International Journal of Industrial Engineering & Production Research

June 2011, Volume 22 Number 2
pp. 123-126

http://IJIEPR.iust.ac.ir/

ISSN: 2008-4889

RTY-Based Model for Organizational Performance Measurement

Abbas Saghaei* **& Hoorieh Najafi**

* ***Abbas Saghaei,*** *Associate professor, Department of Industrial Engineering, Science and Research Branch, Islamic Azad University, Tehran, Iran,* ***Hoorieh Najafi,*** *Msc student, Department of Industrial Engineering, Science and Research Branch, Islamic Azad university, Tehran, Iran,*

KEYWORDS

Six sigma,
Rolled throughput yield,
Organizational performance

ABSTRAC

Six Sigma is a well- established approach to improve the capability of business processes in order to gain satisfaction of customers. The performance assessment of a given process is essential to some phases of six sigma methodology. So far, different indicators are used to demonstrate the performance of a process, while many organizations tend to report their organizational performance level. Unfortunately there have been few methods on calculating overall performance. This paper introduces a quantitative model that is formulated by focusing on process features. In addition, a number of numerical examples illustrate the performance of our proposed method in comparison to other methods.

© 2011 IUST Publication, IJIEPR, Vol. 22, No. 2, All Rights Reserved.

1. Introduction

Six Sigma, a systematic framework for quality improvement and business excellence, has been widely publicized in recent years as the most effective means to combat quality problems and win customer satisfaction [1]. Six Sigma is based on recognizing the root causes of the problems to implement effective improvement plans.

Quality sigma level is one of the measurement criteria for performance in this methodology. Six Sigma is defined as having less than 3.4 defects per million opportunities or a success rate of 99.9997% [2]. Sigma level is often used to determine the capability of a process and during the recent years, the tendency of managers to report the organization performance by sigma level has increased.

The proportion of the outputs to the inputs is one of the measures to calculate the yield of organization processes. Rolled throughput yield (RTY) as shown in the relation 1 is also another measure to estimate the quality sigma level [3] and [4].

$$RTY = \prod_{k=1}^{n} P_k \quad (1)$$

RTY demonstrates the capability of the organization processes in producing corrective products. Moreover, normalized rolled throughput yield can be applied in the following form:

$$Normalized - RTY = \sqrt[n]{\prod_{k=1}^{n} P_k} \quad (2)$$

Ravinchandran [5] represented a method for calculating organizational sigma level by assigning weights to all critical processes based on their importance. His proposed method has been modified in 2007, cost-based process weights has been used to determine a unique weights for each defects per million opportunities (DPMO) [6].

The principal motivation in presenting the following paper is introducing a new approach in calculating the organizational performance through separating defects to scraps and reworks, considering the costs of each, and regarding various situations of rework loops.

* **Corresponding author. Abbas Saghaei**
Email: *a.saghaei@srbiau.ac.ir, h.najafi@srbiau.ac.ir*
Paper first received Oct. 12. 2010, and in revised form May. 15. 2011.

[Downloaded from ijiepr.iust.ac.ir on 2026-09-12]

2. Proposed Model

The proposed model attempts to divide defects into scraps and reworks and consider their costs in order to present a realistic estimation of organizational process performance. Including a process stage in which the reworks and/or scraps take place, is a significant characteristic of this model. The proposed method for various rework loop situations would lead to different results. Moreover, this model is capable of assigning separate weights to rework and scrap. Fig. 1 represents the stages of calculating organizational performance according to the proposed method. Variables and their descriptions are listed below.

