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# Evaluating Software Maintenance KPIs in Bangladesh's Software Industry

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**ABSTRACT** Maintenance, a vital part of the software development lifecycle (SDLC), accounts for the majority of the considerable expenses associated with software ownership. Maintenance activities include integrating new features, enhancing performance, and repairing errors to ensure software remains operational and relevant in a continuously changing technological context. Effective management of software-driven business processes is crucial to sustain its value for many stakeholders. Key Performance Indicators (KPIs) are valuable tools for analyzing and guiding maintenance actions. They provide measurable indicators to evaluate the quality and efficiency of efforts. KPIs provide a standardized framework for performance tracking, allowing organizations to make data-driven choices to improve software performance and reduce operating expenses. There exists a gap between the theoretical frameworks on KPIs and their application in practical fields. Even with the highly flourishing software business in Bangladesh, implementation of best practices related to software maintenance and use of KPIs are still at their infancy stage. The present study investigates the status of KPIs utilization in the software industry in Bangladesh. It aims to find the discrepancy between theoretical recommendations presented in literature and real-life practices of companies. This study will investigate how maintenance KPIs are developed, used, and evaluated by an in-depth survey of 22 software companies.Key findings state key performance indicators: "post-release defects," "maintenance cost as a percentage of total software cost," "customer satisfaction," and "task completion rate." It is also inferred from the data that large organizations and small firms use KPI for different purposes; the latter review their KPI more frequently. It, therefore, underlines the urgent need for structured integration of KPIs in such a way that it takes into account specific challenges faced by industries within this context. It actually calls for further research in the development of these indicators in such a way that it enhances their effectiveness in maintenance performance.

**INDEX TERMS** KPI, Weighted Average

## I. INTRODUCTION

A CONSIDERABLE part of the whole cost of owning software goes to software maintenance, which is widely viewed as an integral element of the software development lifecycle (SDLC). Software maintenance covers several tasks, like adding new features, boosting performance, and fixing faults. These tasks are all meant to preserve software operating, adaptable, and useful in a continually expanding technological context. Software is increasingly driving business operations, thus it is necessary to offer effective management of software systems so that they stay honest and preserve value for diverse groups.

Key Performance Indicators (KPIs) have become key instruments for analysing and directing software repair tasks. KPIs offer companies numeric and emotive measures to assess the quality, effectiveness, and efficiency of their repair operations. KPIs enable businesses in making data-driven choices to raise software performance, reduce operating costs, and enhance software reliability by providing an organised framework for tracking performance. Boehm [1] notes that maintenance may account for as much as 50% of the money given for software development, emphasising the significance of correctly establishing KPIs to ensure the best use of these resources.

However, despite the general awareness of KPIs as crucial to software maintenance, there is a large disparity between

theoretical models of KPI frameworks and their actual execution in real-world conditions. Most theoretical models propose comprehensive sets of metrics that represent a wide range of qualities from software maintenance: stability, maintainability, and adaptability. The metrics are based on a good understanding of the discipline of software engineering and are supposed to allow holistic assessments of the repair process. Most of these theoretical models fail in implementation within organizations due to many factors that range from budgetary constraints to a lack of understanding to unique challenges given by the industries they belong to.

### A. THEORETICAL KPIS VS. PRACTICAL APPLICATION

Many works have provided an attempt to build a theoretic framework for software support KPIs. For an example, Fenton and Pfleeger [2] provided the core foundation of a form of software measure, but from which several Key Performance Indicators or KPIs applied to support roles have since been derived. They noted that in order to have a holistic view of how a system will perform over time, one has to conduct an analysis of the software quality characteristics such as maintainability, reliability and flexibility. KPIs derived from such models are created with an aim of measuring the Technical and Managerial efficiency of software support comprehensively.

Al Dallal [2] conducted a detailed review on the research issues dealing with the aspect of software maintenances, particularly for object oriented software systems,(sqrt). His study draws the attention necessarily to the internal quality factors such as inheritance, coherence and couplet that to decisive for the software maintainability. This research therefore emphasizes the centrality of maintainability criteria in directing maintenance processes especially within settings that incorporate op. Al Dallal has proposed a rather sound framework for defining KPIs and has discussed the factors related to the maintainability of software solutions.

