Sabaragamuwa University Journal of Computer Science

Journal homepage: https://www.sab.ac.lk/sujcs/

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Factors Affecting to the Success of Computerized Maintenance Management System in Multinational Beer Companies

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Abstract

Received 14 May 2021

Accepted 31 July 2021

A computerized maintenance management system or CMMS is software that centralizes maintenance information and facilitates the processes of maintenance operations. It helps optimize the utilization and availability of physical equipment like vehicles, machinery, communications, plant infrastructures and other assets. CMMS essential because they make it easier and more efficient for maintenance managers and departments to meet their primary objective: reliable uptime. Purpose of the study was to identify the factors affecting to success CMMS in multinational beer companies. A quantitative study was performed and structural modeling was used to analyze data with the aid of SmartPLS software. Results suggested that the Data standard, role assignment and Continues improvement are significant predictors successful CMMS and findings contribute to the existing literature on computer science. Further managerial implications are encouraged for better implementation of CMMS.

Keywords: CMMS (Computerized maintenance management system), Data availability, Data standard, Role assignment, Continuous improvement

Sabaragamuwa University Journal of Computer Science

ISSN : 2783-8846

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Introduction

The growth and evolution in Information Technology has led to a dramatic increase in the capability and availability of software tools to support maintenance. During past 20-30 years, the term 'Computer Maintenance Management System (CMMS)' has become synonymous with productivity improvement and control of maintenance management processes. The tools and methodologies available today for managing maintenance and operations are truly astounding (Mather, 2002). CMMS is a type of software for management functions such as support management and monitoring operations and maintenance. CMMS automate most of the functions of logistics provided by maintenance (Bloch 2005; Abdel-Raouf 2014). It is a is a solution that improve the way of managing maintenance operations, teams, inventory, workflows, compliance, and other processes or activities (Laurila, 2017). It is packaged software tool which designed specifically to support companies in maintenance management. Most businesses that maintain equipment today have some sort of CMMS in use and there are hundreds of commercially available packages to choose from.

Understanding CMMS functionality, comparing different software options and aligning them with business goals together with management support are key to successful implementations. Typically, smaller companies using specialized solutions are most satisfied with their CMMSs. The two most important features for successful implementation are ease of adapting to maintenance processes and user-friendliness. (Campbell, 2016). Software is one part of the system and there is less understand of other relative facts of CMMS (CMMS, 2018) which present in Figure: 1.

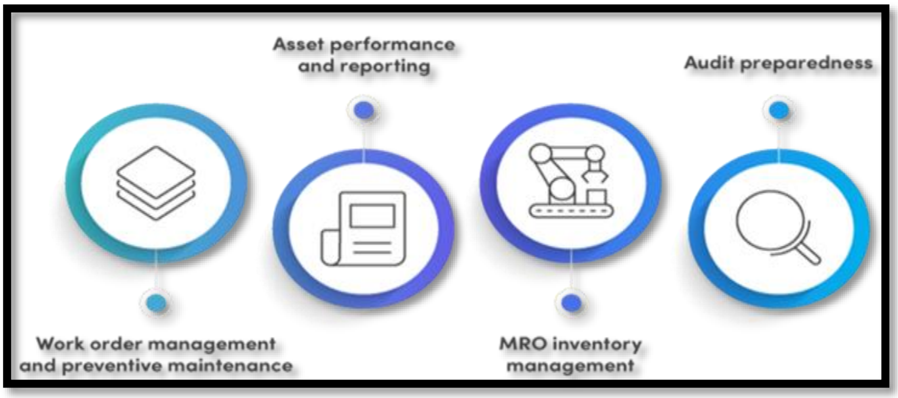


Figure Error! No text of specified style in document.**:** Functions of CMMS

Source: (CMMS, 2018)

Maintenance is key in every industry, and CMMS software facilitates businesses in different ways. The production and manufacturing are companies that occupy heavy equipment require frequent maintenance. CMMS software helps in facility maintenance which deal with structural, heating, ventilation, and air conditioning (HVAC), and water-supply problems. Fleet maintenance important in construction sites, car rental companies, city buses, transport ships, and fleets of tow trucks needed to have repairs scheduled, which can be taken care with a CMMS. Linear asset maintenance category of maintenance for companies that have assets like roads, water pipes, or fiber optic cables that cover great distances. A CMMS can help manage the complex maintenance required to keep these assets running. Field services maintenance deals with a variety of assets spread across large areas or several sites and that operate independently of each other. For example, windmills, solar panels, cell phone towers, and oil wells. A CMMS helps organize contractors and make maintenance resources accessible in the field. A computerized maintenance management system opens the door to a completely new set of possibilities for maintenance team. A CMMS can empower operations and help it take a huge leap forward in the areas of control costs, reduce downtime, increase efficiency, centralize information, improve health and safety etc. (Donoghue & Prendergast, 2004).

Since the CMMS software is well developed and world recognized system, the maintenance management of the particular company and industry should be at greater level. When analyzing the maintenance management success parameters, company still not reached to the expected success. There should be some factors missed in the implementation and operational level of this system implementation. Proactive world-class maintenance management is nearly impossible without computer-based support. But the success rate in implementing these Computerized Maintenance Management Systems (CMMS) is surprisingly low. Maintenance of equipment is a significant part of the total operating costs in most industry sectors but its real impact is often under-estimated. The "Iceberg Model" (see Figure 2) highlights the hidden cost impact of maintenance upon the business which is much greater than just the direct Costs associated with traditional maintenance.

