Performance appraisal of CMMS in two-wheeler manufacturing industry: A case study

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Abstract: CMMS (computerized maintenance management system) is the professional software for maintenance management of the manufacturing industries to handle complex tasks, work orders, spare part management, asset management, and automatic report generation effectively which saves production time and optimizes maintenance cost. The purpose of this paper is to analyze the maintenance performance of CMMS in the two-wheeler manufacturing industry. CMMS is analyzed in terms of input factors such as computerized material management and inventory control (CMMIC), resource and asset management (RAM), computerized maintenance planning and scheduling (CMPS). Profit, sales, and income are considered as output factors. It has been observed that by implementing CMMS yielded higher profits, reduced downtime by controlling the failure rate, and enhanced productivity by uninterrupted operations.

Keywords**:** Computerized Maintenance Management System (CMMS), Maintenance Management, Maintenance Performance, Manufacturing Industries, Case Study.

1. Introduction

World-class maintenance cannot be achieved without the best practices of maintenance management. The usage of the latest tools like computer-integrated maintenance management systems is suggested by [1]. CMMS performs functions like generating work orders, implementing tasks of preventive maintenance, tracking spare parts and optimizing the cost of inventory, budgeting time and finally, generating graphs and reports of the various fields [2, 26]. The new emerging technologies introduced in maintenance management are smart objects, mobile technology, Internet of Things, and cloud technology. These characteristics are integrated with the CMMS [3]. CMMS focuses on maintenance planning and scheduling, spare-part management and performance improvement [4]. It is necessary to evaluate the maintenance activities with a computer-aided system [5]. CMMS is suitable for Industry 4.0. for the large data to be acquired, processed and transmitted in real-time with the usage of a new technology known as the industrial internet of things [6]. 'CMMS is used to collect, store, and retrieve all maintenance-related data'. Information and communication technology (ICT) is effective in information sharing and is taken over by CMMS in maintenance [7]. As compared with the TPM (Total Productive Maintenance), RCM (Reliability-Centered Maintenance) and CBM (Condition-Based Maintenance), CMMS ranked at the top for the maintenance applications through the Analytical Hierarchy Process (AHP) [8, 30]. Some of the researchers used multi-criteria decision-making, (MCDM) techniques such as AHP, TOPSIS, VIKOR Fuzzy-TOPSIS, and Fuzzy-AHP for the selection of CMMS including AHP[27, 30, 33].

The structure of the paper is as follows: the previous related work is elaborated in Section 2 followed by the introduction in Section 1, Section 3 describes the objective of the study, Section 4 elaborates research methodology, Section 5 highlights the case study of a two-wheeler manufacturing industry, Section 6 explained the results and discussion and Section 7 presented the limitations and future scope of the research work. Finally, the conclusion is presented in Section 8 followed by the references.

2. Literature review:

Digitization is the future of manufacturing industries. Multi-criteria decision-making (MCDM) techniques like Decision tree analysis (DTA) and variation mode effect analysis (VMEA) are used for the selection of maintenance policies [7]. A model was developed to integrate Information technology (IT) with the maintenance management system which yielded higher efficiency and effectiveness of the equipment[9]. If the industry does not have well-planned maintenance strategies, it has to deploy external experts for the problems [10]. The impact of internet technology was explored for the purchasing of spare parts and managing information concerned with maintenance [11]. A model reduced the total downtime from 800 hours per month to less than 100 hours per month [12]. The need for CMMS with informed decision-making analysis is highlighted by a hybrid model [13].

Sensors for data acquisition, smart tags and signal processing with wireless technology enhanced the efficiency of maintenance operations. It is depicted that e-maintenance and new business ideas produce high efficiency in the industry [14]. In a case study, small and medium enterprises (SMEs) are investigated for affordability due to economic issues in Italy [15]. In another case, a textile manufacturing industry in Irish implemented CMMS and the return on investment (ROI) analysis revealed 0.46 years as the payback period [16]. Initially, a low success rate was observed in large-scale industries for implementing CMMS but World-class maintenance cannot be achieved without the implementation of CMMS [17, 18]. The advanced downtime analysis program (ADAP) and work cycle time are managed through CMMS planning tools which yielded a decrease in downtime of the machines [19]. Decision-making for maintenance planning and scheduling is represented by a critical literature review of Computerized Maintenance Management Information System [20]. Then a project is recommended for the development of CMMS for the manufacturing industry [21]. The AHP technique is a multi-criteria decision method (MCDM) used by Industries to select CMMS as per the suitability of the organization [22]. CMMS should be also flexible and adaptable as per the suitability of the industry because every industry is unique [23]. Therefore, a package of maintenance like CMMS is the requirement of the company so that the industry can sustain itself in the market [24, 25].

