*Review*

# A hybrid model for a performance measurement system of business: A case study in critical logistics process

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The performance evaluation of companies is an important issue. Balanced Scorecard (BSC) and Six Sigma approaches are widely in use in business in this context. In this study, BSC and Six Sigma performance management systems have been elaborated, their strengths, which can be used in practice by a number of enterprises in a variety of sizes, have been identified; and a new hybrid model of performance measurement system has been developed by merging together the aspects of both management systems that complement each other. The hybrid system can be expressed in terms of operational availability data, and can compare performance qualifications. In practice, performance measurement results obtained for five critical branch offices of a logistics business, by applying the model for operations/processes from the perspectives of Costs, Internal Processes, Customer and System Development and Assessment have been compared by model performance and model efficiency, and the results achieved have been scrutinized.

**Key words:** Balanced scorecard, six sigma, six sigma business scorecard, logistics, operational availability.

## INTRODUCTION

Performance measurement and assessment of complex processes or systems are indeed of vital importance. In a globalizing world, performance measurement should be regarded as a must, rather than as an option. Organizations cannot be sustained without setting strategic goals, using operational methods, achieving and maintaining targeted results; nevertheless, in cases when the changes in the management are not integrated with the performance obtained, success can only be achieved by chance.

Rapid development in information systems in recent times has both facilitated and generalized access to information. As a result of technological developments globally removing local boundaries, in addition to the concepts, price, place where the product is sold together with the distribution channels, and promotion – as set forth by Prof. Eugene McCarthy in his "Basic Marketing" (Perreault and McCarthy, 2004), "marketing mix" or so-called 4P approach (Product, Price, Place, Promotion)-performance and process management have also become essential. Products developed as a result of large scale surveys also have to be backed up by rigorously elaborated strategies, so that the products can achieve the targeted market share.

Performance assessments, as in other statistical studies, are performed on a limited number of sampling

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processes representing the characteristics of all processes. Only in this manner can a set of controllable processes and also controllable budgets, schedules, tools and staff be achieved. The processes included in the sample universe should be chosen among those processes that represent the characteristics of the whole. Negative aspects arising in chosen processes should be characterized as having tangible impacts on general performance. Those processes, which possess such characteristics as described, can be designated as critical processes in this study. Critical processes should be capable of representing business performance and assuring accordance between the strategy and process by an analysis of performance.

Performance measurement models are studied in many areas also in an academic environment. Kumar et al. (2008) emphasized the importance of the implementation cost of six sigma methods and represent new two optimization models that will assist management to choose process improvement opportunities. Parast (2011) developed a theoretical base for the effectiveness of Six Sigma projects on innovation and firms' performance. Farooq and Hussian (2011) prepared a questionnaire and collected the responses from organizations which were segregated on the basis of public and private sector and also manufacturing and service industry. Rajes et al. (2012) proposed a set of strategies for BSC of 3PL service providers by the aid of Delphi method. Jazayeria and Scapens (2008) researched the evolution of a performance measurement system in BAE Systems, for a UK aerospace company. Zheng et al. (2009) used the rough set theory and fuzzy set together to reduce the data processing and reduced computation complexity of measurement model. Yu et al. (2010) developed an organizational performance evaluation framework that takes account of the dynamical system behaviors for innovative healthcare service by the interactions in the traditional Balance Scorecard structure. Morgan and Strong (2003) presented an empirical investigation about performance management structure of medium and large, high technology, industrial manufacturing firms. Bentes et al. (2012) presented the case of a telecom company to illustrate and critically analyzed the integration of the two methodologies, Balanced Scorecard (BSC) and Analytic Hierarchy Process (AHP) with the discussion of the advantages and disadvantages of the design. Lyell and McDonnell (2007) emphasized that health system performance management is a complex problem and offered a dynamic Balance Score Card structure. Paranjape et al. (2006) evaluated Balanced Scorecard in the study and mentioned the difficulties of implementations into dynamic systems. Ahmadi et al. (2012) suggested a model based on Balance Score Card, for performance evaluation and conducted a case study through this model. Kuik et al. (2010) presented a Six Sigma implementation strategy within the global supply chain network in a developing

country, i.e. Malasia. MacBryde et al. (2014) mention the positive effects of having a performance management system like Balanced Scorecard in order to have a progress towards achieving strategic goals despite the absence of nine critical success factors defined in management literature. Shahada and Alsyouf (2012) discuss the efficiency of using six sigma, balance scorecard, simulation and cost-benefit analysis in identifying the process problem(s) and solving them effectively. Zhang et al. (2010) show the six-Sigma quality process operation pattern and the differences between six-sigma quality process and traditional management method in supply-chain management processes and associated technology.

In this study, a model, which can be used in businesses on various scales, is proposed. In the model, a hybrid model of performance measurement system, which is developed by utilizing the Balanced Scorecard (BSC) and Six Sigma approaches, is used. The BSC approach has been included in the model, within the businesses organized vertically from top to bottom, considering its relatively high effectiveness – compared to its peers – in the achievement of strategic and financial targets. The Six Sigma approach, on the other side, has been incorporated into the model as an effective approach in increasing customers' satisfaction from bottom to top in hierarchical processes/operations on the business base. In the developed model, business performance is represented in terms of operational availability data used widely in the field of logistics.