Along the same line of thought, Mohagheghi  Conradi [3] also considered the compatibility between software metrics as well as project performance. By their investigation of large telecom products, they demonstrated that appropriate choice of the metrics significantly influences the project results with the emphasis on the maintenance phase. Their work stresses the relationship between the measures to be used and the goals of the business, or the characteristics of a particular project. Accordingly, both Mohagheghi and Conradi's investigation provides credible evidence to support the notion that KPIs should ideally be 'project specific', a view that clearly underlines the authors' belief that a more generic approach is unlikely to work in the real world.

Another essential article that classified a systematic approach toward the selection of software metric is Kitchenham et al. [4] This original research is also well appropriate when measuring KPIs in maintenance contexts. Their method focuses on the manner in which the metrics should be validated in order to indicate the software quality attributes they are expected to reflect. Following these structured methods, users are able to build robust KPIs that can augment the maintenance activities in accordance to the needs of their projects.

Pigoski [5] emphasized how important it is to create KPIs that take software systems' adaptability into consideration. As software systems become more complicated and interconnected, so does the demand for maintenance monitoring. Pigoski argues that the spectrum of maintenance responsibilities in modern software systems may go over the limitations of usual KPIs. In order to ensure that KPI models continue to be useful in the face of changing technology and financial realities, he is a proponent of their constant growth.

After conducting a comprehensive analysis of software maintainability prediction models, Riaz et al. [6] provided insightful recommendations for selecting metrics in software maintenance. Their study emphasizes the increasing importance of predictive models in software maintenance, particularly when used in conjunction with preventative maintenance programs.

### B. CONTEXT OF SOFTWARE MAINTENANCE IN BANGLADESH

Despite Bangladesh's developing reputation as a software development and IT services powerhouse, the usage of software maintenance KPIs remains underexplored. The Bangladesh software business has risen substantially in recent years, with a growth in the number of software development organizations serving both local and foreign consumers. However, the application of best practices for software maintenance, such as the utilization of KPIs, is still in its early stages.

Resource limits, constantly expanding technology, and industry-specific demands result in substantial variances in the KPIs that organizations utilize. While some major organizations with international clients may have the means and experience to construct entire KPI systems, smaller enterprises generally rely on ad hoc approaches to assess their maintenance efforts. This mismatch emphasizes the need for a more scientific approach to KPI adoption in the Bangladesh software industry, one that takes into consideration the particular constraints encountered by firms operating in this context.

This research tries to solve these concerns by concentrating on the software business in Bangladesh. We did a detailed analysis of several software firms to discover how maintenance KPIs are produced, applied, and analyzed. The goal of this research is twofold: first, to identify discrepancies between the theoretical KPIs prescribed in the literature and the practical KPIs used by businesses; and second, to propose a structured approach to bridge this gap, allowing organizations to better align their maintenance performance metrics with industry best practices.

### C. RESEARCH CONTRIBUTIONS

This research contributes to the burgeoning corpus of knowledge on software maintenance by investigating the adoption of KPIs in Bangladesh's software business. Our suggestions

are supported by research and may be extremely beneficial to practitioners in the company and academics who are endeavoring to enhance their KPI frameworks to reflect industry best practices. Therefore, in order to achieve sustainable excellence across maintenance functions as new technologies are developed, it is now important to focus on the enhancement of the KPI selection cycle. To this end, the formulation of KPIs is ongoing in order to closely correlate it with the demand of software systems.

## II. RELATED WORKS

In the context of Bangladesh, it has been found that, the measurement of operational performance through KPI serves a crucial role to improve the performance of Software companies. This section can thus benefit the software industry by summarising current research relating to the choice and use of KPIs as well as their consequences in different industries.

César Duarte Freitas Gonçalves et al. [7] propose a MCDM model for the definition of maintenance KPIs into industrial scenarios. In their study, they revealed that performance measurement was comprised of four elements namely, Key Performance Indicator compatibility with standards and organisational goals as well as costs and maintenance feasibility. This method enables software companies to determine KPIs that influence both software quality and maintenance performance.