Some of the case studies were carried out in the windmill and gas industries [28, 29]. CMMS is very vital in decreasing downtime and optimizing production. It improved the asset life and reduced the maintenance cost. On the other side, maintenance problems disrupt production, delay lead time, reduce the uptime of the machines, and increase downtime which leads increase the production time, and ultimately reduces productivity and increases the cost of the product. This will lead to forfeiture of competitiveness and profitability in the market[31, 32]. Without proper management and automation systems in maintenance leads to waste of resources in the industry.

3. Objectives of the study:

To analyze and validate the effect of CMMS implementation in the manufacturing industry for evaluating the maintenance performance by input factors like CMMIC, RAM and CMPS on output factors such as profit, income, and sales of a two-wheeler manufacturing industry.

4. Methodology

The input factors CMMIC, RAM and CMPS are selected based on the previous study which was published in the international journals through two papers [25, 26]. The input factors chosen for the case study are the top three key performance indicators

(KPIs) out of seven input factors of CMMS which are gathered from the literature survey and the expert opinions from industry and academia [25].

Then, these seven factors are ranked for priority based on MCDM methods like AHP, Fuzzy-AHP, TOPSIS and VIKOR. As a result of these techniques, CMMIC ranked at first position and RAM and CMPS ranked second and third position respectively [26].

Then, for validation, top three ranked input factors CMMIC, RAM and CMPS are evaluated for their contribution to boost the performance of CMMS in the industry. The output factors considered are profit, sales and income to see the impact of CMMS implementation.

5. Case study of a Two-wheeler manufacturing industry

The two-wheeler manufacturing company manufactures ten variants of motorcycles. The company had started its 2-wheeler operations in 2001 in north India. Over the past two decades, this company has become the second-largest two-wheeler company with 55 million happy customers as per their website report.

The required data for the last five years was collected from the two-wheeler manufacturing industry regarding the different factors like CMMIC, RAM, and CMPS as input factors and profit, sales, and income as output factors. The data is tabulated and also shown with the graphical presentation in the sequence of input and output factors respectively.

5.1 CMMIC: Table 1 depicts the CMMIC data of the industry for the previous five years. Inventory control is measured in the percentage of the stock available in the industry during the period from 2018 to 2023 year-wise in phases.

Table 1: CMMIC data of the industry for the previous five years

S.No.	Year	Phases	Inventory Control
1	2018-2019	1	64%
2	2019-2020	2	50%
3	2020-2021	3	35%
4	2021-2022	4	22%
5	2022-2023	5	12%

Figure 1 illustrates the progress of the inventory control management year-wise in different phases. The industry has controlled the inventory from 64%, 50%, and 35% in phase 1, phase 2, and phase 3 respectively. Phase 4 and Phase 5 are further controlled at 22% and Rs 12% respectively. Overall, this is a good outcome of the CMMS because it is reduced to a great extent successively.

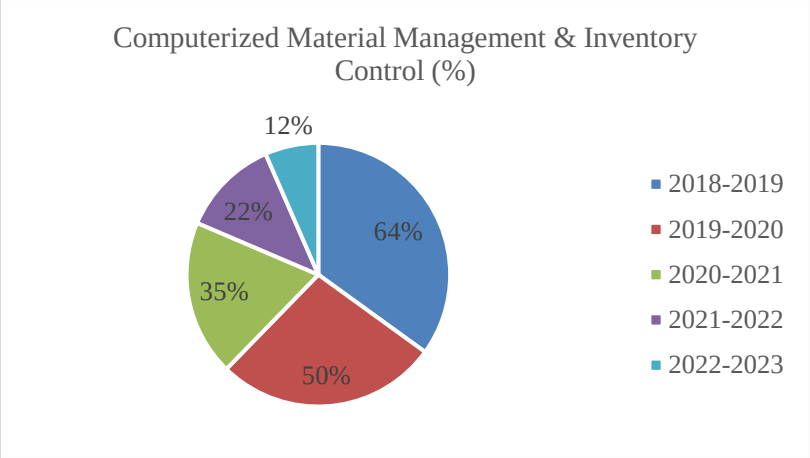

Figure 1: Profit of the Industry for the last five years

5.2 RAM: Table 2 depicts the Asset Management and annual failure rate data of the industry for the past five years. The annual failure rate and asset management are measured in percentage and are complementary to each other.

