}, c_i$

To acquire the real value, the minimum acceptable value, and the highest value of each performance measure, a data source such as a data base, secondary reports, a survey or an interview should be investigated. The minimum value and the highest value are acquired by a decision maker's estimation. In addition to these values, if the type of the performance measure is an NTB, the most desirable value is obtained based on judgments of decision maker [5].

4.4. Decide r, s & t

The factors r, s, and t describe the shape of the desirability function. The selection of a suitable value of r offers the user flexibility in the definition of desirability function [3]. It may be reasoned that all times less than the highest value make the measure much less desirable and this would lead to a curve such as that obtained with $r = 3$. On the other hand, it might be reasoned that anything higher than lower acceptable value becomes rapidly more desirable and this would then require a desirability

function such as that with $r = 0.3$. It is up to the user to decide. That is, the values of the factor r , s , and t are decided by the user and experts.

Based on the survey of 5 experts, we determined r , s and t , and the type of the BSC performance measure.

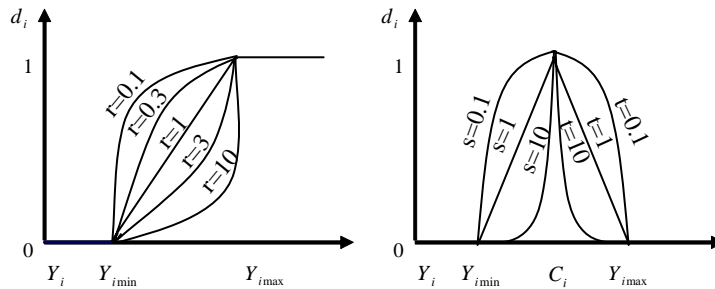


Figure 2. Graph of transformation for various value of r , s , and t [6]

5. Calculation phase

The desirability function involves transformation of each estimated response variable y_i to a desirability value d_i , between $d_i = 0$, for a completely undesirably value, to $d_i = 1$ for a fully desired response, above which further improvements would have no importance [7]. The desirability value denotes a normalized parameter representing the distance between the estimated response and its target in units of the maximum allowable deviation. The bounds on a response (y_i^{\min} and y_i^{\max}) should be specified in advance according to the specification limits of the product or process, or the subjective judgment of the decision makers. The overall desirability D , another value between 0 and 1, is obtained aggregating the individual desirability value. The desirability function has been proven to provide a reasonable and flexible representation of human perception [5] [19], [20] and is analytically convenient. And this makes it possible to combine result obtained for properties measured on different scale [13].

5.1. Construct the desirability value

The desirability value of each performance measure can be acquired based on Equation (2), (3) and (4). [Table 1] shows that these values vary between 0 and 1. If the value of performance measure (y_i) is equal to, or below, the lowest possible limit set for that criterion, then $d_i = 0$. If y_i is higher than, or equal to, the highest possible limit set for that criterion, then $d_i = 1$. Here 0 indicates a completely unsatisfactory result, whereas 1 indicates that the required level of response has been reached.

There are three types of transformations possible, LTB, STB and NTB. The NTB and STB transformation (Equation (2) and (3)) are applied to the cases where the target of the performance measure is either the minimum value or the maximum value. In addition to these transformations, the NTB transformation is applied to the cases where the target of the performance measure is nominal. [Table 1] shows the

calculation results of the desirability function of each performance measure.

$$d_i = \left[\begin{array}{c} 0 \\ \left(\frac{Y_i - Y_i^{\min}}{Y_i^{\max} - Y_i^{\min}} \right)^r \\ 1 \end{array} \right] \left[\begin{array}{c} \text{if } (Y_i \leq Y_i^{\min}) \\ \text{if } (Y_i^{\min} < Y_i < Y_i^{\max}) \\ \text{if } (Y_i \geq Y_i^{\max}) \end{array} \right] \dots (2) \quad d_i = \left[\begin{array}{c} 0 \\ \left(\frac{Y_i - Y_i^{\max}}{Y_i^{\min} - Y_i^{\max}} \right)^r \\ 1 \end{array} \right] \left[\begin{array}{c} \text{if } (Y_i \geq Y_i^{\max}) \\ \text{if } (Y_i^{\min} < Y_i < Y_i^{\max}) \\ \text{if } (Y_i \leq Y_i^{\min}) \end{array} \right] \dots (3)$$

$$d_i = \left[\begin{array}{c} \left(\frac{Y_i - Y_i^{\min}}{C_i - Y_i^{\min}} \right)^s \\ \left(\frac{Y_i - Y_i^{\max}}{C_i - Y_i^{\max}} \right)^t \\ 0 \end{array} \right] \left[\begin{array}{c} \text{if } (Y_{i\min} \leq Y_i \leq C_i) \\ \text{if } (C_i < Y_i \leq Y_{i\max}) \\ \text{if } (Y_i < Y_{i\min}) \\ \text{or } (Y_i > Y_{i\max}) \end{array} \right] \dots (4)$$