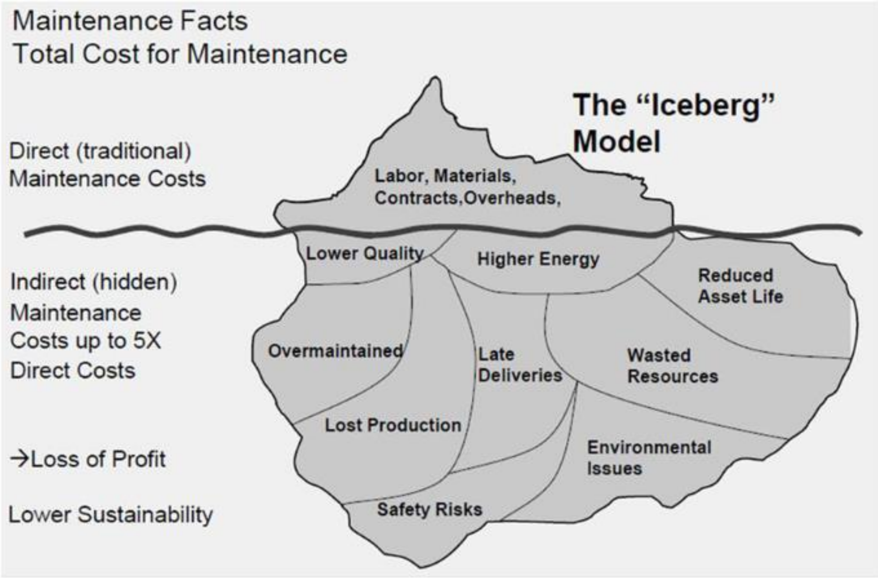


Figure 2: Total Costs of Maintenance - the "Iceberg" Model (Wienker, M., Henderson, K., & Volkerts, J. (2016).

For many companies, reducing these hidden costs requires a shift from the traditional reactive approach ("fix it when it breaks") to a proactive reliability-based approach. For such a shift to be sustainable, a number of key elements must be put in place including:

- A clear strategy
- Policies to support the strategy
- Procedures & processes to enable implementation of the strategy & policy
- Tools to support this implementation
- A well-established Maintenance Business Process with checks and balances

These key elements form the basis of "maintenance management". Such maintenance management is a complex process requiring an effective combination of technical and economic expertise. One part of maintenance management is to interpret the data available and turn it into useful information in order to manage the equipment in the best possible way. To do so, the data must be gathered and analyzed in a structured manner otherwise it cannot be effectively utilized. Managing this process effectively without computer-based support is almost impossible and that is where a well implemented CMMS system is one of the key tools that is essential to underpin proactive maintenance management.

Success of the maintenance management can be measured using two parameters; leading and lagging international business machines factors. The leading indicators predict future events and the lagging indicators followed the past events. Further the petameters can measure in different scales. The Planned maintenance percentage (PCC) represents the percentage of time spent on planned maintenance activities against the unplanned maintenance. An effective maintenance system should deliver more than 90% of planned maintenance percentage. Overall Equipment Effectiveness (OEE) measures the productivity of a piece of equipment. This indicates data on how effectively organization maintains the equipment quality, performance, and availability. If an organization maintains 100% OEE, it means that the system is free of defects, maintains high-speed and delivers continuous production. Mean time to repair (MTTR) is the average repair time start until operations are restored. This includes repair time, testing period, and return to the normal operating condition. The goal of every organizations is to reduce and maintaining this MTTR as much as possible. Mean time between failures (MTBF) predicted time between one breakdowns to the next breakdown during normal operation. Higher MTBF means that equipment work longer time before it experiences failure. Knowing the equipment's lasting time helps to prepare for a failure or schedule some preventive work. Preventive maintenance compliance (PMC) indicates the percentage of the preventive work scheduled and completed in a set time.

The data relevant to these parameters of maintains success were gathered from the study companies for past two years. Accordingly, the OEE of both bottle and can line is under 60 implying weak maintenance management. The MTTR of canning line has declined and the average time required to repair a failed component of bottle line has increased. Mean time between failures of both can line and bottle line have increased continuously. This indicates there are more breakdowns in the machineries of the both can line and bottle line which signals the loophole of maintenance management system.

Since computerized maintenance management system is a good platform to manage organization's maintenance activities, now a day's most of companies adopt CMMS to manage their maintenance activities. After successful implementation of CMMS, the improvement of productivity can be raised .and it is noticeable. If particular organization fails to align the new software with its objectives or business processes, it highlights the importance of an investigation. Thus present study aims to examine the factors affecting to the Success of Computerized Maintenance Management Systems specially referring to the Multinational Beer Companies in Sri Lanka.

Maintenance can be considered as an information processing system that produces vast amount of data. However, data is not synonymous with information; but that data must be proessed with data analytical tools to extract the information (Eriksson, 1999). Every software performs according to it's program and data entered to it. Even the computer program in a good quality level, it couldn't deliver a desired output without proper raw data. The increased availability of data makes it possible for accurate and precise decision-making in maintenance, given that the collected data are relevant, used correctly and maintain the expected level of quality. It is necessary to have a high quality of data since correct information is essential in assisting the decision-making process (Aljumaili *et al.*, 2012). Inaccurate or poor data may influence the decision incorrectly, especially if the system using the data is not able to verify the quality (Tretten *et al.*, 2011). Hence, it is important for maintenance tools to be aware of data quality issues and actively reduce them (Markeset and Kumar, 2003; Tretten *et al.*, 2011). Modern software has self-learning function such as after several process it learn the data arrangement and predict future process. However, it need some time and circles to arrange those data perfectly. When consider those factors data paly important role in the CMMS system.