Christer Stenström et al. [8] investigated value-based maintenance performance measures, with the focus on the link between maintenance processes and organisational strategies. Their studies show that KPIs should not only flow in the 'silos' of organisational efficiency but also demonstrate the organisational worth of that efficiency. This perspective is important to software firms who seek to align the maintenance activities with other business strategies.

Their empirical study on maintenance performance monitoring within Belgian companies, Peter N. Muchiri et al. [9], reveal some difficulties with KPI applications. Their conclusions about data acquisition and processing indicate the need for applied approaches to KPI management. These points can help the software companies of Bangladesh how to optimize the KPI usage for performance evaluation.

Paulina Gackowiec et al. [10] have reviewed the process monitoring applied on mining industry using KPI, insisting on the real time data and predictive analysis. This approach shows how KPI increases operational efficiency when decisions are made at the right time for software development and maintenance activities.

Long-term KPIs have been shown to prevent environmental issues and reduce excess water and energy use in textile dyeing mills in Bangladesh as identified by Abdullah Al Mamun et al. [11] during their analysis of groundwater and energy utilization in Bangladeshi textile dyeing mills. This research also emphasizes the use of Sustainable KPIs, through which the software companies can bolster responsible business practices.

As applied to clothing and textile SCs in Bangladesh, Khan Md. Ariful Haque et al. [12] showed how KPIs improve the sustainability and resource utilisation performance. As indicated by their recommendations, the study has an implication that software companies can achieve optimal resource management and process optimization by adopting similar performance measurement systems.

Regarding the challenge of energy access, Dipta Majumder et al. [13] analyzed KPIs for small solar PV-diesel hybrid grid in remote islands of bangladesh. They argue that their conceptualisation of KPIs requires specific context which aligns to the performance and reliability assessment – something that software companies should bear in mind while looking for relevant KPI to adopt concerning their operation challenges.

In general, these investigations concern with the great significance of identifying and applying KPIs relevant to organizational needs and requirements. The insight and use of specific KPIs for software maintenance and development make the software companies of Bangladesh discover that the organization's overall performance can improve notably if it relates and aligns the efficiency improvements derived from valuable KPIs with the overarching organizational goals and strategies.

## III. METHODOLOGY

The objectives of this research are as follows; This paper aims at identifying how KPI defined objectives are useful in software maintenance in the Bangladesh software industry. While in this section, we first need to solve the root causes of the problem. In the recent past few years, some new ventures vendors have started in Bangladesh; but very many among them are unable to meet their needs as well as face problems after delivering the software products. It is here that the importance of maintenance KPIs is realized. The survey was a part of our research, and we analyzed several factors for questioning as well as decision making.

### A. DEFINE MAINTENANCE KPI

When it comes to software maintenance, it is important that a set of objectives is defined congruent with the general organizational objectives. These goals provide a framework for performance measurement and improvement; targeting key operational issues like system accessibility and utilisation, costs, dependability and user satisfaction. By setting these objectives, we can identify relevant Key Performance Indicators (KPIs) to measure success and optimize maintenance efforts. Therefore, we began by defining several objectives, and subsequently outlined the corresponding KPIs.

#### 1) Maximize System Availability

**Objective:** Guarantee that the software system remains accessible and functional for users, minimizing downtime as much as possible.

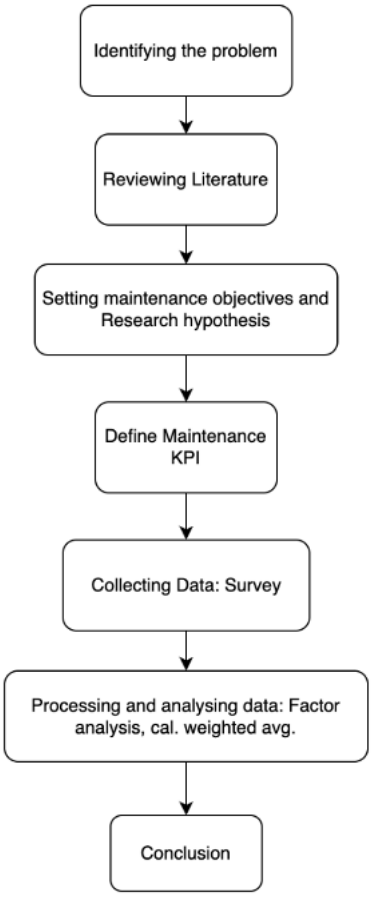


**FIGURE 1.** Methodology

**Mean Time Between Failures (MTBF):** The average duration between two successive system failures.

$$\text{MTBF} = \frac{\text{Total Operating Time}}{\text{Number of Failures}}$$

A higher mean time between failures (MTBF) indicates greater system reliability.

