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Assessment of Six Sigma Selection Using TOPSIS Method

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Abstract: *Production organizations have had success using six sigma as a business strategy in recent years to lower the number of defective products from production processes, cutting costs and increasing profitability. Six Sigma is considered a way for raising the caliber of procedures and goods that is well-structured. Through all the effective application of a construction approach, it aids in achieving the firm's operations aim. Research Significance: Since Six Sigma is a project-driven approach, it is crucial to give projects that would benefit the firm financially the highest priority. But in reality, creating and prioritizing the crucial Six Sigma initiatives is a tremendous issue. Research methodology: In this study, the "technique for order of preference by similarity to ideal solution (TOPSIS)" is employed to select one or more six sigma projects that result in the maximum benefit to the organization. Different criteria are given specific weights of importance according to the "equal weights method (EWM)". Result: The rank of alternative consultants using the TOPSIS method for Project A is second, Project B is first, Project C is third, Project D is fifth, Project E is sixth and Project E is fourth. Conclusion: The result indicated that project B with greater financial impact, an expected increase in sigma quality, expected percentage increase in productivity.*
Keywords: *Six Sigma, COPQ, rise in productivity, project cost, project length and multi-criteria decision-making.*

1. Introduction

One of the effective business techniques that enhances quality initiatives across numerous sectors globally is Six Sigma. It is a methodical method used throughout the entire firm to achieve ongoing process improvements. Using Six Sigma means creating only 3.4 flaws out of every million chances for a business operation. This is true both of the technique and the concept. The use of Six Sigma advancements and methodology has grown and developed significantly in businesses [1]. Six Sigma has attracted a lot of attention in international companies, particularly in the last 10 years, as a transition and improvement method to produce the most business gain and competitive edge. The initials D-M-A-I-C can also be used to represent the five basic steps of this strategic method, which are defined, measured, analyses, improve, and controlled [2]. The define phase is a crucial step in choosing the best project because it helps to properly identify the issue. Potential advantages and contributors are described. concentrating on client demands Six Sigma projects are created, the needs and existing performance are assessed, the criteria and crucial factors that have an impact on customer happiness are evaluated, the process is enhanced, and the process is regulated by monitoring and reviewing the systems. One of the most delicate aspects of implementing Six Sigma is choosing the appropriate Six Sigma project [3,4]. Six Sigma originated from language related to the statistical modelling of manufacturing processes. The conceptualization of Six Sigma is multifaceted and incorporates several concepts, including a) a framework for identifying and eliminating flaws, mistakes, or failures in company mechanisms and systems; b) a set of analytical techniques for continuous improvement; c) an operational and market philosophy; d) an analysis procedure; and e) an enterprise culture [5]. Motorola was the organization that originally used Six Sigma, and a ten-fold reduction in defects was previously the goal. The corporation boosted its annual earnings by 20%, its revenues by 5%, and its ability to save more than $10 billion during the ensuing ten years [6]. "Finance, marketing, and health" are just a few of the industries outside of manufacturing where Six Sigma techniques are being used. The Six Sigma methodology has been widely applied in the industry to save costs, boost quality, accelerate shipping times, and boost customer contentment [7]. It takes time and effort to establish Six Sigma as an organization's business concept and culture. A Six Sigma culture usually takes four to five years to completely adopt, and it costs a lot of money for training and growth over that time. Six Sigma should have the complete and open commitment of the top administrative team. The bulk of the processes chosen for Six Sigma development are crucial procedures for the organization and have a cross-functional focus [8]. Top management's active participation will guarantee the removal of obstacles related to problems with cross-organizational, cross-functional processes. The organization's upper executives establish the overarching goal of implementing Six Sigma, make sure it aligns with the various organizational priorities and secures organizational support. The top management must also determine the macro-organizational objectives that need to be optimized and selected by everyone as the top priorities for the organization [9, 10]. Project selection is typically approached as a "multi-criteria decision-making (MCDM) problem", and the majority of methods used in the research use a descriptive model that gives the project's supplies and outcomes a priori weighting. The various DMUs in the six-sigma application selection problem make up the six-sigma projects that can be implemented. We select six fictitious projects as alternative parameters. "Financial impact, the anticipated rise in sigma quality, anticipated rise in productivity as a percentage, anticipated project cost, and anticipated project length in days".