When appropriately configured, and interfaced, with other systems within a company, such as an Enterprise Resource Planning system, a CMMS can become a critical and useful tool in handling maintenance organization activities (Marquez and Gupta, 2006). The capabilities of handling large quantities of data facilitate a thoughtful maintenance approach (Labib, 2004), however, the handling of large amounts of data is not much worth much if the data is not used correctly (Tanter *et al.*, 2006).

Accordingly present study focused on data related factors on success of CMMS. Thus, the following research objectives were developed.

- To identify the impact of availability of data on success of CMMS?
- To identify the impact of standard of data on success of CMMS?
- To identify the impact of role assignment on success of CMMS?
- To identify the impact of continues improvement of data on success of CMMS

Literature Review

There were scanty of articles published by giving attention to the factors that contribute to the success of CMMS implementation. Their main focus was on the implementation of CMMS.

Wadi(2016) identified five factors which affect to the success of CMMS. Those are top management commitment and support, ERP system suitable for organization, business process re-engineering, vendor support, and training users. According to the conclusion of the study, followings are the major conclusions

- Top management is greatly supporting its organization implementation processes by maintaining a financial plan for related activities.
- Public sector organizations follow a precise and accurate procedure in the process of collecting data and storage
- CMMS system matching the organization would will helps to smooth flow of system
- Business process reprocess re-engineering helps to success of CMMS implementation
- Vendor support effects the implementation process sensitively
- Training users was found to be crucial where it increases their acceptance of the system

Mojca (2009) stated that CMMS projects are more about changing the organizations' business processes than information technology. If any organization which is not prepared to change its business processes, they may fail to achieve improvement in performance and competitiveness. Business process modelling is an important role; especially in the first stages of the CMMS implementation.

Liang Zhang (2003) Stated that nearly 90 % of CMMS implementations are late or over budget and the success rate with CMMS implementation is about 33% in China. In the Western countries, the success rate of implementing CMMS systems is extremely low at 10%. In this research, they have identified critical success factors of CMMS implementation in China are Top Management Support, Business Process Reengineering, Effective Project Management, Education & Training, Suitability of Software & Hardware and data accuracy. According to researches, business process re-engineering and organizational culture have biggest positive impact CMMS implementation in China.

Mahyar (2013) introduced a model of determinants of successful implementation of CMMS. The key factors were categorized based on common characteristics. The categories are

- Cultural and structural aspects
- CMMS software characteristics
- Firm characteristics
- Implementation team characteristics
- Characteristics of top management
- Implementation process
- Characteristics of end-users

Cultural aspects of the environment factors are in the environment are cultural and structural. The critical success factors included under environment/cultural aspects are cultural importance on training and systems, resistance to change, cultural readiness, open and honest communication, expectations and social commitment.

The characteristics of the software are important factor to successful implementation. Companies must be have careful to understanding when selecting software package under consideration for adoption to the needs of the company. There are differences in these different software products and can have major effects on the successful implementation of the CMMS.

Brady (2005) identified 11 success factors that were critical to CMMS implementation success. Such as

- CMMS teamwork and composition
- Change management program and culture
- Top management support
- Business plan and vision
- Business process re-engineering and minimum customization
- Effective communication
- Project management;
- Software development, testing, and trouble shooting
- Monitoring and evaluation of performance
- Project champion
- Appropriate business and information technology legacy systems

Six factors were tested for success and failure of CMMS implementations by Brady (2005). Those are functionality and maintained scope, project team/management support/consultants, inadequate internal readiness, training inappropriate planning and budgeting that contribute to success of implementation.

According to the previous literature, various factors have been tested for success of CMMS implementation where the studies have conducted in different contexts and relating to different industries. There were lack of studies conducted to investigate the critical success factors of CMMS implementation in Sri Lankan context. The data quality and accuracy affecting to the success of ERP implementation success but he has not statically proven that. Main data using for CMMS are Spare part data, maintenance plans data and CMMS user data and machine data .To measure quality and accuracy of data, data availability and data standard should be measured, therefore data availability and data standard can be considered as two independent variables (Mahyar, 2013). Further he stated that the user involvement affects to the success of CMMS implementation where the correct role assignment is important to measure the success of CMMS. (Wadi, 2016) stated that the business process reengineering affect to the success of CMMS indicating that business process should be improved catering to the requirements of CMMS. Hence the continuous improvement may impact for the success of CMMS.

Based on literature support the research model is developed for the study as presented in Figure 3.