## Approaches to performance measurement systems

Businesses have to achieve their growth targets set in order to survive and to increase their profitability. The control of what extent the targets in question are achieved is done by methods called performance management systems.

After World War II, several national economies grew significantly, leading to a globally competitive environment. From time-motion studies to quality improvement tools, businesses employed methods to improve their performance. Beginning in the 1970s, Japanese auto makers challenged the U.S. industry by Utilizing quality management tools taught by J. M. Juran, Edwards Deming, Phil Crosby, Genichi Taguchi, and others. In the 1980s, other ways to promote the process and performance standards were created, such as the ISO 9000 quality management system developed by the International Organization for Standardization (ISO) and the Malcolm Baldrige National Quality Award (MBNQA) guidelines established by the U.S. Motorola pioneered and successfully implemented the Six Sigma methodology to reap rich benefits (Pande et al., 2000). Figure 1 shows the evolution of various techniques (Gupta, 2003).

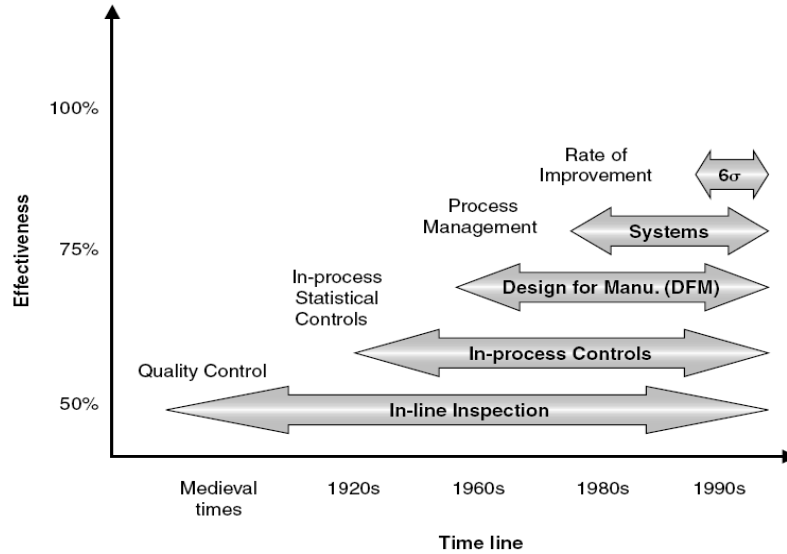Franceschini et al. (2007) denote that global process

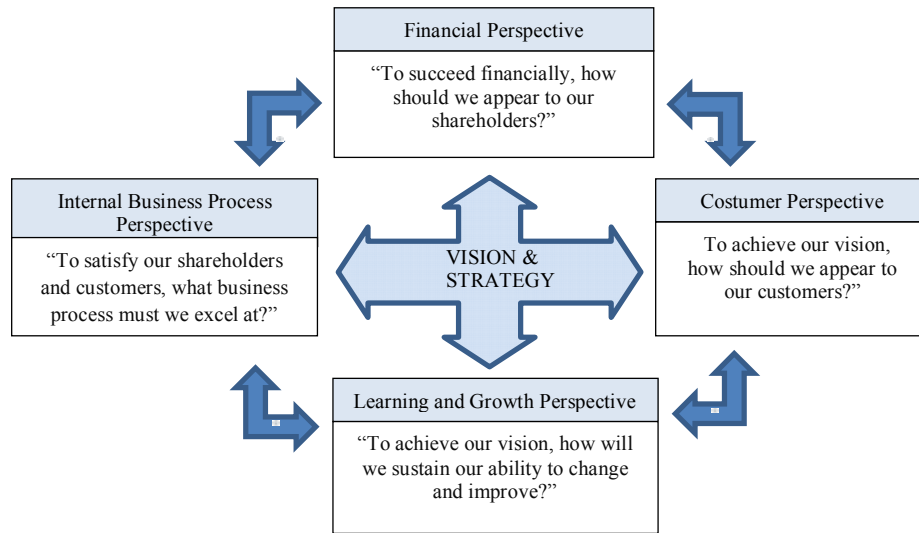**Figure 1.** Performance Control Methods (Gupta, 2003).



**Figure 2.** BSC Points of View (Kaplan and Norton, 1996a)

management and coordination are carried out by the performance measurement system that is at the highest level of the hierarchy. The performance measurement system is responsible for coordinating indicators across the various functions, and for aligning the indicators from the strategic (top management) to the operational (shop floor/purchasing/execution context) levels.

Performance control methods are utilized to monitor business processes in operation and to keep the deviations identified in performance under control. Beneath their monitoring and control functions, performance management systems are further expected to be sensitive to internal and external developments in businesses. The Six Sigma Business Scorecard (SSBSC) model is defined as a model that was evaluated as to reduce the factors of failure of the BSC and Six Sigma approaches in practice.