A: n×1 Matrix

a_j: Expectation of scrap costs for sub-process

N_j: Random variable of scrap numbers for sub-process

$S^{(j)}$: Random variable of unit scraps cost in sub-process

B: n×n Lower triangular matrix

b_{ji}: Expectation of occurred rework costs by sub-process and return to sub-process

N_{ji}: Random variable of occurred rework number by sub-process and return to sub- process

$R^{(ji)}$: Random variable of the total cost caused by rework in sub-process and return to sub-process

r_j: Random variable of the correcting costs for sub-process

μ_k: Boolean variable. It takes 1 if the defect goes through the sub-process and 0 otherwise.

g_k: Random variable of the cost of producing a unit of proper product in sub-process

n: Number of sub-processes

w_j: Weight of sub-process

e_k: $1\times n$ matrix s.t $e_k = \begin{Bmatrix} 1 j = k \\ 0 j \neq k \end{Bmatrix}$

P_j: The probability of a unit to pass sub-process defect free

y: Entrance to the first sub-process

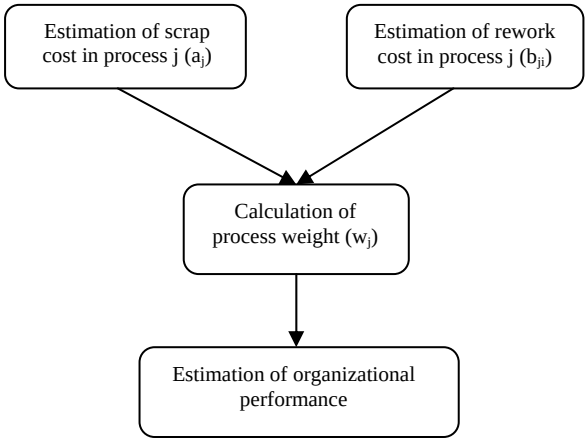


Fig. 1. Proposed method

In each stage of process, defects might be found. If the products in any stages of the process do not meet the defined criteria, they should be either corrected in that same stage or returned to previous stages for rework. Otherwise, they are considered scrap and must be discarded from the production line. According to describe above and variable definitions, total rework cost can be written in the following:

$$R^{(ji)} = r_j + \sum_{k=1}^{j} \mu_k g_k \tag{3}$$

The related weight of each sub-process is calculated by (4), (5) and (6). Details of the model formulation can be referred to in the Appendix. Finally, the proposed RTY is obtained by using (7).

$$a_j = E(\sum_{k=1}^{N_j} S_k^{(j)}) = E(N_j)E(S^{(j)}) \tag{4}$$

$$b_{ji} = E(\sum_{k=1}^{N_{ji}} R_k^{(ji)}) = E(N_{ji})E(R^{(ji)}) \tag{5}$$

$$w_j = \frac{a_j + \sum_{k=1}^{j} (e_j B)_k}{\sum_{k=1}^{n} a_k + \sum_{q=1}^{n}\sum_{k=1}^{q} (e_q B)_k} \tag{6}$$

$$RTY_{proposed} = \prod_{k=1}^{n} P_k^{w_k} \tag{7}$$

Where $\sum_{k=1}^{n} w_k = 1$

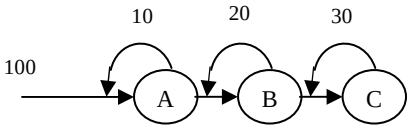
3. Comparison

Assume $g_1 = 5$, $g_2 = 10$, $g_3 = 15$, $r_j = 1$, $j = 1,2,3$, $E(S^{(1)}) = 5$, $E(S^{(2)}) = 10$, $E(S^{(3)}) = 15$ and $\mu_k = 1, k = 1,2,3$. The two examples in this section depict the superiority

[Downloaded from ijiepr.iust.ac.ir on 2026-09-12]

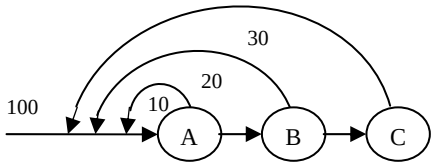
of this approach over other current performance measurement methods. Example 1 demonstrates the effect of various rework loop situations on overall yield. Example 2 shows the importance of scrap eliminating at a specific stage.

Example 1:



NRTY=0.79
$RTY_{proposed}$=0.78

(2.1)



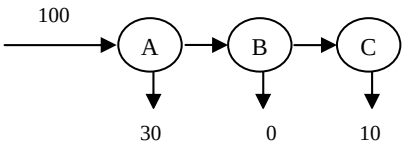
NRTY=0.79
$RTY_{proposed}$=0.74

(2.2)

Fig. 2. Comparison of two processes with different rework cycles

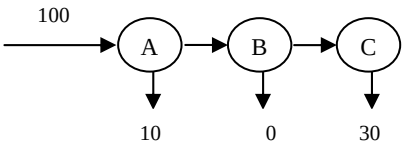
According to Fig. 2, it can be seen that the NRTY could not distinguish these situations but the proposed method presents higher performance value for the better process.