2. Materials And Methods

To evaluate MCDM issues, the assessment method "TOPSIS" is frequently employed. It can be applied to a wide range of real-world tasks, including assessing an industry's financial sustainability, contrasting economic outcomes, and investing in state-of-the-art manufacturing methods. But there are certain restrictions as well [11]. The "TOPSIS method" does have some serious drawbacks, unfortunately. The possibility for the occurrence known as "rank reversal" is one of the issues that TOPSIS brings. The "order of preference for the alternatives" changes when an opportunity is added to or withdrawn from the decision-making problem [12]. A "Total rank reversal" occurs when priorities are fully reversed and the choices that were formerly considered to be ideal are now the worst whenever a solution is added to or withdrawn from the system. Such an event could not be advantageous in many situations [13,14]. A range of possibilities must be looked at and assessed in "MCDM" depending on a set of factors. The goal of MCDM is to let the decision-maker choose from a variety of options. As a result, practical circumstances usually involve several conflicting criteria, and no solution can likely fulfil all of the criteria at once. Therefore, the answer is a balanced option based on the decision objectives. According to TOPSIS' guiding principle, the best outcome will be the option that is "the Negative Ideal Solution (NIS) and most similar to the Positive Ideal Solution (PIS)". The final score is calculated using the proximity metric [15,16].

Step 1: The decision matrix X, which displays "how various options perform concerning certain criteria", is created.

$$x_{ij} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

Step 2: Weights for the criteria are expressed as

$$w_j = [w_1 \cdots w_n], \quad where, \sum_{j=1}^{n}(w_1 \cdots w_n) = 1 \quad (2)$$

Step 3: The matrix x_{ij}'s normalized values are computed as

$$n_{ij} = \frac{x_{ij}}{\sqrt[2]{\sum_{i=1}^{m} x_{ij}^2}} \quad (3)$$

"Weighted normalized matrix N_{ij}" is calculated by the following formula

$$N_{ij} = w_j \times n_{ij} \quad (4)$$

Step 4: To begin, let's establish the "ideal best and ideal worst values": Here, we need to decide if the influence is "+" or "-. " If a column has a "+" impact, its greatest value is the "ideal best value for that column," and if it has a "-" influence, its poorest number is the "ideal worst value."

Step 5: Now we need to find "the difference between each response from the ideal best",

$$S_i^+ = \sqrt{\sum_{j=1}^{n}(N_{ij} - A_j^+)^2} \quad for\ i \in [1, m]\ and\ \ j \in [1, n] \quad (5)$$

Step 6: Now we need to find "the difference between each response from the ideal worst",

$$S_i^- = \sqrt{\sum_{j=1}^{n}(N_{ij} - A_j^-)^2} \quad for\ i \in [1, m]\ and\ \ j \in [1, n] \quad (6)$$

Step 7: Now we need to find "the Closeness coefficient of i_{th} alternative"

$$CC_i = \frac{S_i^-}{S_i^+ + S_i^-} \quad where, 0 \le CC_i \le 1, i \in [1, m] \quad (7)$$

The number of "The Closeness Coefficient" shows how much better the options are in relation. A "significantly worse alternative" is indicated by a smaller, CCi. and a "substantially better alternative" by a larger, CCi.

Project choosing is typically approached as a "multi-criteria decision-making (MCDM) problem", and the majority of methods used in the literature use a parametric model that gives the project's inputs and outputs a priori weighting. The various DMUs in the six-sigma project selection problem make up the six-sigma projects that can be implemented. We select six fictitious projects as alternative parameters. Financial impact, the expected increase in sigma quality, expected percentage increase in productivity, expected project cost and expected project duration in days are used to evaluate the selected projects.

Financial impact: Six sigma projects are frequently chosen and evaluated using the COPQ as a primary criterion. The direct benefit of six sigma for manufacturing organizations is a decrease in the number of defects as a result of enhanced production processes. Any increase in the sigma level is expected to result in a decrease in COPQ. The cost of repair, excessive energy use, warranty-related expenditures, and needless resource use are all factors that affect the COPQ as a consequence of manufacturing failures. Minimizing the COPQ is among the six-sigma project's primary goals [17].