Table 2: Resource & Asset Management and Annual failure rate (AFR) for the last five years

S.No.	Year	Phases	Asset Management	AFR
1	2018-2019	1	34%	66%
2	2019-2020	2	45%	55%
3	2020-2021	3	58%	42%
4	2021-2022	4	67%	33%
5	2022-2023	5	90%	10%

Figure 2 illustrates the asset management year-wise in different phases. The industry has managed the assets 34%, 45%, and 58% in Phase 1, phase 2, and Phase 3 respectively. Phase 4 and Phase 5 it is further controlled at 67% and Rs 90% respectively. CMMS helped to reduce the annual failure rate of the assets from 66% to 10% in successive phases from 2018 to 2023. Overall, this is a good outcome of the CMMS.

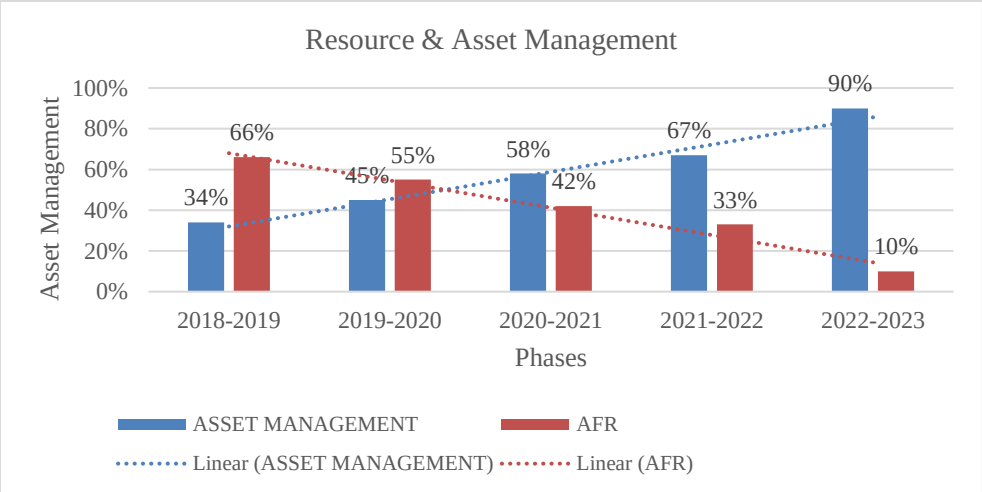

Figure 2: Resource & Asset Management and Annual failure rate (AFR) for the last five years

5.3 CMPS: Table 3 depicts the work order success rate of the industry for the past five years. This is measured in terms of the work orders ratio between executed work orders and planned work orders and is shown in percentage.

Table 3: work order success rate in % for the last five years

S.No.	Year	WO success rate %
1	2018-2019	39
2	2019-2020	50
3	2020-2021	62
4	2021-2022	77
5	2022-2023	90

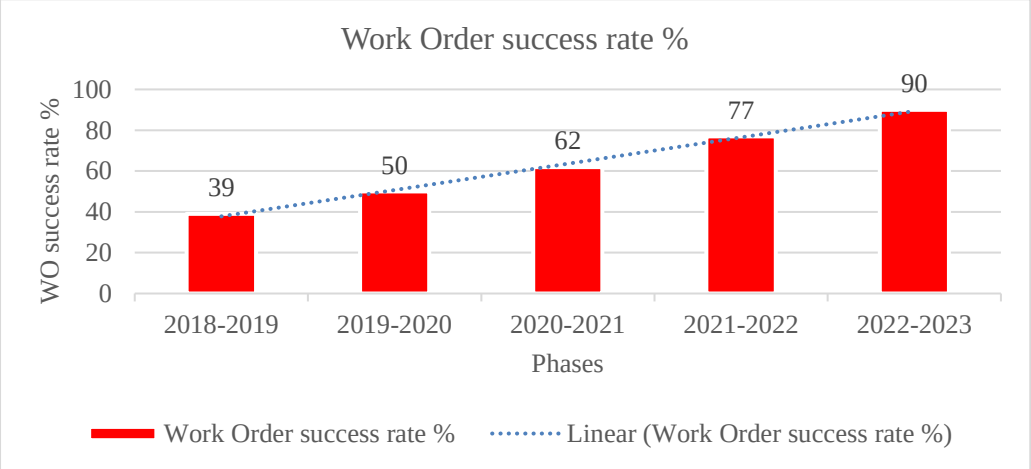

Figure 3: CMPS (work order success rate %) for the last five years

Figure 3 illustrates the computerized maintenance planning and scheduling year-wise in different phases. The industry has achieved a success rate in completing the work orders from 39% to 90% in the successive years phase-wise from 2018 to 2023. This enhanced the productivity and reduced the lead time in the industry.