**Mean Time to Repair (MTTR):** The average time required to restore a system after a failure.

$$\text{MTTR} = \frac{\text{Total Repair Time}}{\text{Total Number of Failures}}$$

A low mean time to repair (MTTR) suggests that the maintenance team can resolve issues swiftly, thereby reducing downtime.

**Post-Release Defects(PRD):** The number of defects identified after the software is released to users.

$$\text{Post-Release Defects} = \frac{\text{Defects Found After Release}}{\text{Total Defects}} \times 100$$

This tracks the software's quality at release.

### 2) Minimize Maintenance Costs

**Objective:** Reduce the costs associated with maintaining software systems, including bug fixes and updates.

**Average Cost per Bug(ACB):** The average cost incurred to fix each bug or defect.

$$\text{Average Cost per Bug} = \frac{\text{Total Bug Fixing Cost}}{\text{Total Bugs Fixed}}$$

This KPI gives an insight into the financial impact of software defects.

**Rework Cost Factor(RCF):** The percentage of total maintenance costs attributed to rework activities.

$$\text{Rework Cost Factor} = \frac{\text{Cost of Rework}}{\text{Total Maintenance Cost}} \times 100$$

It helps assess how much of the maintenance budget is spent on fixing errors that should have been prevented initially.

**Maintenance Cost as a Percentage of Total Software Cost(MCPTSC):** The proportion of the total software project cost that is spent on maintenance activities.

$$\text{Maintenance Cost Percentage} = \frac{\text{Total Maintenance Cost}}{\text{Total Software Cost}} \times 100$$

This KPI shows how much of the software budget is dedicated to maintaining the system.

**Requirement Change Cost (RCC) Factor:** The cost associated with changes in requirements after the initial specification is made.

$$\text{RCC Factor} = \frac{\text{Cost of Requirement Changes}}{\text{Total Maintenance Cost}} \times 100$$

Calculation Example: If the cost of requirement changes is \$8,000 and the total maintenance cost is \$40,000, RCC = (8,000 / 40,000) × 100 = 20%.

### 3) Improve Software Reliability

**Objective:** Increase the reliability of the software to reduce system failures and defects.

**Defect Rate(DR):** The number of defects or bugs identified per 1000 lines of code.

$$\text{Defect Rate} = \frac{\text{Total Defects Found}}{\text{Total Lines of Code}} \times 1000$$

This helps track software quality by identifying how frequently bugs occur.

**Percentage of Rework(PR):** The proportion of total work that needs to be redone due to defects or errors.

$$\text{Percentage of Rework} = \frac{\text{Rework Hours}}{\text{Total Work Hours}} \times 100$$

This KPI helps monitor inefficiencies in the maintenance process.

**Technical Debt(TD):** The cost of reworking the software due to shortcuts taken during development.

$$\text{Technical Debt} = \frac{\text{Cost of Fixing Technical Debt}}{\text{Total Development Cost}} \times 100$$

This tracks how much of the maintenance is spent addressing sub-optimal code or technical flaws.

#### 4) Optimize Resource Utilization

**Objective:** Efficiently use development and maintenance resources, including time and personnel.

**Task Completion Rate (TCR):**The percentage of maintenance tasks completed within a given period, relative to the total tasks assigned.

$$\text{TCR} = \frac{\text{Tasks Completed}}{\text{Total Tasks Assigned}} \times 100$$

This KPI ensures that maintenance tasks are being completed efficiently.