Research model

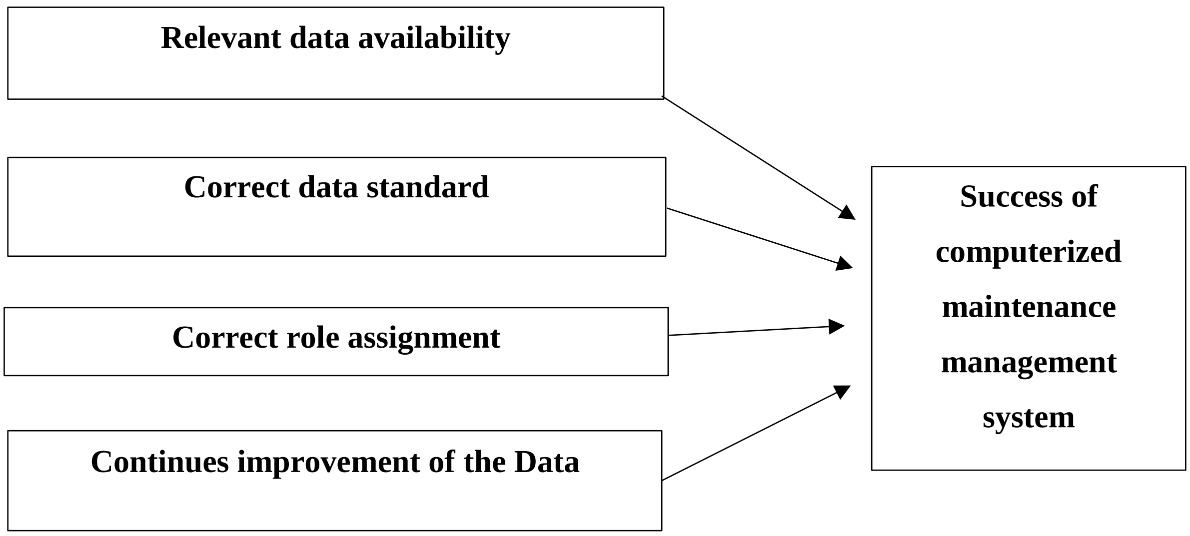


Figure 3: Research Model

According to the research model, four hypotheses were proposed.

H1: Having relevant data significantly affect the success of CMMS

H2: Having correct data standard significantly affect the success of CMMS

H3: Having correct role assignment to the user significantly affect the success of CMMS

H4: Having continues improvement of the data significantly affect the success of CMMS

Materials & Methods

A quantitative empirical study was conducted covering 30 multinational beer companies which belong to 25 countries. The companies currently adopting CMMS and Maintenance departments of the each companies were subjected to the survey. The unit of analysis is employees occupy in maintenance departments of multinational beer companies. Accordingly, the maintenance related executives and shop floor technicians were the key responders to the survey.

A self-administrated questionnaire was distributed among the maintenance department's employees of Asia Pasic region's multination beer companies. Five point Likert scale was used to measure responses and Structural Equation modeling performed for data analysis. Path model developed base on the research model and reflective constructs adopted to develop the questionnaire. Reflective constructs loading used to access reliability and based on the result, the path model is refined. The construct reliability and validity results test the reliability of the model. SmartPLS Bootstrapping and PLS algorithm calculation results were used to generate statistic results. Accordingly values of path coefficients and P valve used to test hypothesis.

Results & Discussion

Questionnaires distributed to 100 maintenance related employees who are having experience on CMMS. Accordingly 73 have been responded to the questionnaire recording over 70% of response rate. As per the results of demographic analysis, 56% of respondents are belonged to middle management level who are the key users of CMMS and having greater awareness on CMMS. 44% of the Respondents are shop floor employees who are the end users of CMMS. Hence the demographic profile satisfies the relevance of respondents for the study.

Reliability of Model

Tish (2018) stated that indicator reliability denotes the proportion of indicator variance which explained by the latent variable.