5.4 Sale: Table 4 represents the sales of the two-wheeler industry for the last five years from 2018 to 2023 year-wise in five phases.

Table 4: Sale of the Industry for the last five years

S.No.	Year	Sale (Rs in Thousands)	Remarks
1	2018-2019	21001	increase
2	2019-2020	20593	Low growth due to Covid19
3	2020-2021	17872	Low growth due to Covid19
4	2021-2022	21852	increase
5	2022-2023	29089	increase

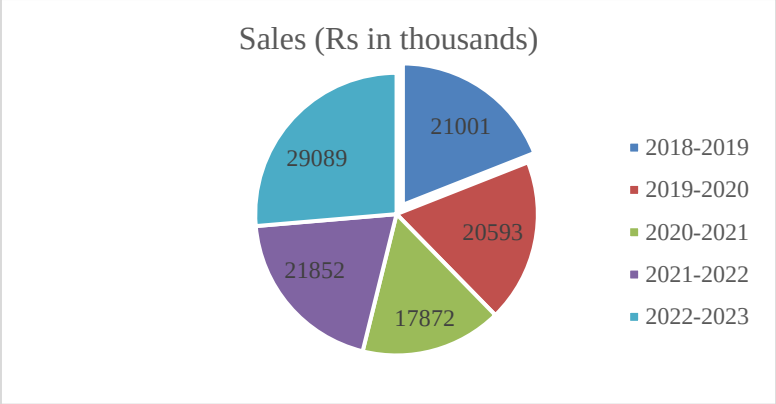

Figure 4: Sale of the Industry for the last five years

Figure 4 illustrates the growth of the sales year-wise in different phases. The industry has generated an income of Rs 21001, Rs 20593, and Rs 17872 in Phase 1, phase 2, and Phase 3 respectively. Phase 2 and Phase 3 noticed low growth in income due to the covid19 during that period. Phase 4 and Phase 5 observed an increase of Rs 21852 and Rs 29089 respectively.

5.5 Profit: Table 5 illustrates the profit of the industry for the previous five years.

Table 5: Profit of the Industry for the last five years

S.No.	Year	Profit (Rs in Thousands)	Remarks
1	2018-2019	2916	increase
2	2019-2020	2856	Low growth due to Covid19
3	2020-2021	2246	Low growth due to Covid19
4	2021-2022	3114	increase
5	2022-2023	4887	Further, decrease

Figure 5 illustrates the growth of the profit year-wise in different phases. The industry has generated profits of Rs 2916, Rs 2856, and Rs 2246 in Phase 1, phase 2, and phase3 respectively. Phase 2 and Phase 3 noticed a slow growth in profit due to the COVID-19 period. Phase 4 and phase 5 observed an increase of Rs 3114 and Rs 4887 respectively.

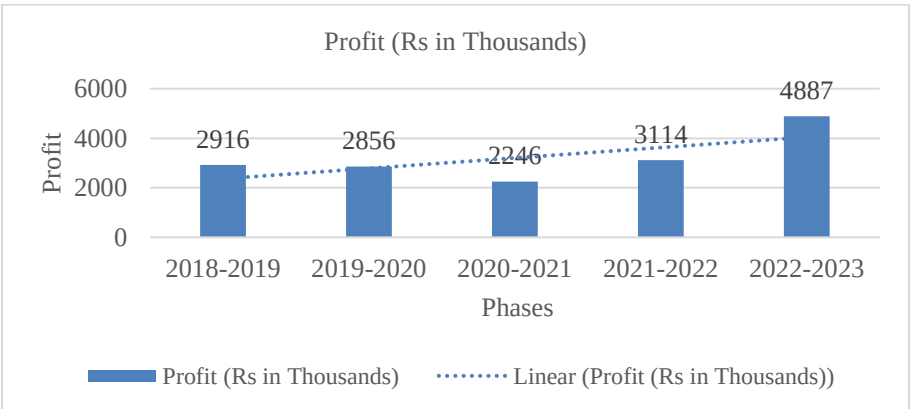

Figure 5: Profit of the Industry for the last five years

5.6 Income: Table 6 represents the income of the industry rupees in thousands for the previous five years from 2018 to 2023.