### Balanced scorecard

As shown in Figure 2 (Kaplan and Norton, 1996a), the BSC, instead of traditional financial data of enterprises with performance reviews, can be enriched by the

following operating processes that have been aligned with the vision and strategy (Ahmadi et al., 2012):

1. The customer perspective (How do our customers see us?)
2. Internal Business / internal process (What do we need to be superior?)
3. Learning and growth perspective (Are we developing by creating the value continuously?)
4. Financial perspective (How should we be seen by our shareholders?)

Balanced Scorecard is a dynamic performance assessment system or management technique (Zheng et al., 2009), which is based on non-physical dimensions (values) such as humans, systems, and development and perfection of incorporating activities in line with future customers' satisfaction, orientation and expectations. It is also beneficial in learning and developing the methods to keep up with the change – together with physical (financial) values derived from historical data the businesses have in hand; this measures these dimensions using specific indicators that provide strategic feedbacks to maintain equilibrium and integration between these dimensions. It also determines applicable strategies of data.

Construed in a general sense, the aim of the BSC performance management system is to achieve a steady and gradual growth of corporate development and corporate life, and to bring success to the business in a competitive environment of the recent information age by changing the performance (Kaplan and Norton, 1996b).

Moreover, BSC is not only a measurement system. Businesses open to innovation use BSC as the center and regulatory framework of management processes. Businesses may at the first stage establish a Scorecard for very limited purposes. For example, such purposes may be reaching consensus, focusing on strategy and ensuring complete penetration of strategy across the corporation. The real power of BSC is demonstrated not only as a measurement system, but also in cases when it is used as a management system (Kaplan and Norton, 1996b).

## Six Sigma

Linderman et al. (2003) have defined Six Sigma as a systematic problem-solving technique aiming to decrease customers' defined defect rates substantially or to improve system inputs by using statistical and scientific methods in the development of new strategic systems, products and services.

Total Quality Management (TQM) and Six Sigma are approaches which support each other. TQM is a management philosophy targeting an ideal perfection at "zero-defect" level. On the other side, Six Sigma is a method, a methodology, which can be used for the measurement of the quality of processes as one of the focal points of TQM. Its goal is to decrease defect rates to a level of 3.4 per million. Six Sigma differs from TQM or similar approaches primarily in the measureability of its results, in its penetration covering all processes across the entire corporation without being limited to a single department or function, and in how it can alter the corporate culture (Gupta, 2003).

As a statistical measurement technique, Six Sigma is a quantitative indicator measuring how good the products, services and processes are. It shows by how much the process deviates from the zero-defect ideal.

The Six Sigma approach uses "Defects per Unit" (DPU) as measurement unit. A defect is defined as anything that causes customer dissatisfaction. DPU is the best tool for measuring the quality of a process or a product. Sigma coefficients used as three Sigma, four Sigma or six Sigma represent the occurrence frequency of defects. The higher the Sigma value is, the lower the probability of defect.

## Balanced Scorecard and Six Sigma weaknesses

The inadequacy of two methods mentioned above is summarized as follows in practice.

Saydam (2007) suggests vertical and horizontal integration for an effective performance and perception management in businesses. Vertical integration represents the compatibility among all layers of an organization from bottom to top. In other words, the subject the organization seeks to manage and key messages to be created around this subject should be expressed by a newly recruited office personnel or for example by a driver, demonstrating same enthusiasm, same diligence and same content, as is done by the top manager of the corporation. Furthermore, horizontal integration is defined as "ensuring the compatibility and cooperation among communication works managed by social stakeholders, since these are interacting with each other strongly" (Saydan, 2007).

Most businesses have measurements for sales and profitability. They do not, however, have measurements for operational effectiveness (Gupta, 2003). Indeed, sales figures and profitability are the outputs of the business. Measures to increase profitability and efficiency have to be applied to the inputs. Positive outcomes from regulations to be imposed on outputs have never been observed. For performance and efficiency, one has to start with regulations on input(s) compatible with the strategy, and henceforth maintain vertical and horizontal integration.

Regarding the Six Sigma approach, it appears that Six Sigma measurements focus on performance at the process level; however, the measurements are not aggregated or correlated to corporate wellness.

Corporations have found it difficult to establish a corporate sigma level that correlates with the overall corporate performance (Gupta, 2003).

Six Sigma is a performance management system envisaging control over all organizational processes of the business. However, the impression of Six Sigma in practice is that difficulties are experienced in achieving a process/strategy synergy with Six Sigma. The effectiveness attained in process management cannot, either always or directly, be reflected towards the upper levels of the organization.

While implementing a BSC, managers articulate their strategy for the organization. Departments go through the training and attend sessions to develop the vision, strategy, and measurements that will lead to a BSC (Harry and Schroeder, 1999). They develop objectives and targets as well as action plans. Weaknesses in the organization can be identified through the reporting process and corrected through the learning process.