**Extra Time Spent for Implementation(ETSI):** The difference between the estimated and actual time taken to complete a maintenance task.

$$\text{Extra Time Spent} = \text{Actual Time} - \text{Estimated Time}$$

It helps track delays in the maintenance process.

#### 5) Enhance Customer/User Satisfaction

**Objective:** Ensure that the system meets or exceeds user expectations in terms of performance and stability.

**Customer Satisfaction(CS):** A measure of how satisfied users are with the maintenance services provided.

**Formula:** Collected through surveys or feedback, often using a Likert scale or Net Promoter Score (NPS).

#### 6) Increase Return on Investment (ROI) in Maintenance Activities

**Objective:** Ensure that the maintenance activities provide a positive financial return by improving software reliability and efficiency.

**Return on Investment (ROI) of Maintenance Activities:** Measures the financial return of maintenance efforts relative to their cost.

$$\text{ROI} = \frac{\text{Cost Savings from Maintenance} - \text{Maintenance Cost}}{\text{Maintenance Cost}} \times 100$$

A positive ROI indicates that maintenance activities are providing a return that justifies the cost.

### B. PROCESS DATA

In this study, data was collected via Google Forms, with responses from 12 different companies, totaling 22 responses. We gathered 14 KPIs from the survey, but removed duplicated data. Each KPI was evaluated on a scale from 0 to 5, corresponding to "Strongly Disagree," "Disagree," "Neutral," "Agree," and "Strongly Agree."

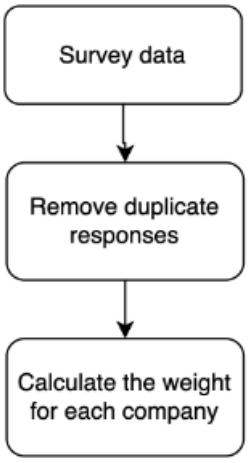


**FIGURE 2.** Data processing

### C. RESPONSE SEPARATION

We got responses from 4 sizes of companies: Small(1-50 Employees), Medium(51-200 Employees), Large(201-1000 Employees), Enterprise(1001+ Employees). For our calculation we merged the responses of small and medium together and large and enterprise together. The percentage of both groups was 11 each.

### D. CALCULATED WEIGHTED AVERAGE

For analysis for each question weight was assigned. For each question each option had been assigned a value from 1 to 5. 1 means the participant strongly disagrees with KPI selection and 5 indicates that they strongly agree with the KPI selected.

Then we calculated weighted average for overall responses as well as for Small and Large Size companies separately. For overall calculation total responses is 22 and for small and large size companies 11 each. The value ranges from 1 to 5 and 3 indicating neural and greater than 3 means participants strongly agree and less than 3 represents the opposite. Equation for weighted average calculation is given below:

$$\text{Weighted Average} = \frac{\sum(\text{weight} \times \text{number of responses})}{\text{Total number of responses}}$$

## IV. COMPARISON AND DISCUSSION

In this section, Authors compare and discuss the findings after calculating the averages. In this study, the weighted values of all KPIs were calculated first. We scaled the weighted average by three because of the minimal response, which aids in the explanation. According to Figure 3, the values range between 0 and 12, with "Post-Release Defects,"