Table 6: Income of the Industry for the last five years

S.No.	Year	Income (Rs in Thousands)	Remarks
1	2018-2019	18085	increase
2	2019-2020	17737	Low growth due to Covid19
3	2020-2021	15626	Low growth due to Covid19
4	2021-2022	18738	increase
5	2022-2023	24202	increase

Figure 6 illustrates the growth of the income year-wise in different phases. The industry has generated profits of Rs 18085, Rs 17737, and Rs 15626 in Phase 1, phase 2, and Phase 3 respectively. Phase 2 and Phase 3 noticed a slow growth in income due to the covid19 during that period. Phase 4 and phase 5 observed increases of Rs 18738 and Rs 24202 respectively.

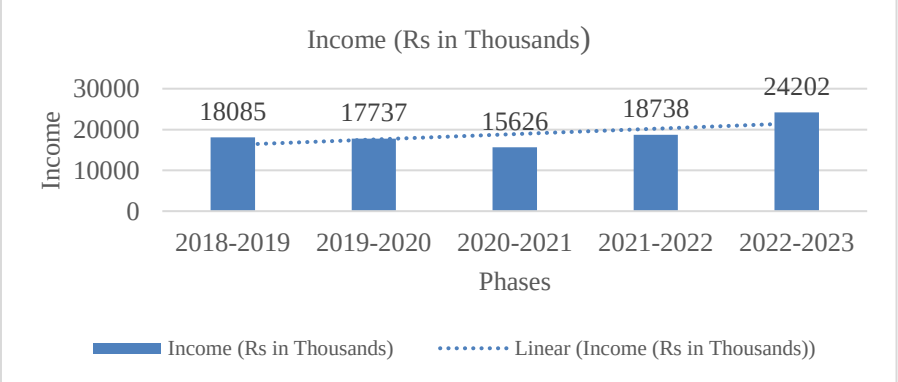

Figure 6: Income of the Industry for the last five years

6. Results and discussion

- CMMIC: The company has effectively controlled the inventory level from 64% to 12% in the successive years from 2018 to 2023. Therefore, the cost of holding inventory was reduced. Cost saving in this way enhances profitability.
- RAM: The asset management has improved from 34% to 90% due to the effective control of the annual failure rate from 66% to 10% due to the implementation of CMMS in the last five years. Thus, RAM has increased the overall efficiency and effectiveness of the machines and equipment of the industry.
- CMPS: The company had improved its planning and scheduling by completing the work orders from 39% to 90%. Time-saving in this way will lead to more availability of machines and productivity of the industry.
- PROFIT: The profit has been raised to Rs 4887 from Rs 2916 in thousand units.
- SALES: The sales output has been raised from Rs 21001 to Rs 29079 in thousand units.
- INCOME**:** The income has been grown from Rs 18805 to Rs 24202 in thousand units.

7. Limitations of the Study and Future Research Directions

1. The case study was conducted in northern India only. The replication of the study in different regions of India would enable better generalizability of the findings of the study.

2. The present case study can be compared with the other competitors in the market.

3. The study was limited to manufacturing industries. Therefore, it can be extended to other sectors such as health care, education, banks, aerospace, service industry, and in Government sectors.

8. Conclusions

The case study uncovers the positive growth in the profit, sales, and income of the industry after the implementation of CMMS in the manufacturing industry. The above input factors like CMMIC, RAM, and CMPS enhanced the outcome of the industry. It is found that output factors income, sales, and profit of the industry have increased during the last five years. The overall productivity, efficiency, and effectiveness of the machines and equipment improved. Consequently, CMMS is recommended as a maintenance package for manufacturing industries to enhance productivity which leads to profitability and ultimately competitiveness and sustainability. The timely adoption of the CMMS package leads to overall organizational achievement and sustainability in the global market.

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Table 7: Definitions and Abbreviations used for different factors of CMMS

S.No.	Definition	Abbreviation
1.	Computerized Maintenance Management System	CMMS
2.	Computerized Maintenance Planning & Scheduling	CMPS
3.	Computerized Material Management & Inventory Control	CMMIC
4.	Computerized Report Management	CRM
5.	Enterprise Asset Management	EAM
6.	Resource & Asset Management	RAM
7.	Productivity Improvement	PI
8.	Advanced Downtime Analysis Programme	ADAP
9.	Safety, Health & Environment Improvement	SHEI
10.	Multi-criteria decision-making	MCDM
11.	Cost Optimization	CO
12.	Total Productive Maintenance	TPM
13.	Reliability-Centered Maintenance	RCM
14.	Condition-Based Maintenance	CBM
15.	Analytical Hierarchy Process	AHP
16.	Small And Medium Enterprises	SME