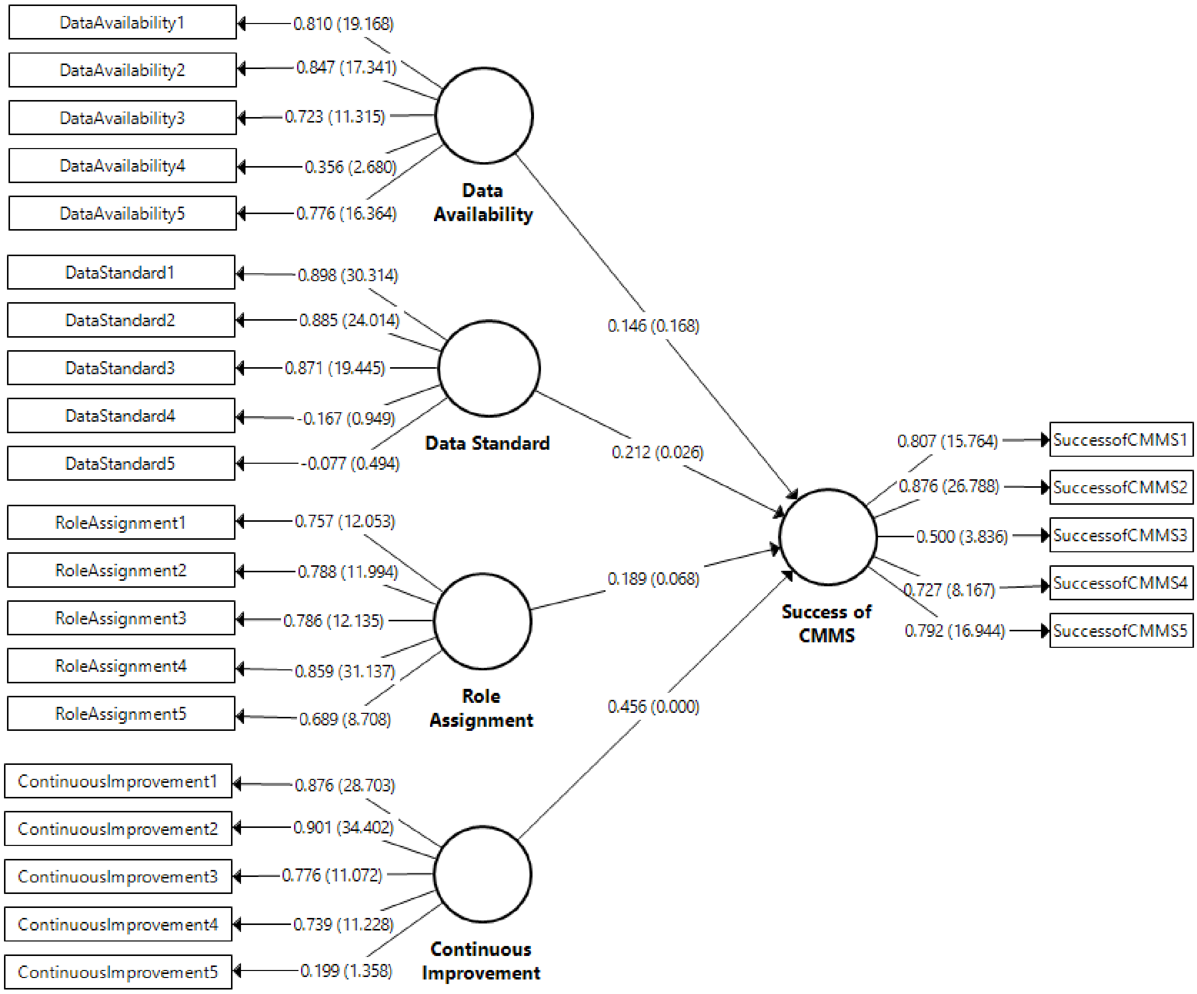


Figure 4: Outer loadings of variables before refinement the model

Source: Survey Data (2021)

Least contributed outer loading removed from the model and recreated the model. Figure 4 displays the outer loadings for manifest variables of the conceptual model with each depicting loadings above 0.7. The loadings are considered as highly satisfactory and signify that criterion for individual item reliability has successfully met.

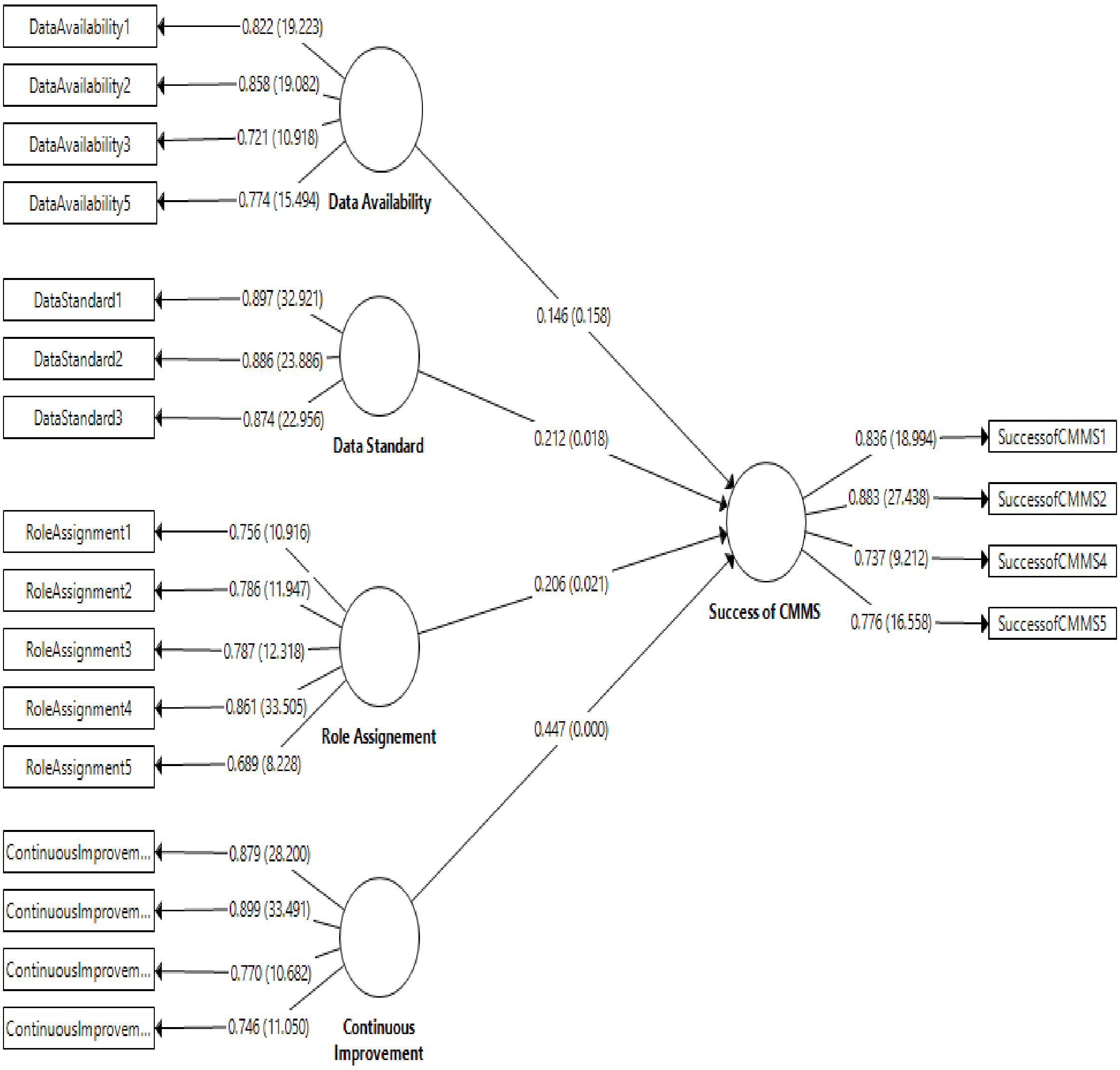


Figure 5: Outer loadings of variables after refinement of the model

Source: Survey data (2021)