BSC practice starting at the management level is observed to be extremely effective in setting the vision, strategy and performance assessment parameters at the department level, by trainings and active participations. However, the strategy constituting BSC's starting point cannot be duly delegated or explained to employees at the process level. In practice, this makes the success of the BSC approach effective in many cases only up to the department level, but not at the process level. Such failure observed by 90% in the business where the BSC is applied is correlated with this practice (Gupta, 2003).

Consequently, accomplishing integration under the framework of a strategy is of vital importance for businesses from the perspective of performance management. BSC practices as performance management tools are inadequate below the department level at organizational layers and in process management, whereas Six Sigma practices are inadequate in achieving the integrity of process and strategy.

### Six Sigma Business Scorecard

The strengths and convenient practices of BSC and Six Sigma practices, which could not achieve the desired success individually, have been analyzed under the scope of this study. The Six Sigma Business Scorecard (SSBSC) has been developed as an easily adaptable performance management system that inspires leaders who are going to embrace the business as a whole, and offers managers, chances for development and employees opportunities for innovation by maintaining profitability and growth at optimum level. An effort has been made to in the study to winnow out the weaknesses of the analyzed methods and to integrate the areas in which they are effective, together, in order to build integrity.

In this model, the business was considered in the form of a pyramid. The business pyramid and the positioning of the performance management systems are shown in Figure 3. The upper part of the pyramid represents the top management layer of the business. The performance measurement system used effectively for top management is the BSC approach. In this layer, strategies are developed, and, starting with the transformation of the strategy into a vision and measurable targets, BSC approach processes are run.

For middle management, which constitutes the second layer of the business pyramid, analyses of costs, internal processes, system development and assessment and also for customers' points of view are conducted and success scores are calculated, again using the BSC approach.

The Six Sigma approach is used for the base of business pyramid, the parts designated as operation/process level. At this stage, operation/process success scores are calculated using the BSC approach, and then converted into values of defects per unit and probability of corporate defect rates at the per million level, and finally into operational availability data, in order to establish a decision mechanism. The business pyramid and the positioning of the performance management systems are shown in Figure 3.

Turkey is a rapidly developing country. And most of the companies in Turkey are small and medium sized. These organizations are performing the 62.6% of the overall import and 38.5% of the overall export according to the reports published in 2014 for the year 2013 by the Turkish Statistics Organization (TUIK). It is difficult for those small and medium-sized organizations to run big ERP applications or hire BSC or Six Sigma professionals to monitor their performance. On the other hand, these organizations set goals, objectives and targets to maximize performance. With this proposed model, basic elements of the BSC and six Sigma models are combined together to support these small and medium-sized companies in establishing their goals, objectives and targets aligned with their processes.

In the developed model, the following are explained in depth in the case study;

1. Determination of the strategy,
2. Determination of indicators  of viewpoints of cost, internal processes, customer and system development-evaluation, and calculation of their weights and scores of success for realization of the strategy and
3. The performance of the business to be expressed as operational availability data

### Case study: The performance measurement practice in critical logistics processes

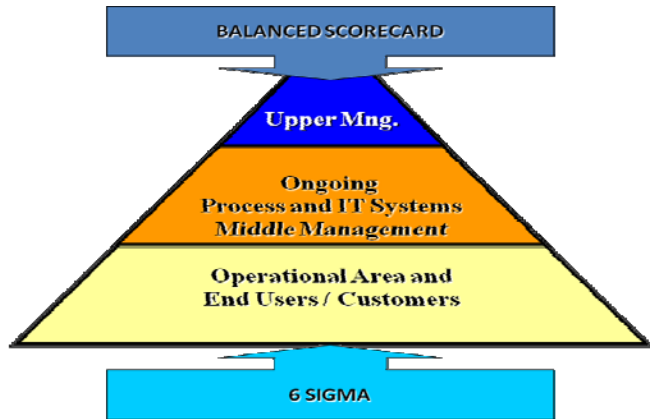In practice, the performance of a logistics business

**Figure 3.** SSBSC performance management system model.

providing services of estimating spare part needs of branch offices, planning, and collecting spare part needs is expressed in terms of operational availability data, using the SSBSC Performance Measurement System. Data are obtained from a real case study.

The algorithm of the new model and the details of each step of the procedure are given below under relevant titles. For the selected five branch offices, performance measurement values obtained in the model are given in the section where the algorithm is detailed.

### Model of SSBSC

The SSBSC model algorithm that is developed to be used in the performance measurement in a logistics business that offers spare parts management service is defined below:

1. Set strategy,
2. Identify points of view to be used in the model,
3. Identify the indicators of operation/process that reflect the viewpoints,
4. Read the maximum, minimum and average values of the operation/process indicators
5. The operation/process indicators are expressed in terms of achievement scores
6. Identify the weights of operation/process indicators by the AHP method,
7. Calculate the weighted achievement scores by multiplying the operational/process indicator values and weights,
8. Calculate the business performance by summing all of the weighted success scores,
9. Calculate the defects per unit of business,
10. Calculate the possibility of defects per million of the corporate defect rates,
11. Calculate / read the value of operational availability of the business,

12. Make suggestions for decisions on assessing the performance of the business,

The basic and major processing steps of the SSBSC Performance Measurement System model algorithm are described below.