**TABLE 1.** KPI Weights calculation for Overall, Large, and Small Companies

| KPI | Overall | | | | | | Large | | | | | | Small | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | AVG | 1 | 2 | 3 | 4 | 5 | AVG | 1 | 2 | 3 | 4 | 5 | AVG |
| TCR | 0 | 0 | 3 | 15 | 4 | 4.05 | 0 | 0 | 2 | 6 | 3 | 4.09 | 0 | 0 | 1 | 9 | 1 | 4.00 |
| RCF | 0 | 0 | 8 | 12 | 2 | 3.72 | 0 | 0 | 3 | 6 | 2 | 3.90 | 0 | 0 | 5 | 5 | 1 | 3.63 |
| CS | 0 | 1 | 4 | 10 | 7 | 4.05 | 0 | 0 | 4 | 3 | 4 | 4.00 | 0 | 1 | 0 | 7 | 3 | 4.09 |
| DR | 0 | 2 | 6 | 10 | 4 | 3.72 | 0 | 1 | 4 | 5 | 1 | 3.54 | 0 | 1 | 2 | 6 | 2 | 3.81 |
| ACPB | 1 | 3 | 8 | 7 | 3 | 3.36 | 1 | 1 | 4 | 3 | 2 | 3.36 | 0 | 0 | 4 | 5 | 2 | 3.81 |
| ETSI | 0 | 2 | 4 | 14 | 2 | 3.72 | 0 | 1 | 1 | 8 | 1 | 3.81 | 0 | 2 | 3 | 5 | 1 | 3.27 |
| RCC | 0 | 1 | 5 | 13 | 3 | 3.81 | 0 | 0 | 3 | 6 | 2 | 3.91 | 0 | 1 | 2 | 7 | 1 | 3.72 |
| MTTR | 0 | 2 | 10 | 10 | 0 | 3.36 | 0 | 2 | 7 | 2 | 0 | 3.00 | 0 | 1 | 1 | 9 | 0 | 3.72 |
| MTBF | 1 | 2 | 11 | 6 | 2 | 3.27 | 0 | 1 | 6 | 3 | 1 | 3.36 | 1 | 1 | 3 | 4 | 2 | 3.45 |
| PR | 0 | 1 | 7 | 12 | 2 | 3.68 | 0 | 1 | 6 | 4 | 0 | 3.27 | 0 | 0 | 2 | 8 | 1 | 3.91 |
| MCPTSC | 0 | 0 | 6 | 13 | 3 | 3.86 | 0 | 0 | 3 | 5 | 3 | 4.00 | 0 | 0 | 3 | 7 | 1 | 3.81 |
| PRD | 0 | 0 | 4 | 13 | 5 | 4.05 | 0 | 0 | 4 | 5 | 2 | 3.81 | 0 | 0 | 0 | 9 | 2 | 4.18 |
| TD | 0 | 2 | 7 | 9 | 4 | 3.68 | 0 | 1 | 4 | 3 | 3 | 3.72 | 0 | 1 | 4 | 4 | 2 | 3.63 |
| ROI | 0 | 3 | 8 | 9 | 2 | 3.45 | 0 | 1 | 4 | 4 | 2 | 3.63 | 0 | 2 | 4 | 5 | 0 | 3.27 |

"Maintenance Cost as a Percentage of Total Software Cost," "Customer Satisfaction," and "Task Completion Rate (TCR)" having the highest values. These values also indicate that companies use these KPIs the most.

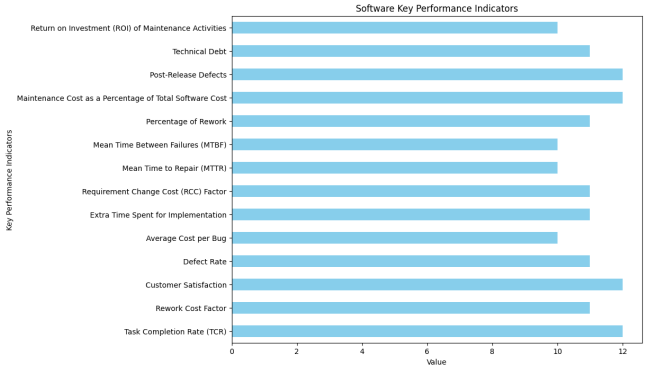


**FIGURE 3.** Software Key Performance Indicators

After finding the weighted average of all KPIs, then the KPIs are separated into large and small companies.The pie chart shows the responses collected on the basis from 4 types of companies according to their employee size. To analyse the factor, large and enterprise and small and medium companies are combined together.

