The Impact of Preventive Maintenance Practices on Malaysian Manufacturing Performance

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Abstract- This paper explore the influence of Preventive maintenance (PM) practices namely; Time-based maintenance (TBM); condition based maintenance (CBM); Predictive maintenance (PdM); on Malaysian manufacturing sector. The reason behind these PM integration on manufacturing performance is to obtain efficiency in minimize the error of production operational activities and machine breakdown in promoting effective towards realizing the goal of organization performance. Moreover there are many studies has proved that PM acted as a prominent paradigm to improve the manufacturing performance to gain further competitive advantage. Thus this research analyse the influence of Preventive maintenance (PM) practices on manufacturing performance in terms of cost, Quality, flexibility and delivery. This study employed quantitative analysis. From total 600 questionnaires distributed only 155 questionnaires was retuned. The Smart-PLS was used to analyse the data. The overall analysis shows that preventive maintenance practices (TBM; CBM; PdM) was positively contribute to the Malaysian manufacturing performance. The result will help Malaysian manufacturing companies in improving manufacturing performance through PM practices to compete in global market.

Keywords: *Preventive Maintenance, Time-based maintenance, condition-based maintenance, manufacturing performance,*

1.0. Introduction

The manufacturing industry is second large contributor to Malaysian GDP after service sector it can be found from the report stated by Malaysia Department of Statistics that in December 2019 the Manufacturing sector contribute 70 percent to GDP [1]. However [2] stated that Malaysian manufacturing organization has faced many obstacle from their global competitor that not only have affected company‘s profitability but also the overall economy. This is because most Malaysian manufacturing organizations faced with various challenging to enhance sustainability and to improve the productivity that needs to optimize their production system to meet higher global standard [3]. In addition the Ministry of International Trade and Industry urge that Malaysian manufacturing companies required to develop a suitable productivity improvement system in order to achieve competitive advantage. In line with this argument, the objective of this study is to measure the preventive maintenance (PM) practices such as time-based maintenance (TBM); condition-based maintenance (CBM); predictive maintenance (PdM) among contribution to the growth of Malaysia manufacturing organizations. The reason behind these three (TBM; CBM; PdM) practices was applied in this study because there are large number of studies has carried in the field of manufacturing sector and most researchers has found that these practices proven to be the best practices for costing saving and managing an effective environmental strategy [4],[5],[6]. This was supported by [7] where stated that (TBM); (CBM); (PdM) practices are combinations of prediction, inspection, trace uncertainties and maintenance repair of elemental defects in their propagation stage that minimize manufacturing expenses, which can achieved by business performance improvement. In adding [8] were pointed that basically the TBM practices can reduce the consequences of failure and extend the life of a system. Moreover [9] added that these TBM activity can perform using various maintenance actions such as repairing, replacing, overhauling, inspecting, servicing, adjusting, testing, measuring and detecting faults to avoid any failure that would lead to interruptions in production operations.

As studied in literature, there is positive association between preventive maintenance and Manufacturing organizational performance. However, [10] pointed that not every organization has implemented an effective preventive maintenance policy because it can independently increase the operation cost.

According to [11] much of the research have studied the concepts of preventive maintenance rather than the limitations hindering the organization from effective optimize their production system. Moreover there is less research conducted on how the Malaysian manufacturing organizations can overcome their barriers in enhance their competitiveness through preventive maintenance approaches [12].

Thus it is important to identify how the preventive maintenance practices; time-based maintenance (TBM); condition-based maintenance (CBM); predictive maintenance (PdM) contribution to the growth of Malaysian manufacturing organizations along with the ways to overcome these barriers. According to [13], one of the threat that faced by most manufacturing plant is when production stops because of equipment breakdown or machine failures due to improper maintenance activity and as a result it will directly increase the cost in a manufacturing organization that can effect the efficiency in operational activities. Therefore this study intent to clarify the impact of preventive maintenance practices on the performance of Malaysia manufacturing organizations.

2.0. Literature Review

The goal of maintenance is to preserve machine and system in use throughout checks, servicing, repairing or replacing of necessary devices, their lifecycles. Basically the maintenance activity is divided in to two category it is planned maintenance and unplanned maintenance[14]. Under the planned maintenance there are two activities involve (Preventive Maintenance and Corrective Maintenance). Meanwhile for unplanned maintenance have three activities namely (Reactive Maintenance; Breakdown Maintenance and Failure-Driven Maintenance). The oldest maintenance strategy only used unplanned (reactive) maintenance it also called as “fix it when it breaks”, which lead to various problems including unscheduled downtime, that increase product lifecycle costs possible serious safety violations that become more complicated to manage due to potentially significant damage to manufacturing equipment that becoming more challenging [15].