The expected increase in sigma quality level: A greater sigma level signifies fewer faults are made through an operation, whereas a smaller sigma level signifies defect rate. The process failure rate is measured by the sigma quality level. Sigma's level of performance can be applied for benchmarking and aids in assessing process quality. During the DMAIC cycle of process improvement, the sigma performance level also aids in establishing a reasonable goal for process quality advancement. Thus, a key factor in choosing a six-sigma project is how an "increase in quality level" will affect financial performance [18].

***The expected increase in productivity**:* The goal of six sigma is to raise the production system's performance; as a result, an essential output of six sigma deployment is an increase in production efficiency. The relationship between "COPQ, sigma quality level, and productivity" is nonlinear. The DPMO drops at a declining rate as the sigma level rises. Similar to this, production (yield) improves at a diminishing pace as the sigma level rises [19].

The expected value of the project cost: Implementing six sigma might need a sizable financial outlay. The project budget is a crucial factor in choosing the six-sigma project. However, even with innovative methods like activity-based pricing, it is challenging to anticipate the cost of any venture with accuracy (ABC). For this reason, we base our analysis in this study on the estimated value of project costs [20].

Expected project duration: The project's length is crucial since a lengthy implementation period may necessitate a greater resource investment and delay the realization of benefits. We employ the expected value of the project length in the DEA model, just like we did with the project cost because the period is a random process [21].

3. Analysis And Discussion

TABLE 1. Inputs and outputs for hypothetical projects

	Financial impact	**The expected increase in sigma quality**	**Expected percentage increase in productivity**	**Expected project cost**	**Expected project duration in days**
Project A	331	0.24	20	212	70
Project B	342	0.77	23	199	63
Project C	333	0.33	10	214	88
Project D	303	0.48	10	280	77
Project E	240	0.41	11	263	72
Project F	306	0.52	17	203	70

Table 1 shows the performance data of Inputs and outputs for hypothetical projects. Financial impact, the expected increase in sigma quality, expected percentage increase in productivity, expected project cost and expected project duration in days are used to evaluate the selected projects.

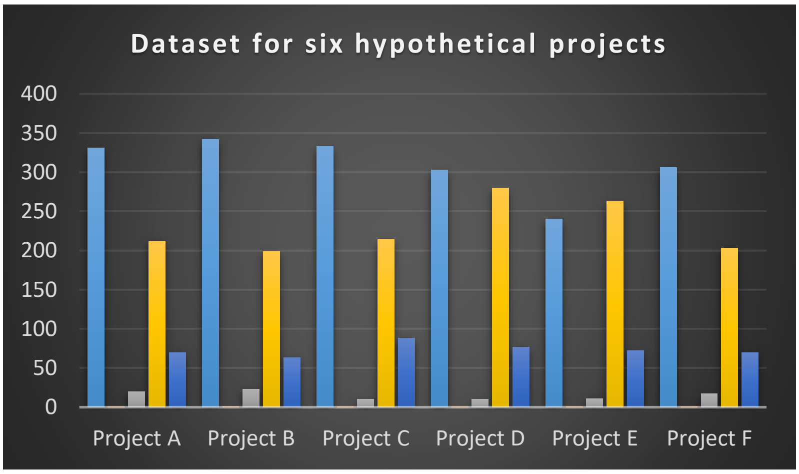

FIGURE 1. Inputs and outputs for hypothetical projects

Figure 1 shows a graphical view of Inputs and outputs for hypothetical projects. Financial impact, the expected increase in sigma quality, expected percentage increase in productivity, expected project cost and expected project duration in days are used to evaluate the selected projects.

TABLE 2. Normalized Data

0.4744	0.0003	0.0287	0.3038	0.1003
0.4902	0.0011	0.0330	0.2852	0.0903
0.4773	0.0005	0.0143	0.3067	0.1261
0.4343	0.0007	0.0143	0.4013	0.1104
0.3440	0.0006	0.0158	0.3769	0.1032
0.4386	0.0007	0.0244	0.2909	0.1003

The normalized matrix of the Ratings of the performance of the selection of the six-sigma project is displayed in Table 2 above. This matrix was produced using equation three.

TABLE 3. Weight

0.20	0.20	0.20	0.20	0.20
0.20	0.20	0.20	0.20	0.20
0.20	0.20	0.20	0.20	0.20
0.20	0.20	0.20	0.20	0.20
0.20	0.20	0.20	0.20	0.20
0.20	0.20	0.20	0.20	0.20

The preferred weight for the evaluation parameters is shown in Table 3. In this case, weights are equally distributed among " Financial impact, expected increase in sigma quality, the expected percentage increase in productivity, expected project cost and expected project duration in days ". The sum of weights distributed equals one.