Construct reliability and validity

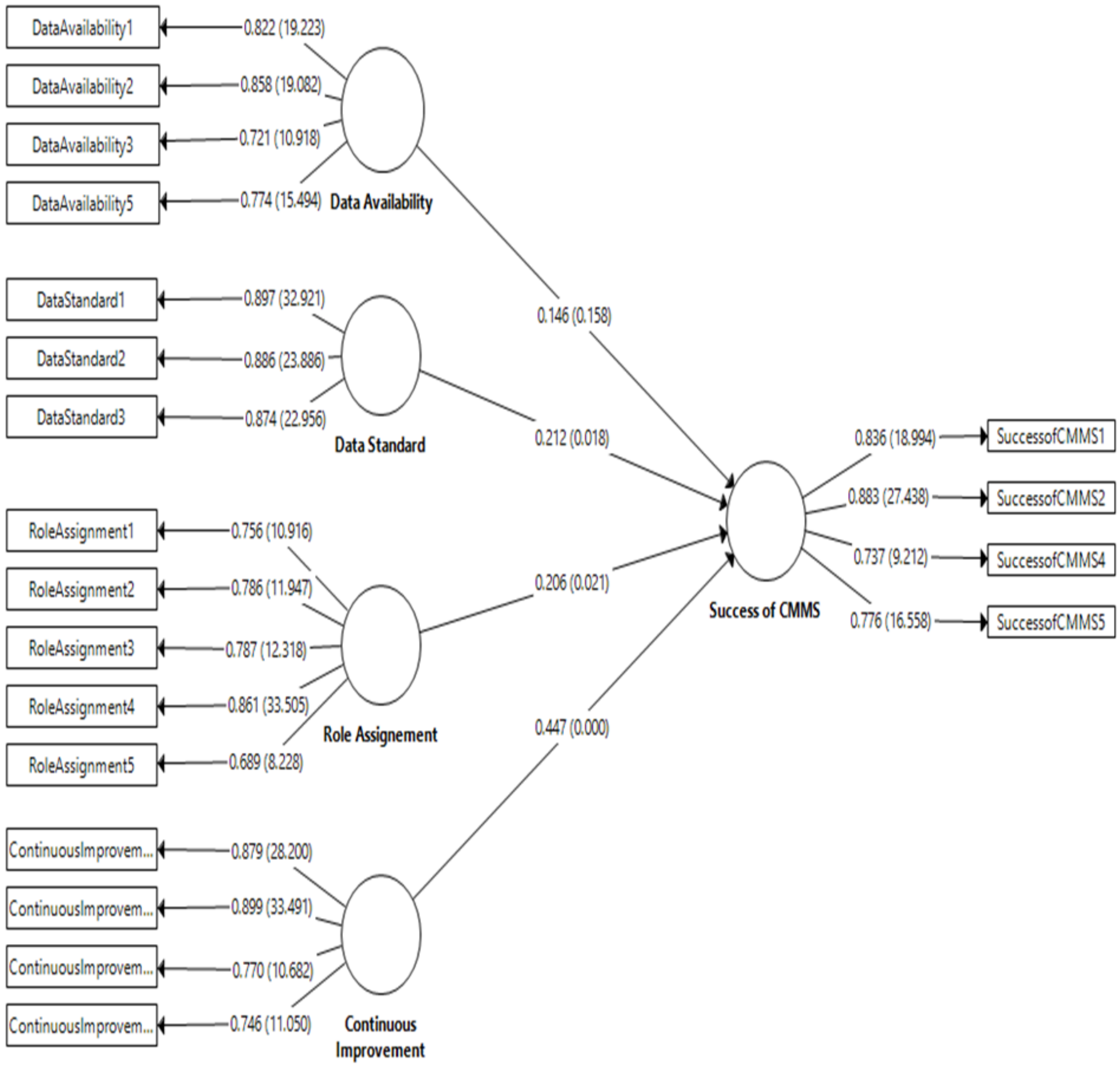
The results derived would not serve the purpose unless the validity and reliability of the measures are established. Cronbach's alpha tests to see if multiple-question Likert scale surveys are reliable. If Cronbach's Alpha is ≥0.9, the internal consistency of scale is excellent (Salkind, 2015). Table 1 presents the statistics on standards properties of the model.

Table 1: Statistics on the Properties of the Model

	Cronbach's Alpha	rho_A	Composite Reliability	(AVE)
Continuous Improvement	0.844	0.863	0.895	0.682
Data Availability	0.805	0.814	0.873	0.632
Data Standard	0.862	0.864	0.916	0.784
Role Assignments	0.838	0.868	0.884	0.605
Success of CMMS	0.823	0.830	0.884	0.656

Source: Survey data (2021)

According to survey results shown in table 1, all Cronbach's Alpha values of each variable recorded greater than 0.8 which confirms the internal consistency of the constructs. Further other coefficients such as rho_A, Composite Reliability and AVE effect values further confirm the reliability and validity of the constructs.