### Starting of SSBSC Model Practice and Setting the Strategy

The business and performance measurement processes, where the model is to be applied, have been analyzed. The analysis results that were obtained were used in the relevant steps of the procedure of the model.

The strategy of the business is to render a better spare parts service to a higher number of customers with a cost-efficient use of sources. All processes within the business will be performed in parallel to the strategy.

### Definition of the points of view used in the model

From the logistic point of view, spare parts management is a very extensive process starting with the arising of the need, and covering the steps from meeting the need to take the procured material out of service.

In the assessment of the process performance, from the perspective of the selected branch offices and realized processes – consideration of various points of view organizationally from top to bottom is important. In establishing the model – as in the Balanced Scorecard approach, there are four points of views that constitute the general framework:

1. Costs,
2. Internal processes,
3. System development and assessment,
4. Customers' points of view.

The data examined by the Six Sigma approach at the operational/process level have been defined, measured, analyzed and re-correlated with these points of view on general framework.

Within this scope, the processes/operations have been analyzed by each point of view as follows:

From the cost point of view:

1. The financial value of all parts is needed by the branch office in terms of spare parts,
2. The financial value of the spare parts which have been used in the branch office and needed during operations until then (differing from the first criteria in that, if for example, no demand data has been created until then for a part available in the branch office, these have not been included in cost calculations),

**Table 1.** Selected operation/process indicators.

| Points of view | Operation/Process |
|---|---|
| Cost | The indicator decreasing cost-weighted minimum level of depot reserves |
| | The indicator of the spare parts cost of spending for repair |
| Internal Process | The indication of the realization of their provision of spare parts needed |
| | The indicator of lead time of requirement |
| | Technical data quality indicator |
| Customer | The evaluation period for the requested part of indicator |
| System development and assessment | Indigenization status indicator |

3. The financial value of the spare parts always kept in stock by the branch office as emergency repair spare parts, the financial value of the spare parts kept in stock for scheduled maintenance, the financial value of available spare parts kept in central warehouses, the cost of optimizing stock levels of spare parts remaining below maximum and minimum stock levels and the amounts to be re-ordered of available spare parts kept in central warehouses, by reviewing such levels and amounts, and the financial value of the spare parts used in cases when a need arises to repair of the equipment, for which support is provided by the branch office, has been analyzed.

From the internal processes point of view:

The time of procuring the parts to be supplied from the manufacturer or supplier within normal supply processes, adequacy/quality of technical specification data used in supply processes, the conditions of materialization of the supply of needed spare parts have been analyzed.

From the system development and assessment point of view:

The amounts of parts supplied as domestic goods to decrease depending on imported parts have been analyzed quantitatively.

From the customer point of view:

The time elapsing between the initiation of the process in order to meet the need and the reporting of spare part needs of the customer has been analyzed.

### Selection of operation/process indicators representing the points of view

For the implementation of the strategy, the selection of indicators representing the performance of the activities grouped under the points of view is a significant process. The assessment of the effectiveness of the strategy in that point of view is based on the values of the indicators to be selected.

The aim of the performance measurement is to represent the actual condition of the business. The indicators used in representing the performance of the business should not overestimate the performance and not be of a nature to interrupt general process. For example, the number of calls answered should not be selected as an indicator value in call centers. A parameter to represent the satisfaction of the customer for the call carried out with the call center should be selected as a performance indicator.

Those selected as operation/process indicators under the points of view are given in Table 1.

### Reading the values of operation/process indicators and expressing indicators in terms of success scores

Maximum, minimum and average values given in Table 1 for the operation/process indicators have been created with the help of records kept for the related processes. After creating the values of operation/process indicators to represent the performances of the points of view, the indicators are expressed in terms of success scores.

In calculating the indicator success scores, the approaches used by Franceschini et al. (2007) calculating World Development Sequences are employed.

$$B_{Score} = (D_A - D_{Min})/(D_{Max} - D_{Min}) \tag{1}$$

$B_{Score}$ : Success score,
$D_A$ : Average of indicator values,
$D_{Max}$ : Maximum of indicator values,
$D_{Min}$ : Minimum of indicator values

The success scores values range, calculated by Eq. 3-1, is between $0 \leq B_{Score} \leq 1$. The success scores for operation/process indicators measuring failure are

**Table 2.** Operation/process weightings.

| Points of view | Operation/Process | Weight |
|---|---|---|
| Cost | The indicator decreasing cost-weighted minimum level of depot reserves | 0.2551 |
| | The indicator of the cost of spare parts spent for repair | 0.1239 |
| Internal Process | The indication of the realization of their provision of spare parts needed | 0.2169 |
| | The indicator of lead time of requirement | 0.1735 |
| | The indicator of the technical data quality | 0.0723 |
| Customer | The indicator of evaluation period for the requested part | 0.0964 |
| System development and assessment | The indicator of indigenization status | 0.0620 |