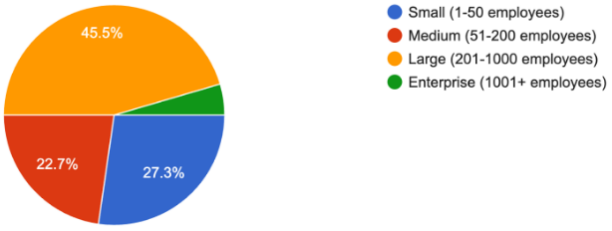


**FIGURE 4.** Company size by employee numbers

Now authors calculate the weight average for these companies. Figure 4) shows how large and small companies use maintenance KPIs. In Figure 5), large companies are denoted by sky blue and small companies are shown in orange. This bar chart shows some major differences in KPI usage between the companies. In large companies, "Task Completion Rate," "Customer Satisfaction," "Requirement Change Cost," and "Maintenance Cost as a Percentage of Total Software Cost" are considered high priorities. These KPIs are frequently tracked and analysed. However, there are some KPIs, like "Mean Time to Repair," that also need to be considered. If the maintenance team cannot fix issues quickly, it will increase downtime, creating problems in maintenance. On the other hand, according to their structure, small companies also use specific KPIs. The most commonly used KPI in small companies is "Post-Release Defects," as it reflects.

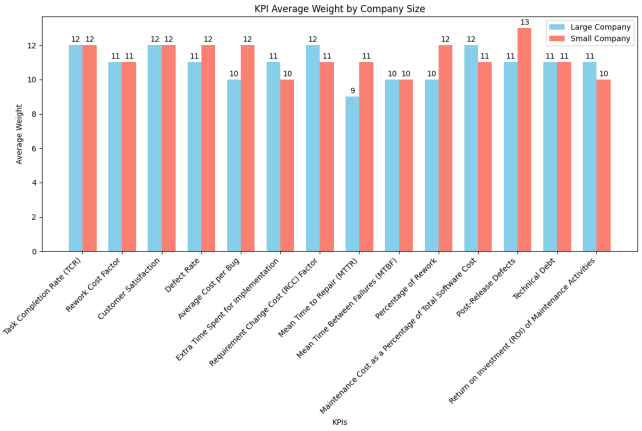


**FIGURE 5.** KPI Average Weight by Company Size

In this study, the authors examine how companies review their KPIs on a monthly, quarterly, and yearly basis. Figure 6) shows KPIs reviewed by company size. Small companies are represented in sky blue, while large companies are shown in orange. According to the grouped bar chart, small companies review KPIs more frequently than large companies. However, on a quarterly basis, the review frequency is the same. On an annual basis, large companies are more focused on reviewing their KPIs. KPI variations can occur due to differences in

organisational structure. For example, small companies often have smaller teams, so when new technologies emerge, their needs shift. As a result, their KPIs tend to change more frequently than those of large companies.