In this study the terms “Preventive maintenance practices” consisted of three practices namely: Time-based maintenance (TBM); Condition-based maintenance (CBM); Predictive maintenance (PdM). Where the time-based maintenance (TBM) referring to all the maintenance activity must be scheduled in advance[16]; condition-based maintenance (CBM) relies only on real-time sensor measurements and the maintenance activity only performed based on indicator sign [17]; Predictive maintenance (PdM) track the performance based on real time conditions of assets through heat sensor; sound; infrared and vibration analyzers of equipment and performed when maintenance activity based on real time conditions of assets [21].

2.1.1 Time-based Maintenance

Time-based maintenance also known as scheduled maintenance where the maintenance activity was carried based on operating hours [17]. This activity executed regularly at predetermined intervals e.g. Inspect exterior sealant every 3 years; Clean gutters every six months; Lubricate pumps every 6,000 run hours [18]. The TBM maintenance actions are basically conducted based on experiences or recommendations from original equipment manufacturers and based on their suggestion the maintenance activity will be performed [19]. On other hand [15] pointed that any manufacturing companies which utilize real-time and historical data related to part specifications, parts ordering, and maintenance schedules for each machine can decrease product lifecycle costs while increasing system availability .

2.1.2 Condition-based Maintenance

Condition-based Maintenance (CBM) is a well-known maintenance technique that relies only on real-time sensor measurements and by monitors the actual condition of an asset in order to executed required maintenance activity. In general, CBM act as a guide on identify and diminish the vagueness to prevent deterioration and possible failure at the earliest possible and these CBM activities only employed on operating asset based on requirements indicated by the condition of equipment [20]. In any industry‘s system, presence of products with defects can create serious repercussions, therefore, [13] recommend CBM as an best technique that operates using sophisticated and efficient assets. Hence, in this study the CBM was used as main indicator to improve the manufacturing performance by detect machine damage or problems in advance to reduce the costs and increase effectiveness manufacturing firms.

2.1.3 Predictive Maintenance

The predictive maintenance is techniques to determine, estimate and track the performance of equipment in order to prevent unexpected equipment failures during plant operation[21]. Predictive maintenance is viewed as a principal method to assist the determination of the condition of equipment in-service employed through vibration, lubricating oil analysis and wear particle

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analysis to optimise the average life cycle of an asset.

As mentioned [22], the advantages of predictive maintenance are tremendous from a cost-savings perspective and include minimizing planned downtime, maximizing equipment lifespan, optimizing employee productivity and increasing revenue compared to time-driven preventive maintenance procedures, predictive maintenance is condition-driven. Another advantage of predictive maintenance is its ability to monitoring control or equipment performance for early detection trough (vibration analysis, infrared thermography, motor circuit analysis, etc.) is to find defects and elimination of equipment defects that allows asset managers to improve outcomes and better balance priorities such as profitability and reliability[23].

2.1.4 Manufacturing Performance

This study is using manufacturing performance as dependent variables in order to identify Malaysian manufacturing performance in the dimension of cost, quality, flexibility and delivery. These dimensions are employed because Skinner [24] categorized manufacturing performance into four dimensions, namely, quality, cost, delivery, and flexibility. Therefore, in this study, the cost, quality, delivery, and flexibility are referred to as the manufacturing performance dimensions. On the other hand, [25]stated that machine or equipment failure not only affects quality but also delivery and flexibility. Thus, [26], [27] and [28]assert that in order to compete for global demand every firm must improve their performance by decreasing production costs and increasing quality as well as delivery and performance. In this study there are three hypotheses were proposed it was:

H1: The Time-based maintenance is positively influenced manufacturing performance of Malaysian manufacturing organization.

H2: The Condition-based maintenance is positively influenced performance of Malaysian manufacturing organization.

H3: The Predictive maintenance is positively influenced performance of Malaysian manufacturing organization.

3. Methodology

In this study the quantitative approach was used to collect the data. The scope of this study is organizational level where each questionnaire only can be answered by one manufacturing company. Thus the researcher decided to distribute the questionnaire trough postal letter. This decision was made after the researcher failed to receive positive response from manufacturing companies when the researcher tries to collect the data trough fax, telephone and email.