Example 2:



NRTY=0.84
$RTY_{proposed}$=0.74

(3-1)



NRTY=0.84
$RTY_{proposed}$=0.69

(3-2)

Fig. 3. Comparison of two processes with different sequence of occurred scraps

In example 2, if two stages of a process with two different numbers of scraps are replaced for each other, NRTY will not reflect this difference, while the made scraps in the final stage will cause the organization higher costs. The proposed RTY again provides more significant results.

4. Conclusion

Six Sigma is a capable methodology in improving organizational processes through decreasing reworks and defects. The proposed approach is a new method of estimating the performance of processes. This method tries to divide defects into scraps and reworks to consider their costs, and to consider various situations of rework loops in order to reach a better estimation of organizational capabilities.

Considering the weights according to reworks and scraps enables managers to realistically realize the process performance. It also helps practitioners to make the best decisions through eliminating or minimizing rework loops, decreasing scraps or costs.

It is possible to define other criteria for sub-process weighting based on the strategies of different organizations. This model can be applied in each organizations which implementing Six Sigma such as healthcare, servicing sectors and various industries.

References

[1] Goh, T.N., "*A Strategic Assessment of Six Sigma*", Quality and Reliability Engineering International, Vol. 18(5), 2002, pp. 403-10.

[2] Antony, J., Banuelas, R., "*Key Ingredients for the Effective Implementation of Six Sigma Program*", Measuring Business Excellence, Vol. 6(4), 2002, pp. 20-27.

[3] Pyzdek, T., The Six Sigma Handbook, McGraw-Hill, New York, NY, 2003.

[Downloaded from ijiepr.iust.ac.ir on 2026-09-12]

[4] Graves, S., "*Six Sigma Rolled Throughput yield*", Quality Engineering, Vol. 14(2), 2002, PP. 257-266.

[5] Ravichandran, J., "*Six Sigma Milestone: an Overall Sigma Level of an Organization*", Total Quality Management & Business Excellence, Vol. (8), 2006, pp. 973-80.

[6] Ravichandran, J., "*Cost-Based Process Weights for DPMO and the Overall Performance of an Organization*", The TQM Magazine, Vol. 19(5), 2007, pp. 442-453.

Appendix

Equation (3) provided in section 2 can be proved as the following:

$$E(\sum_{k=1}^{N_j} S_k^{(j)}) = E(E(\sum_{k=1}^{N_j} S_k^{(j)} \Big| N_j))$$

Since

$$E(\sum_{k=1}^{N_j} S_k^{(j)} \Big| N_j = n) = E(\sum_{k=1}^{n} S_k^{(j)} \Big| N_j = n)$$

$$= E(\sum_{k=1}^{n} S_k^{(j)}) = nE(S^{(j)})$$

$$E(\sum_{k=1}^{N} S_k^{(j)} \Big| N_j) = N_j E(S^{(j)})$$

Therefore

$$E(\sum_{k=1}^{N} S_k^{(j)}) = E(NE(S^{(j)})) = E(N)E(S^{(j)})$$

Where, for each j, $S_k^{(j)}, k = 1,..., N_j$ is independent identified distribution and for each j, $S_k^{(j)}$, $k = 1,..., N_j$ is independent from N_j.

Similar to the procedure of equation (3) formulation, we can prove (4). Also, $E(R^{(ji)})$ is obtained as below:

$$E(R^{(ji)}) = E(r_j + \sum_{k=i}^{j} \mu_k g_k) = E(r_j) + E(\sum_{k=i}^{j} \mu_k g_k)$$

$$= E(r_j) + \mu_k \sum_{k=i}^{j} E(g_k).$$

[Downloaded from ijiepr.iust.ac.ir on 2026-09-12]