**Table 3.** Operation/process weighted success scores.

| Operation/Process | Branch Office | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | E |
| The decreasing cost-weighted minimum level of depot reserves | 0.0002 | 0.0003 | 0.0263 | 0.0000 | 0.0596 |
| The cost of spare parts spent for repair | 0.1068 | 0.1084 | 0.1084 | 0.1084 | 0.0869 |
| The realization of their provision of spare parts needed | 0.2039 | 0.2059 | 0.2169 | 0.2169 | 0.2140 |
| The lead time of requirement | 0.1349 | 0.1505 | 0.0817 | 0.0747 | 0.1428 |
| The quality of technical data | 0.0218 | 0.0310 | 0.0271 | 0.0000 | 0.0218 |
| The evaluation period of the requested part | 0.0946 | 0.0835 | 0.0644 | 0.0723 | 0.0940 |
| Indigenization status | 0.0030 | 0.0053 | 0.0000 | 0.0000 | 0.0073 |

calculated using the Eq. (2).

$$B_{Score} = 1 - (D_A - D_{Min})/(D_{Max} - D_{Min}) \tag{2}$$

In this context, the achievement scores calculated for each operation/process are presented in Appendix1.

### Setting operation/process indicator weightings by AHP method

In order to implement the strategy, the values of theoperation/process indicator selected under the points of view should be arranged to represent the performance across the business in general. The importance of each operation varies from business to business. The AHP approach can be used to determine the operational priorities within the business consistently (Saaty, 1980). The weightings were calculated, as in normal AHP method, by making dual comparisons to reflect the importance of each indicator. The weightings evaluated by the AHP method for operations/processes are presented in Table 2.

### Calculation of weighted success scores and business performance

The weighted success score of the operation/process is calculated by multiplying the operation/process indicator values by the weightings of these indicator values calculated by the AHP method. The weighted success score for each branch office examined are given in Table 3.

The stage of evaluating the business performance is the stage at which the meanings of the operation/process success scores for the business are assessed. The equation used in the calculation of the performance is represented by Eq. (3). As seen in this equation, the weighted success score of the operation/process is calculated by multiplying the success score calculated for each operation/process by the relevant weighting and the sum of the weighted success scores found represent the Business Performance (BP) (Gupta, 2003).

$$BP = \sum_{f=1}^{n} \left( FS_{W-f} \times B_{Score-f} \right) \tag{3}$$

BP      : Business performance,
$FS_{W-f}$  : Weight of operation/process,
$B_{Score-f}$ : Success score of the operation/process
f        : Order of the operation/process
n        : Number of the operation/process

Business Performance values calculated by using Eq. (3) are given in Table 4.

**Table 4.** Values calculated for branch office, business performance, defects per unit, probability of corporate defect rates at the per million level, sigma value and operational availability data.

| Branch Office | Business Performance | Defects per Unit | Probability of Corporate Defect Rates at per Million | Sigma Value | Operational Availability Value (Ao) |
|---|---|---|---|---|---|
| A | 0.5651 | 0.5708 | 22833.52 | Between 3.4-3.5 | 0.9772 |
| B | 0.5849 | 0.5363 | 21452.40 | Between 3.5-3.6 | 0.9785 |
| C | 0.5248 | 0.6447 | 25787.89 | Between 3.4-3.5 | 0.9742 |
| D | 0.4723 | 0.7500 | 30001.70 | Between 3.3-3.4 | 0.9700 |
| E | 0.6265 | 0.4676 | 18703.95 | Between 3.5-3.6 | 0.9813 |

### Defects per unit calculation for the business

In the Six Sigma approach, the concept of defects per unit represents the ratio of the number of defects identified in the process examined to the total number of examinations (Gupta, 2003). The Defects per unit is calculated by Eq. (4).

$$DPU = \left(\sum K_Q\right) / \left(\sum I_Q\right) \tag{4}$$

DPU   : Defects per unit,
$K_Q$     : Number of defects,
$I_Q$     : Number of examined parts

The relation between the business performance (BP) and the defects per unit is represented by Eq. (5) (Gupta, 2003). Eq. (6) is obtained by rearranging Eq. (5).

$$BP = e^{-DPU} \tag{5}$$
$$DPU = -Ln(BP/100) \tag{6}$$

The performance of the business calculated by the Eq. (6) can be converted into defects per unit. Defects per unit values calculated for the equipments examined are given in Table 4.

### Calculation of the probability of defect occurrence and the operational availability of the business

The probability of corporate defect rates at per million is also a calculation used by the calculations of the Six Sigma approach. It represents the probability of defect by unit per employee at per million levels (Gupta, 2003).

$$PCDRPM = (DPU \times 1000000) / NEOP \tag{7}$$

PCDRPM: Probability of Corporate Defect Rates at per Million,
NEOP   : Number of employees in the operation/process,

For the branch office examined, the values of probability of corporate occurrence of defect by the unit at per million levels calculated by Eq. (7) taking the number of employees working in the operation/process as 25 employees are given in Table 3.