- d_i : The desirability value
- y_i : The real value of i th performance measure,
- y_i^{\min} : The minimum acceptable value of y_i
- y_i^{\max} : The highest value of y_i
- c_i : The most desirable value of y_i
- r, s, t : Variables for determining relationship between y_i and desirability value [6]

Table 1. Desirability value of the performance measure

Performance measure	Desirability value	Performance measure	Desirability value
# of employee	0.707106781	Revisit possibility	0.039751648
Asset	0.632288595	Total cost for managing the web site	0.992387564
Net Sales	0.104100534	Frequency of contents update	0.577350269
Ordinary Profit	0.000742447	Total Cost for web site promotion	0.378929142
The % of appropriate response to Customer inquiry	1	# of specific events for promotion	0.037037037
Avg. Delivery time after order fulfillment	0.64	Security Level	0.07776
Response time to customer inquiry	1	Usability	0.11139497
# of response channel to customer inquiry	0.333333333	Attractiveness	0.181660888
The total # of members	0.00983965	Navigation Efficiency	0.188735308
% of transaction conducted by members	0.068041382	Consistency of site structure	0.449775743
Avg. page views per day	0.19245009	# of web management staffs	0.447213595
Avg. Visit per day	0.219280978	Technological capacity	0.577350269
Product diversity	0.621	Frequency of hardware upgrade	0.447213595
Detailed product information	0.449775743	R & D investments	0.234247732
Timeliness sales in popular product	0.167847809		

5.2. Derive the total score

The overall desirability function D is defined as the weighted geometric average of n individual desirability functions. Harrington [11] proposed the use of a geometric mean to aggregate the individual d_i value. Derringer [6] also proposed a weighted geometric means, where w_i are the relative weights among the performance measure, $i = 1, 2, \dots, k$. If one of the properties has an unacceptable value (that is, if $d = 0$), the overall product will also be unacceptable, regardless of the value of the remaining properties. On the other hand, if all the properties are acceptable, the value of D will fall in the interval $[0, 1]$ and will increase with increasing desirability values.

The overall desirability function value is the total score of company M . The values of the desirability function, given in Equation (2, 3, 4), were combined into the single the total score using Equation (4). For the year 2000, the total score turned out to be 0.9342. However, as the company envisioned the core problems and made efforts to raise their competitive advantage, the total score increased. So, as of 2001, the total score of company M turned out to be 0.9808.

$$D = (d_1^{w_1} * d_2^{w_2} * \dots * d_k^{w_k})^{1/\sum w_i} \dots (4)$$

6. Decision making phase

The outcome of the collection phase, as explained previously, can benefit a company in a strategy planning process, as well as, can set up strategy for each performance measure, and provide beneficial information in term of grasping a whole picture of the organization. Also, by analyzing the normalized value, and the weight of each performance measure based on the importance-score diagram, organization can recognize and classify an important or less important division parts to set up a proper strategic plan for improving competitive advantage. Using the importance-score diagram, decision makers can derive the critical performance measure to increase the total score, which in its turn, reflects full organizational accountability.

6.1. Analyze the total score of time periods

Measuring the total score is useful for evaluating effectiveness of a company strategy and analyzing the current situation of the company. At a corporate or division level, this score allows for assessment of the strategy beyond the immediate and intermediate outputs. The total score provide a mechanism for a company to assess the impacts of its strategy on its products, services, processes, and its clients. Furthermore, by comparing the total score at time periods, a company can estimate the achievement level of its strategy. The result of the total score analysis can benefit the company in its strategy planning for improving core parts that influence competitive advantage, and provide beneficial information in terms of grasping a whole picture of current situation of the company. In particular, a relatively decreased value of the total score, or the incremental ratio of the total score is decreased between time periods indicates the weakening in terms of competitive advantage.

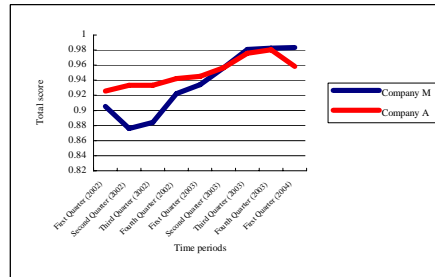


Figure 3. The change of the total score depending on time periods

By comparing the desirability values over the time periods, it is possible to determine critical performance measures which cause the decrease of the total score. Furthermore, by comparing the total scores of benchmarked companies, we can find the state of a company in the market. As [Figure 3] shows, company M experienced difficulties in the second quarter, of 2000, which caused the decrease of the total score, as opposed to company A whose total score grew steadily. After 2000, the situation in company M had improved for the management of the company adopted the methodology proposed in this study. As a result, the company innovated their performance measurement system to identify their problems.