TABLE 4. Weighted normalized decision matrix

0.09488	0.00007	0.00573	0.06077	0.02007
0.09803	0.00022	0.00659	0.05704	0.01806
0.09545	0.00009	0.00287	0.06134	0.02522
0.08685	0.00014	0.00287	0.08026	0.02207
0.06879	0.00012	0.00315	0.07539	0.02064
0.08771	0.00015	0.00487	0.05819	0.02007

Table 4 shows the weighted normalized matrix of the decision matrix and it is calculated by table 2 and table 3 using equation 4.

TABLE 5. Positive Matrix

0.0980	0.0002	0.0066	0.0570	0.0181
0.0980	0.0002	0.0066	0.0570	0.0181
0.0980	0.0002	0.0066	0.0570	0.0181
0.0980	0.0002	0.0066	0.0570	0.0181
0.0980	0.0002	0.0066	0.0570	0.0181
0.0980	0.0002	0.0066	0.0570	0.0181

Table 5 shows the positive matrix calculated by using table 4. The ideal best for a column is the maximum value of that column in table 4.

TABLE 6. Negative matrix

0.0688	0.0001	0.0029	0.0803	0.0252
0.0688	0.0001	0.0029	0.0803	0.0252
0.0688	0.0001	0.0029	0.0803	0.0252
0.0688	0.0001	0.0029	0.0803	0.0252
0.0688	0.0001	0.0029	0.0803	0.0252
0.0688	0.0001	0.0029	0.0803	0.0252

Table 6 shows the negative matrix calculated by using table 4. The Ideal best for a column is the minimum value in that column in table 4.

TABLE 7. SI Plus and Si negative

	SI +	Si -
Project A	0.0053	0.0331
Project B	0.0000	0.0382
Project C	0.0095	0.0327
Project D	0.0263	0.0183
Project E	0.0348	0.0067
Project F	0.0107	0.0296

Table 7 shows the “Si plus and Si negative values”. The difference between each response from the “ideal best (S_i^+)” is found utilizing equation 5 and the difference between each response from the “ideal worst (S_i^-)” is found utilizing equation 6.

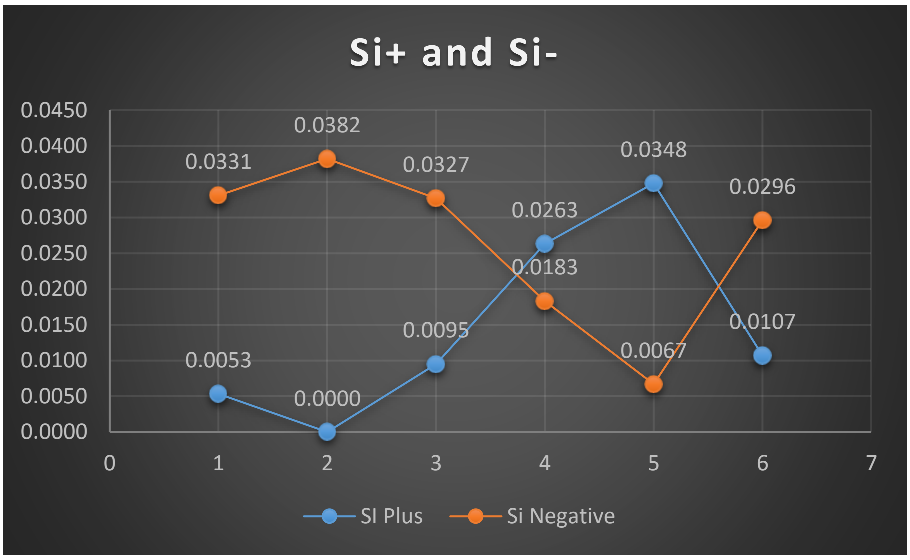

FIGURE 2. SI Plus and Si negative

The figure illustrates the "Si plus and Si negative values" from the analysis. The difference between each response from the "ideal best (S_i^+)" is found utilizing equation 5 and the difference between each response from the "ideal worst (S_i^-)" is found utilizing equation 6.