This concept, designated as the Operational Availability or the conditions of availability, is an approach used quite frequently in technical areas. In the Logistics Support Analysis (LSA), it represents the probability of the system/equipment demonstrating the performance defined for the desired working period under predefined conditions, and is calculated as expressed by Eq. (8) (Bauer et al., 2009).

$$A_o = U_T / (U_T + D_T) \tag{8}$$

$U_T$     : Up time
$D_T$     : Downtime (Logistics Delay Time + Repair Time + Preventive Maintenance Time)
$U_T + D_T$ : Operation Time (UpTime + Downtime)

Its portion expressed as the breakdown time ($D_T$) for the operational availability value is calculated, as shown by the Eq. (8), as the total sum of the time spent originally for preventive maintenance, logistic delay and repair time. However, in this newly developed model, the breakdown period is used to reflect the lag/non-working times of examining operations/processes and the probability of performance of operations/processes of the business, under defined working conditions.

In the new model, the value of operational availability is calculated by direct proportion to find out the probable breakdown period of the equipment, based on the data of probability of corporate occurrence of defect by the unit at per million levels.

For the branch offices examined, the values of operational availability calculated by direct proportion made with the help of probability of occurrence of the defect at per million levels are presented in Table 4.

### Deciding about the performance of the business and the finalization of the model

An assessment scale for the Business Performance,

**Table 5.** Performance assessment scale.

| Business Performance Range | Sigma Range | Operational Availability (Ao) Range from Logistics Viewpoint | Model Evaluation Scale |
|---|---|---|---|
| 0.310847000 - 0.500959603 | 1.0 - 2.3 | 0.308538 - 0.788144 | Fails in Logistics Perspective |
| 0.500959603 - 25.41133123 | 2.3 - 3.1 | 0, 788144 - 0.945201 | Processes need to be reviewed |
| 25.41133123 - 99.99150036 | 3.1 - 6.0 | 0. 945201 - 0.9999966 | Successful in Logistics Perspective |
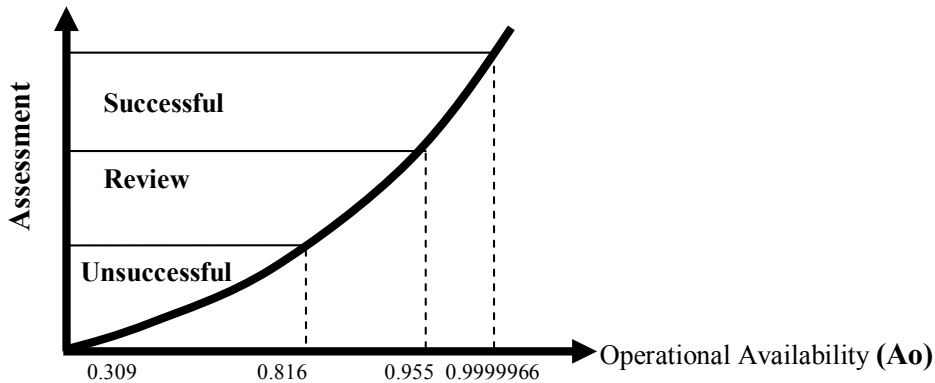


**Figure 4.** Performance assessment by operational availability.

Sigma value, and Operational Availability Data (Ao) results calculated by the developed model in the study is presented in Table 5. By using this scale, an evaluation of the brach office's performance in terms of materials management,  decisions can be given as follows:

1. It is unsuccessful from a logistics viewpoint,
2. It is successful from a logistics viewpoint but the process needs to be reviewed,
3. It is successful from a logistics viewpoint.

The ranges of values used in the created scale may be shifted in line with the needs of the individual business and additional assessment parameters may also be added.

Performance values can be evaluated by scalar calculations as the result of the assessment of the performances for the offices within the business; a decision can also be made for this purpose by finalizing the model by choosing one of the three levels defined by the help of Table 5 and Figure 4. Accordingly,  the operational availability values of the five critical branch offices (A, B, C, D and E) had been changed between 0.9700 and 0.9813; all the branch offices  are successful from the perspective of logistics.

Using the operational availability data calculated in this model, adequate results can be achieved for the assess-ment of business performance. Operations/processes that have to be improved can be easily monitored by this model.

## CONCLUSION AND SUGGESTIONS

In recent days, optimal utilization of limited sources has become the utmost priority of businesses operating in all fields. Actual performances have to be followed up correctly in order to be able to set goals for development and to assess to what extent set goals are achieved.

The Scorecard and Six Sigma performance systems have been analyzed under the scope of this study. Efforts have been made trying to develop an easy-to-use model by making use of these methods in question, each of which has relative strengths and weaknesses.

Balanced Scorecard suggests consideration of different points of view beyond cost in the implementation of strategic decisions. The Six Sigma approach, on the other hand, aims to increase effectiveness and conse-quently decrease costs of operation and process level. Six Sigma aims to achieve integrity within very low defect tolerances.