The results of descriptive statistics presented in Table: 2

Table 2: Descriptive Statistics of the Variables

	N	Mean	Standard Deviation	Excess Kurtosis	Skewness
Data Availability	73	3.7	1.07	-0.1	-0.5
Data Standard	73	4.1	0.7	1.2	-0.8
Role Assignment	73	3.9	0.8	1.0	-0.8

Continuous Improvement	73	3.8	0.8	0.1	-0.6
Success of CMMS	73	3.9	0.7	1.1	-0.6

As per the statistics on Table 2, the variables reflected a mean statistic greater than 3 which indicates very close to value of "Agree". This static implies that selected factors in multinational beer companies relevant to the success of CMMS. Further, Table 1 statistics represent the standard deviation is less than 01 for all the constructs which indicates that there is no significant difference from company to company.

Path Analysis

Structural equation modeling is a multivariate statistical analysis technique used to analyze structural relationships. This technique is the combination of factor analysis and multiple regression analysis, and is used to analyze the structural relationship between measured variables and latent constructs. This method is preferred by the researchers as it estimates the multiple and interrelated dependence in one analysis. The outcome of path analysis along with the path coefficients and significance values of hypothesized paths are drawn in the measurement model shown in Figure 5.

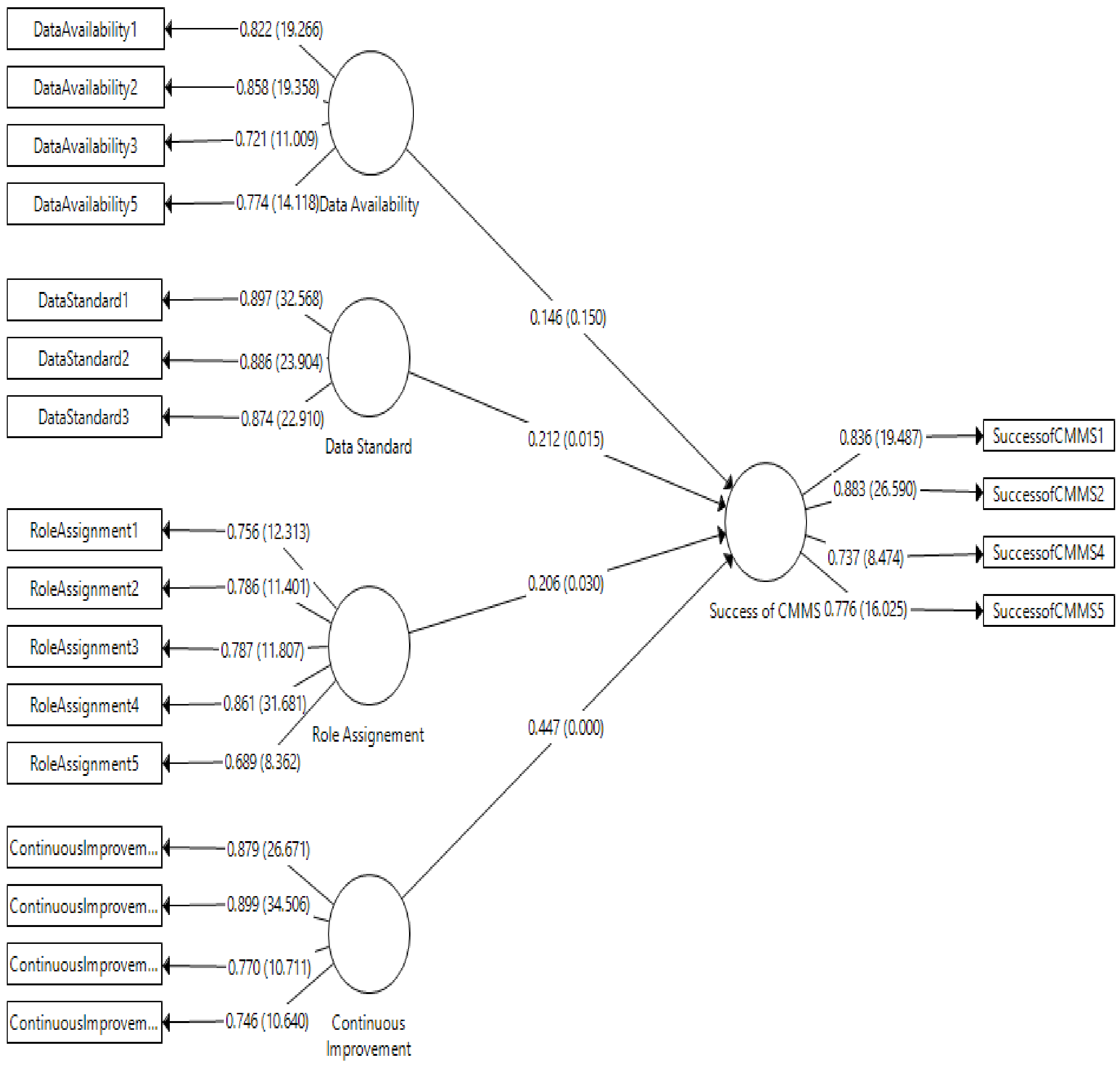


Figure 6: Path model with path coefficients and significance values

Source: Survey data (2021)

Table Error! No text of specified style in document.**.1 : R square value**

	R Square	**R Square Adjusted**
Success of CMMS	0.728	0.712

Source: Survey data (2021)

The overall effect of four exogenous variables (data availability, data standard, role assignment, continuous improvement) found accounting 72.8 % of the success of the CMMS. This is statistically significant (0.728, p = 0.000).However, the data availability found statistically insignificant (0.146, p =0.150) neither adequately describe the success of CMMS. But data standard (0.212, p = 0.015), role assignment (0.206, p = 0.030) and continuous improvement (0.447, p=0.000) variables were identified as predictors of successful CMMS at moderate level. This study hypothesized four relationships to assess the success of CMMS of multinational beer industries. According to the statistical results, it was found that success of CMMS influenced by some factors. Moreover, data standard, role assignment, and continuous improvement found to have strong contribution toward success of CMMS where data availability resulted insignificant contribution. This results confirms the findings of….