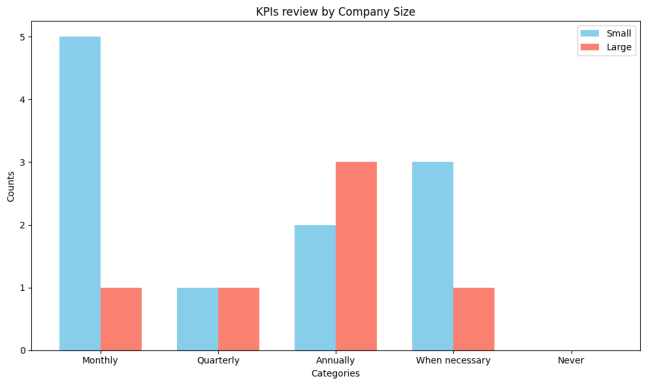


**FIGURE 6.** KKPIs review by Company Size

## V. CONCLUSION

KPIs are essential to maintenance for both small and large companies.This study used a survey to investigate how performance indicators and measurement are used in software maintenance. This was accomplished through looking into the key performance indicators (KPI) used by software businesses in Bangladesh. After processing the survey data and computing the results, 22 responses were obtained, and the use of these indicators on company size was then compared.First, the related papers demonstrated that different authors have presented distinct categories and types of maintenance KPI. Nevertheless, it was noted that a methodical approach to explicitly determining the various KPIs has not been carried out, and users are left to select the appropriate KPI from the provided lists based on their individual circumstances.Among the several reasons for disruptions in software maintenance, the examination of KPIs was found to be the most significant (quality, user experience, performance, etc.).These results highlight the significance of software maintenance KPIs and the necessity of reviewing maintenance KPIs.According to a survey about KPI usage in businesses, 81% of respondents claimed they utilise KPI. Some people modify indicators from literature or industry standards to meet the needs of their companies.The most popular KPIs, according to the factor analysis of the maintenance's impact on KPI selection, are "Post-Release Defects," "Maintenance Cost as a Percentage of Total Software Cost," "Customer Satisfaction," and "Task Completion Rate (TCR)".This further illustrates the strong relationship that maintenance managers have with these KPIs in terms of maintenance (SQA, project manager, etc). The findings, however, could not demonstrate how it enhances maintenance for bigger companies versus smaller ones. Further factor analysis of KPIs review indicated that there is similarity for small companies that they review monthly KPIs more than large companies. In order to incorporate maintenance KPIs into software maintenance performance systems, more study on these metrics that can produce the desired maintenance outcomes must be done. Lastly, an investigation into the software maintenance KPI as a whole is required to determine why maintenance managers are dissatisfied with the measurement of KPIs and why performance is not used enough in decision support. This study may determine whether maintenance KPIs are useful in various software organisations and whether KPIs need to be evaluated in order to improve software maintenance.

## REFERENCES

[1] B. W. Boehm and P. N. Papaccio, "Understanding and controlling software costs," IEEE transactions on software engineering, vol. 14, no. 10, pp. 1462–1477, 1988.
[2] J. Al Dallal, "Object-oriented class maintainability prediction using internal quality attributes," Information and Software Technology, vol. 55, no. 11, pp. 2028–2048, 2013.
[3] P. Mohagheghi and R. Conradi, "An empirical investigation of software reuse benefits in a large telecom product," ACM Transactions on Software Engineering and Methodology (TOSEM), vol. 17, no. 3, pp. 1–31, 2008.
[4] B. Kitchenham, S. L. Pfleeger, and N. Fenton, "Towards a framework for software measurement validation," IEEE Transactions on software Engineering, vol. 21, no. 12, pp. 929–944, 1995.
[5] T. M. Pigoski, Practical software maintenance: best practices for managing your software investment. Wiley Publishing, 1996.
[6] M. Riaz, E. Mendes, and E. Tempero, "A systematic review of software maintainability prediction and metrics," in 2009 3rd international symposium on empirical software engineering and measurement. IEEE, 2009, pp. 367–377.
[7] C. D. F. Gonçalves, J. A. M. Dias, and V. A. C. Machado, "Multicriteria decision methodology for selecting maintenance key performance indicators," International Journal of Management Science and Engineering Management, vol. 10, no. 3, pp. 215–223, 2015.
[8] C. Stenström, A. Parida, U. Kumar, and D. Galar, "Performance indicators and terminology for value driven maintenance," Journal of Quality in Maintenance Engineering, vol. 19, no. 3, pp. 222–232, 2013.
[9] P. N. Muchiri, L. Pintelon, H. Martin, and A.-M. De Meyer, "Empirical analysis of maintenance performance measurement in belgian industries," International Journal of Production Research, vol. 48, no. 20, pp. 5905–5924, 2010.
[10] P. Gackowiec, M. Podobińska-Staniec, E. Brzychczy, C. Kühlbach, and T. Özver, "Review of key performance indicators for process monitoring in the mining industry," Energies, vol. 13, no. 19, p. 5169, 2020.
[11] A. A. Mamun, K. K. Bormon, M. N. S. Rasu, A. Talukder, C. Freeman, R. Burch, and H. Chander, "An assessment of energy and groundwater consumption of textile dyeing mills in bangladesh and minimization of environmental impacts via long-term key performance indicators (kpi) baseline," Textiles, vol. 2, no. 4, pp. 511–523, 2022.
[12] K. M. A. Haque, M. M. Hossain, M. S. J. Hossain, M. A. Islam, M. Hassan, M. Shamshuzzaman, and M. D. Hossain, "Performance evaluation of bangladeshi apparel and textile supply chain network, a case study," Performance Evaluation, vol. 1, no. 1, pp. 211–218, 2011.
[13] D. Majumder, J. Tazdik, K. A. Uddin, and M. A. Al Matin, "Kpi for solar pv-diesel hybrid mini grids in remote islands of bangladesh," Energy Procedia, vol. 103, pp. 262–267, 2016.