TABLE 8. Closeness coefficient

	Ci
Project A	0.8608
Project B	1.0000
Project C	0.7747
Project D	0.4103
Project E	0.1615
Project F	0.7342

Table 8 demonstrates the value of CCi. It is calculated by using equation 7. Here Closeness coefficient value for Project A is 0.8608, Project B is 1, Project C is 0.7747, Project D is 0.4103, Project E is 0.1615 and Project E is 0.7342.

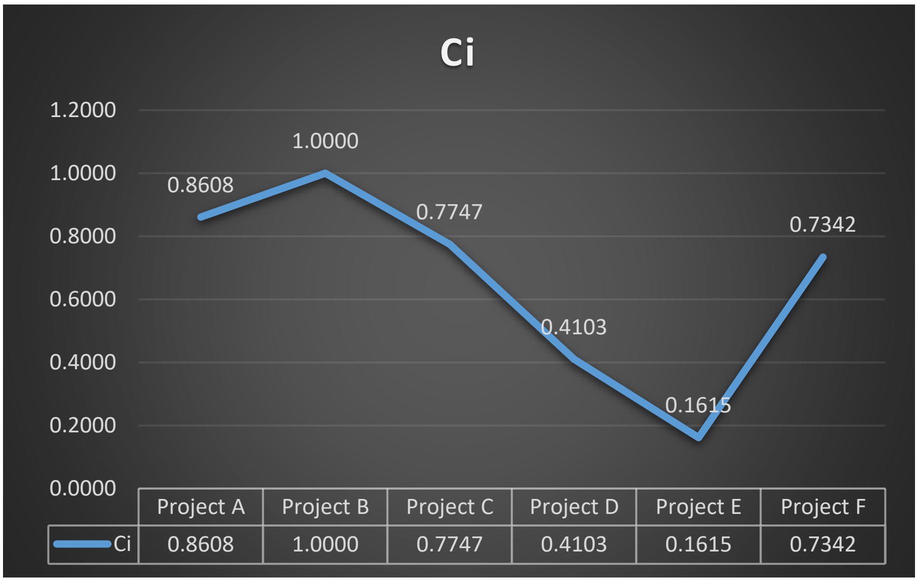

FIGURE 3. Closeness Coefficient (CCi)

Figure 3 illustrates the graphical representation of CCi. It is calculated by using equation 7. Here Closeness coefficient value for Project A is 0.8608, Project B is 1, Project C is 0.7747, Project D is 0.4103, Project E is 0.1615 and Project E is 0.7342.

TABLE 9. Rank

	Rank
Project A	2
Project B	1
Project C	3
Project D	5
Project E	6
Project F	4

Table 9 shows the analysis of the selection of the six-sigma project. Here rank of Project A is second, Project B is first, Project C is third, Project D is fifth, Project E is sixth and Project E is fourth.

FIGURE 4. Rank

Figure 4 illustrates the ranking of Ui from Table 9. Here rank of alternatives using the TOPSIS method for Project A is second, Project B is first, Project C is third, Project D is fifth, Project E is sixth and Project E is fourth. The result indicated that project B with greater financial impact, an expected increase in sigma quality, expected percentage increase in productivity.

4. Conclusion

The "design, measure, analyses, improve, and control (DMAIC)" approach is a systematic project-based strategy used in organizations to execute the Six Sigma strategy. Impressive bottom-line benefits from Six Sigma typically follow from the accomplishment of Six Sigma initiatives. Successful Six Sigma campaigns can be distinguished from mediocre ones by the caliber of their Six Sigma assignments. Perhaps the most important step in starting a Six Sigma programme is projected choosing. Finding and then successfully and efficiently addressing consumer and corporate demands is the ultimate goal of all process optimization approaches. The early achievement and long-term adoption of any Six Sigma programme within a company depends heavily on the selection of the appropriate projects. A key factor in the success of the deployment is the caliber of the project that was chosen. Too broad or high-level a project scope, an imprecise problem or goal description, and a lack of connection to company objectives or client needs are common issues that plague many initiatives. To choose one or maybe more six sigma initiatives that will benefit the organization most in this study, the "technique for order of preference by similarity to ideal solution (TOPSIS)" is used. The outcome showed that project B had a bigger financial impact, as well as projected increases in sigma quality and productivity.

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