6.2. Analyze the importance-score diagram

The importance-score analysis is employed by all best practice companies as the primary tool for identifying improvement opportunities [22]. In short, the importance-score diagram maps out the performance measures according to their normalized score and executive perceptions of importance. The results of the analysis of the importance-score diagram can suggest certain improvement opportunities. The importance-score diagram is shown in [Figure 4].

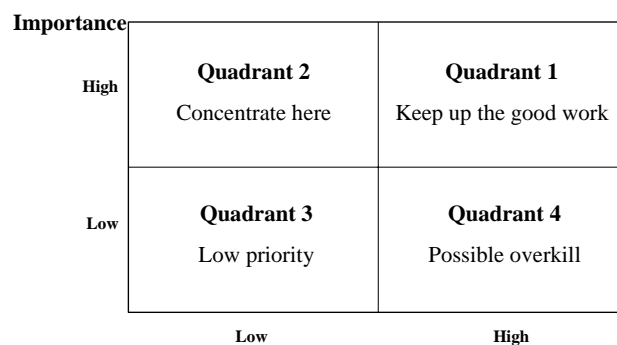


Figure 4. Importance-Score Diagram Score

The performance measures that are important to executive’s decisions but on which the company does not perform well are classified into Quadrant 2, ‘Concentrate here’.

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A company needs to focus on improving its performance on these performance measures. Therefore, we suggested the performance measures in Quadrant 2 to the executives for identifying the core parts of the company to be improved. The importance-score diagram was designed based on d_i and w_i . The performance measure in Quadrant 2 of the importance-score diagram provided an attractive snapshot of how well the company meets strategic achievements and at the same time, offered guidelines for the company future limited resource allocation decisions. The performance measures in quadrant 2 as follows. Based upon the extracted performance measures, we developed strategies for improvement.

- | | | |
|-----------------------------|------------------------------------|--|
| ■ Total number of members | ■ Security level | ■ Usability |
| ■ Number of specific events | ■ % of transaction conducted | ■ Average number of viewed pages per day |
| ■ Ordinary profit | ■ Attractiveness | ■ Navigation efficiency |
| ■ Revisit possibility | ■ Average number of visits per day | |

6.3. Establish strategy

To improve the performance measures suggested in [Figure 4], company M planned the next these 4 possible strategies.

- **Strategy to attract customers**
 - ✓ Strategic alignment with other portal sites, Providing free, flash animated greeting card if customers join membership, Producing a humor flash animation, Gaining customer information through strategic alignment
- **Strategy to provide better service for those customers who have purchasing experience**
 - ✓ Providing discount coupons if customers purchase their products, Giving discount coupons to members per a month, A high number of sales
- **Strategy to improve usability**
 - ✓ Employing usability experts for Web sites, Increasing page-loading speed, Spending more resources and employing more steps to develop new unique services
- **Strategy to increase security level**
 - ✓ Installing Web encryption product that offers real-time 128-bit encryption of the data transmitted between web servers and web browsers

As it was calculated in the preceding section, the total score, as of 2000, was 0.9342, while the total score in 2001 turned out to be higher since the company adopted our methodology. The increase of the total score and the financial measure proved the usefulness of our methodology. In other words, our methodology provided a good basis for improving the Web site of company M for competitive advantage and guidelines for solving the company's core problems.

7. Conclusions

The BSC approach has been used as a tool for suggesting measures that can evaluate

the performance of a company by considering both financial & non-financial perspectives. Although the BSC approach identifies the achievement rate of each measure, it does not provide the information on the overall strategic achievements of a company. Consequently, it is difficult to evaluate the whole strategic performance and find the core obstacles. The current BSC method does not provide techniques to formally define, verify, implement, consolidate and analyze the performance measures.

In this paper, we developed the methodology for deriving the BSC total score the results of which provide a normalization process to reflect the characteristics of the BSC performance measure and a computation process to derive the total score for evaluating the effectiveness of a company based on the performance measures. The total score provided the milestone for the whole organization, and the global strategic target. The model proposed in this paper would provide executives with the single total score as well as the corresponding information model for interpreting the information provided. The availability of the total score could, in turn, lead to the establishment of standard sets of consolidated measures and to the institutionalization of internal-external benchmarking practices. The developed model provides the acquisition of the normalized value to reflect the characteristics of each performance measure based on the desirability function. The model consists of the following three phases: collection phase, calculation phase and decision making phase. The suggested model was illustrated through a case study. The results of the case study justified the usefulness of our model.

Using the proposed model, a company can set up more efficient strategies through proposed model. However, this model is somewhat subjective, as long as the levels of y_i^{\min} , y_i^{\max} , r , s and t are set by decision makers and experts subjectively. Therefore, the future work can be concentrated on the establishing more objective methods for choosing the levels of y_i^{\min} , y_i^{\max} , r , s and t .

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