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Therefore the data was collected via a self-addressed and stamped envelope that was provided to encourage respondents to return the completed questionnaire. The researcher send total 600 postal letter to Malaysian manufacturing companies. The researcher gathered postal address of all 600 companies from Federation of Malaysian Manufacturers (FMM) directory. The questionnaire only targeted to the maintenance officers; Operations manager; Quality manager; Maintenance Manager; Chief Executive Officer who directly involve in maintenance activity. From 600 questionnaire only 155 useable questionnaire were received which show the total respond rate was 23 percent. In order to determine the adequate sample size this study employed G-power tool. After calculating the corresponding sample size using G-power, the required sample size was identified as 103. As such, the sample size of 155 was deemed adequate as it was more than the one suggested by G-power software.

4.0. Research Analysis and Discussion

This study employed Smart PLS to analyse the data. The researcher uses the reflective measurement approach to analysis the proposed variables. The internal consistency of the proposed model was measured through Cronbach's Alpha (CA) and Hair [28] has stated that (CA) value should to be 0.5 or above is considered appropriate.

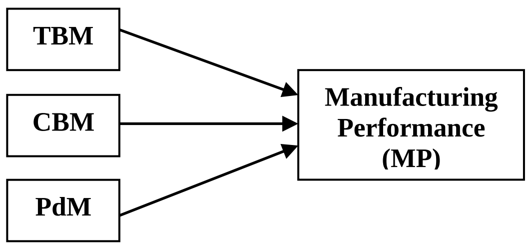

Figure 1: Conceptual Framework

The relationship of variables to the construct is reflected through, composite reliability (CR), Average variance error (AVE) and loading value (LV). According to [29] the rule of thumb of acceptable value for measurement items (CR; AVE; LV) should be equal 0.50 or above is considered acceptable. Based on the outcomes of factor analysis, it confirms that all items are loaded accurately to their respective variables.

Table1: Confirmatory Factor Analysis

Item	CA	CR	AVE
TBM	0.786	0.860	0.607
CBM	0.707	0.810	0.530
PdM	0.827	0.863	0.519
MP	0.835	0.835	0.500

Based on table 1 all the confirmatory factor analysis and the comparison of loading and cross-loadings result show an appropriate value which all reflective measurement models value show 0.5 and above.

Table 2. Discriminant Validity

Item	CBM	MP	PdM	TBM
CBM	0.728			
MP	0.120	0.678		
PdM	0.040	0.255	0.720	
TBM	-0.108	0.185	0.116	0.779

Table 2 show the discriminant validity result for all inner model. After examining the cross-loading items with loading items, the discriminant validity is determined in this research. According to [28] cross-loadings should be lesser than the loading items. As stated on table 2 above the cross loadings for (CBM; MP;PdM; TBM) is less than all the items loadings.

Table 3. Direct Effect

	(β)	SD	T-value	P-value
H1	0.148	0.113	1.150	0.025
H2	0.242	0.100	2.293	0.022
H3	0.160	0.147	1.175	0.024

Table 3 is the result of the structural model that received trough bootstrapping analysis. The structural model has been assessed after the measurement model in this study. A sample of 500 bootstraps and 249 cases has been used in the process of standard bootstrapping for this study. The significant of path coefficient is determined. The direct and indirect impact of the structural model indicate that all the hypotheses have p-value less than 0.05. Therefore this study declare that all three hypothesis in this study was supported.

Table 4. Expected Variance

	R^2
MP	13.8%

Table 4 show the evaluation of predictive criterion of accuracy (R-squared), which was done by using goodness of fit approach. The results of the R-squared value have shown a great deal of agreement with the hypothesized results. Here, 13.8% of the variation in beneficiary satisfaction can be considered to have good predictive relevance. Therefore, the overall result indicates that manufacturing performance was considered adequately explained by the model considering the number of exogenous variables (TBM; CBM; PdM).

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5.0. Conclusion

In this research, the role of preventive maintenance practices in achieving sustainable manufacturing performance was examined. The result of this study reveal that Malaysian manufacturing organisations can enhance competitiveness by implementing preventive maintenance approach. Moreover the empirical evidence revealed that TBM, CBM, and PdM practices are the key to improve manufacturing performance by reduce the machine breakdown and increasing productivity. This is because when the implementation of (TBM; CBM; PdM) was explored, it was found to be preventive maintenance practices create impactful opportunities for Malaysian manufacturing organisations to improve their existing resources. This study empirically proved that the implementation of TBM, CBM, and PdM positively improved manufacturing performance by increase product quality to ensure manufacturing plants to operate smoothly.

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