Results of Hypotheses Testing

As per the path analysis, path coefficient value for data availability was 0.146 with P of 0.158. Hence, data availability didn't find statistically significant neither adequately describe the success of CMMS. As such, based on path analysis the researchers not in a position to reject the null hypotheses**.** H2 assumed that success of CMMS affect by data standard of location naming, asset naming and spare part naming. As per the path analysis, path coefficient value for data standard was 0.0212 with P of 0.018. Hence, data standard finds statistically significant adequately describe the success of CMMS. As such, based on path analysis this hypothesis is accepted. H3 was assumed that success of CMMS affect by correct role assignment to the CMMS users as per the physical job role. As per the path analysis, path coefficient value for data availability was 0.206 with P of 0.021. Hence, correct role assignment finds statistically significant adequately describe the success of CMMS. As such, based on path analysis this hypothesis is accepted. H4 was assumed that success of CMMS affect by continuous improvement of data such as preventive maintenance plans, new asset data and spare part data. As per the path analysis, path coefficient value for data availability was 0.447 with P of 0.000. This is the most affecting variable from all four variables. Hence, continues improvement finds statistically significant adequately describe the success of CMMS. As such, based on path analysis this hypothesis is accepted**.**

Conclusion

Background finding were conducted through an extensive literature review. In this literature review, researcher had found evaluation of the CMMS and what are factors affected to the Success of the CMMS. Gaps were identified in the literature and also the with reference to these studies hypotheses were developed to make assumptions that success of CMMS. These assumptions were statistically tested using collected data, through the self-administered questionnaires from a sample of multinational beer companies located in 17 countries. Questionnaire was distributed through 25 countries and there were responds from 17 countries. Maintenance related people were the key contributors of the sample.

As per the results demographic classification, 56% respondents were middle managers and 44% are shop floor employees which implies that majority of the respondents are key users and end users of CMMS. Therefore, they have hands on experiences on CMMS. When it considered the software used for the CMMS of the respondents, 53% respondents are adopting Maximo and 46.58% are adopting SAP. Both Maximo and SAP software are well established CMMS software in the world and most industries are using this two CMMS softwares. Therefore capability of this software is can be considered as equally good.

Each independent variable had five reflective constructs. After constructing the path model, it was found that loadings of some constructs were not in a acceptable level. Therefore, those constructs were removed from the path model and refined the model. According to path model, Cronbach's Alpha values for each variable recorded greater than 0.8 confirming the internal consistency of the instruments.

Mean of dependent variable success of CMMS was 3.99 and standard deviation was 0.71. The descriptive statistics suggested that the respondents have accepted the success of CMMS in their companies. The mean value for all independent variables are closure to mean score close to 4 and that mean all dependent variables are agreed by the respondents. Except data availability, other three independent variables scattered around the mean with less standard deviation value. Since the standard deviation of data availability is high there are significant deviation of the responses.

Structural modeling path analysis gave path coefficient value of 0.146 with P value of 0.158.Due to the high P value data availability variable not adequately describe the success of

CMMS. But other three variable such as data standard, role assignment and continuous improvement had significant P values. Respective P values are 0.018, 0.021 and 0.000.Path coefficient of the continuous improvements was 0.047 and it gives highest contribution towards the success of CMMS. The path coefficient values for Data standard and role assignment are 0.212 and 0.206 respectively which indicate moderate effect oo the success of the CMMS.

R square value of the dependent variable was 0.728 .The overall effect of four exogenous variables (data availability, data standard, role assignment, continuous improvement) accounting 72.8 % of the success of the CMMS. This is statistically significant (0.728, p = 0.000).

The main objective of the present study is to investigate the factors affecting to the success of CMMS of multination beer companies. Data availability, data standard, role assignment and continuous improvement were suggested from extensive literature review as the constructs of CMMS success. According to the statistics results data standard, role assignment and continuous improvement found as predictors of successful CMMS.

Data standard is moderately affecting to the success of CMMS then following good and sustainable data standard will increase the productivity. As an example if a company following a good naming standard for their spare part management, users can identify spare parts easily and can user for repair work without any delay. It will affect to the maintenance system effectiveness. Because ultimate objective of the maintenance process is machine availability.

Role assignment is also showing moderate affect to the success of CMMS. If the users receive relevant job according to their physical job role, there will not any confusion to the users. Then maintenance process will run smoothly. While implementing the CMMS process, maintenance managers should consider the correct role assignment to the users.

With modern computer technology improvement, most companies are moving to CMMS to manage their maintenance process. As per the literature there are many factors that affect the success of CMMS but in this research article only discusses four factors based on data perspective. Therefore, future research can be discussed how other factors influence the success of CMMS. Further, future research can be use different industries and some more countries to evaluate the success factors of CMMS. And this is only focus on the key users of the CMMS .Future researches can use the stake holder of CMMS to evaluate the performances of CMMS.

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