In Turkey, for most of the business operation in the logistics field, these two approaches, which are thought to require large amounts of investment, have been applied in practice in very limited areas. The application and understanding of the proposed new model are easier compared to its peers. Due to these characteristics of the proposed model, it can be easily used in businesses of any size. Hence, vertical and horizontal integration of employees within the business can be achieved. Achie-ving such integration would be reflected in the businesses as higher profitability, and on the customers as higher

quality and fuller satisfaction.

The SSBSC model, which does not require a large investment and working capital, combines the most useful and integrating parts of Balanced Scorecard and Six Sigma together. With this characteristic, the model is evaluated as:

1. Achieving highly effective results in maintaining the compatibility between the management and operations/ processes,
2. Helping the assessment of critical processes from different perspectives in performance measurement,
3. Enabling the conversion of Operational Availability value in the developed new model into data, which are linked to critical processes and are calculated easily.

With the proposed model, numerical data can be generated for the operational availability of the business. The operational availability data that have been calculated are evaluated as sufficiently qualified to contribute to the Six Sigma and BSC approaches. Interpretation of operational availability data and calculation of the costs required to increase performance and the optimum operational availability values are thought to be worthwhile as subjects for new research and case studies.

This new hybrid model contributes in that top level management and bottom level management overlap systematically by the least number of defects, under the framework of the strategy. One of the significant achievements of this study is that by this model the levels of effective performance measurement systems have been reached by the formulization of such equilibrium maintained between the management and operations/ processes to assess performance.

Each organization has its own processes at the bottom and different strategic targets, goal and objectives at the tab level. There is no crystal ball solution in establishing strategies, processes, indicators and criterion. The basic concept is to monitor the performance within the organization. As given in the case study, a logistics organization is picked for the implementation purposes. With the defined methodology, this model can be applied in different sectors as well. The user has to analyze the whole organization with a system thinking approach and define the critical variables for itself.

The defined hybrid model combines and aligns top strategic management issues with the processes and procedures conducted at the lowest level within the organization. Using this tool will help in monitoring the performance of the similar organization in operational availability figures calculated with the same perspectives. The result from the performance measure can be traced back and forth in the model as well.

## Conflict of Interests

The authors have not declared any conflict of interests.

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**Appendix 1.** Maximum, minimum and average values of the operation /process indicator, and achievement scores.

| Process | Branch office | Maximum | Minimum | Average value | Success score |
|---|---|---|---|---|---|
| The indicator decreasing cost-weighted minimum level of depot reserves | A | 0.48076 | 0.25970 | 0.25954 | 0.0006 |
| | B | 0.48344 | 0.25841 | 0.25815 | 0.0010 |
| | C | 0.51321 | 0.25660 | 0.23019 | 0.1029 |
| | D | 0.50000 | 0.25000 | 0.25000 | 0.0000 |
| | E | 0.49100 | 0.28818 | 0.22083 | 0.2337 |
| The indicator of the cost of spare parts spent for repair | A | 54186105.94 | 0 | 7493950.01 | 0.8617 |
| | B | 788444.47 | 0 | 98555.56 | 0.8750 |
| | C | 480835.35 | 0 | 60104.42 | 0.8750 |
| | D | 2074.68 | 0 | 259.34 | 0.8750 |
| | E | 222248.71 | 219.59 | 66434.48 | 0.7018 |
| The indicator of the realization of their provision of spare parts needed | A | 6.32 | 0 | 0.38 | 0.9399 |
| | B | 8.12 | 0 | 0.41 | 0.9495 |
| | C | 0 | 0 | 0 | 1.0000 |
| | D | 0 | 0 | 0 | 1.0000 |
| | E | 12.12 | 0 | 0.16 | 0.9868 |
| The indicator of lead time of requirement | A | 1376 | 0 | 306.34 | 0.7774 |
| | E | 1357 | 0 | 240.24 | 0.8230 |
| | B | 1489 | 0 | 197.4 | 0.8674 |
| | C | 701 | 0 | 370.75 | 0.4711 |
| | D | 148 | 0 | 84.25 | 0.4307 |
| The indicator of the technical data quality | A | 58 | 0 | 25 | 0.3012 |
| | E | 97 | 0 | 97 | 0.3264 |
| | B | 20 | 0 | 15 | 0.4286 |
| | C | 5 | 0 | 3 | 0.3750 |
| | D | 4 | 0 | 0 | 0.0000 |
| The indicator of the evaluation period for the requested part | A | 104 | 0 | 1.9 | 0.9817 |
| | E | 450 | 0 | 11.11 | 0.9753 |
| | B | 48 | 0 | 6.43 | 0.8660 |
| | C | 27 | 1 | 9.63 | 0.6681 |
| | D | 64 | 0 | 16 | 0.7500 |
| The indicator of indigenization status | A | 1 | 0 | 0.048192771 | 0.0482 |
| | E | 5 | 0 | 0.215277778 | 0.1181 |
| | B | 2 | 0 | 0.114285714 | 0.0857 |
| | C | 0 | 0 | 0 | 0.0000 |
| | D | 0 | 0 | 0 | 0.0000 |